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Constructing

A

Sustainable Impact Assessment

Methodology

An Evaluation of Taiwanese EIA

Of High-Rise Building

Chia Chi Hsiao

PhD

University of Edinburgh

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Supervisor: Roger Talbot & Ian Thomson

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Addendum

I) Page 86, line 10, "GDP" should be **"GWP"**

II) Page 163, line 1, "socio-economic effects can not be dealt with by these would ; they require alternative assessment technique" should be **"socio-economic effects can be assessed in various ways within this model, such as computer models, Aggregate Direct Demand Method, Baseline Assessment etc. "**

III) Page 174, Table 4-6, " Poor Eutrophication" should be **"Low Eutrophication"**

IV) Page 292, letters are lost in **Table 6-6.** The last row should be as following:

International	Ecosystem of ocean	11	2.0	14	19.8
	Extinction of some species in the world	11	2.0	14	
	Deforestation and depletion of natural resources	48	8.7	4	
	Global warming	25	4.5	9	
	Depletion of ozone layer	2	0.4	19	
	Acid rain	12	2.1	13	

V) Page 619, Fig 12-13, the following note is to be inserted: **"Note: the energy consumption of hospitals includes surgeries and clinics , so the energy consumption in the case study buildings comes to be higher than for the hospitals category."**

VI) Page 731, the following second paragraph is to be added:

There has been a significant increase in the use of EIA in the world during the last decade, Valuable and useful lessons have been learnt from this research and experience. A number of considerations are being addressed which should improve the efficiency and effectiveness of the EIA process. These include a critical review and evaluation of the various components of the EIA process not only to show where the constraints in the system are, but also to indicate the alternatives and mitigation measures which could be adopted to overcome them. Furthermore, the benefits of project EIA are generally believed to considerably outweigh its costs . The widespread acceptance of the use of EIA in improving the quality of decisions about proposed projects has led to active consideration of, and some practice in, SEA or the environment impact assessment of policies, plans and programmes. SEA provides the most comprehensive approach to achieve goals of sustainable development. All the alternatives and impacts relevant to sustainability aims are adequately considered. Worldwide, each country has an important individual role to play in ensuring that EIA is carried out and that its conclusions are subsequently implemented, as well as its political and economic framework will allow.

Abstract

This paper examines the socio-political factors that influence the implementation of an Environmental Impact Assessment (EIA) system in Taiwan. The paper also compares the degree of sustainability achieved by an EIA for high-rise building projects. It reviews the overall institutional settings for EIA procedure and analyses the practice of preparing an EIA for high-rise building projects. Initially, the 'triangulation test' concept is focused upon, where policy, practice and performance factors are used to establish an evaluation framework to determine the effectiveness of an EIA. The research then examines other impact assessment concepts, including the life cycle assessment and critical dilution volume. In addition, post-occupancy evaluations have been carried out, including the analysis of collected data by statistical processing and graphical interpretation. This thesis centres on the EIA system in Taiwan with two case studies from high-rise buildings. The first case study focuses on an EIA for a high-rise departmental store (21 storeys), whilst the second concentrates on a mixed-use high-rise building of 32 storeys. Methods applied throughout this research consist of both case and field studies.

The research is divided into five sections totalling 14 chapters.
Section 1 Ideal Model of SIA: this section consists of three chapters, EIA and Sustainable Development Evaluation of the Effectiveness of an EIA, and establishment of ideal model of SIA.

Section 2 This section is divided into four chapters. Issues relating to the life cycle of building. The Development of an EIA in Taiwan, Analysis of EIA Implementation, Context of an EIA for High-rise Building Projects. This section focus on the formation and implementation of the EIA system in Taiwan.

Section 3 The third section has three chapters, which are A case study of So-Go Building, A case study of Formosa Building, and A review of the Implementation of the EIA process on high-rise buildings.

Section 4 There are two chapters in this section, The Application of SIA to high-rise projects and evaluation of implementation of EIA effectiveness. This aims to apply SIA approach for high-rise building. The Evaluation Framework of the effectiveness of an EIA to evaluate the effectiveness of the EIA system for high-rise building projects in Taiwan. It uses policy, practice and sustainability performance to carry out the overall evaluation.

Section 5 Conclusions

Acknowledgements

The fieldwork of this dissertation was funded by grants from the Taiwan Provincial Government and Taichung City Government of the Republic of China. This support is deeply appreciated.

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I also want to give my particular thanks to Terence Russell and Peter Martin for their insightful comments and useful input provided during my oral examination.

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My sincere gratitude goes to the Environmental Protection Administration (EPA), Taichung City Government and Taichung Environmental Protection Bureau (EPB) for their cooperation and for the assistance of their staffs while I conducted the field work for the study .

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In addition , many of my colleagues at the Taichung City Government have kindly provided help and information. I would like to mention a few as representative of the many: Song-Lin Chang; Hsiu-Li Lin; Der-Taur Liao; Lin- Chung Wang; Chiu-Hsiung Chen; Feng-Chun Shih; Chang-Mei Chou, Ruey-Chang Yung, Fang-Ming Lin, Shen-Juh Liu, Jeng-Haw Lee, Min-Ming Liu. Various institutions and individuals have been helpful to this research and are much appreciated: Department of Architecture of Edinburgh University: Chung-Kun Company, Kua-San Company, Hsien-Hsiu Tseng Architect & Associates, Kuei-Huang Wu Architect & Associates, So-Go Department Store, and Tzuu-Yuan Lee Architect & Associates.

Declaration

I declare that this thesis has
been composed by myself and
is my own work throughout

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This partial dissertation is primarily based upon the papers I-VI listed below. The materials provide additional support for the dissertation.

I **Chapter Two based on:** Hsiao, Chia-Chi. Planning and Environmental Impact Assessment, Taipei : TCG, 1998

II **Chapter Four based on :** Hsiao, Chia-Chi. "Toward sustainable development : Implementation of EIA system and improved environmental decision-making in Taiwan ". In Edinburgh Architecture Research pp. 91-104, vol 26, 1999

III **Chapter Five based on :** Hsiao, Chia-Chi. Analysis of environmental Impacts of the Life-Cycle of Buildings.

IV **Chapter Six based on :**Hsiao, Chia-Chi. Historical Development of EIA System in Taiwan, unpublished.

V **Chapter Nine based on :** Hsiao, Chia-Chi. Assessing Environmental Impacts of So-Go Building, unpublished

VI **Chapter Ten based on :** Hsiao, Chia-Chi. Assessing Environmental Impacts of Formosa Building, unpublished

Abbreviations

ADP	Abiotic Depletion Potential
AP	Acidification Potential
APROC	Asia-Pacific Regional Operations Centre
BOD	Biological Oxygen Demand
BRE	Building Research Establishment
C	Carbon
CATV	Community Antennna Television
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
Cd	Cadmium
CDV	Critical Dilution Volume
CEA	Cost-Effectiveness Analysis
CEQ	Council on Environmental Quality (USA)
CEQA	California Environmental Quality Act
CFC	Chlorofluorocarbons
CFC_{12}	Dichorodifluormethane
CH_4	Methane
CITES	Convention on International Trade in Endangered Species
cm	Centimetre
CMD	Cubic Metre Per Day
CMS	Cubic Metre Per Second
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
COE	Corps of Engineers (USA)
Cu	Copper
dB	Decibel
DETR	Department of the Environment Transport and Regions
DOI	Department of Interior (USA)
DNS	Determination of Nonsignificance (US Washington)
DOE	Department of Environment (UK)
DOT	Department of Transport (USA)
DPP	Democratic Progress Party
DS	Determination of Significance (US Washington)
EA	Environmental Assessment (US Federal)
EC	Environment Concerns (USA)

ECA/ECT	Ecotoxicity Aquatic/Terrestrial
EDP	Energy Depletion Potential
EF	Emission Factor
EIA	Environmental Impact Assessment
EIA Commission	Commission for Environmental Impact Assessment (The Netherlands)
EIA Committee	Environmental Impact Assessment Committee (Taiwan)
EIDAR	Environmental Impact Differential Analysis Report (Taiwan)
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EO	Environmental Objections (USA)
EPA	Environmental Impact Administration (Taiwan) Environmental Impact Agency (USA)
EPB	Environmental Protection Bureau (Taiwan)
ES	Environmental Statement (UK)
EU	Environmental Unsatisfactory (USA)
EU	European Union (formerly EC)
FAO	Food and Agricultural Organization of United Nations
FCCC	Framework Convention on Climate Change
FONSI	Findings of No Significant Impact (USA)
GAO	General Accounting Office (USA)
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GFA	Gross Floor Area
GNP	Gross National Product
GWHs	Greenhouse gases
GWP	Global Warming Potential
H	Hydrogen
ha	Hectare
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbon
HDDT	Heavy Duty Diesel Truck
Hg	Mercury
HMSO	Her Majesty Stationery Office
hr	hour
HT	Human Toxicity
IEE	Initial Environmental Evaluation (Canada)
ISO/TC	International Standards Organization /Technical Committee

KMT	Kuomintang
LCA	Life Cycle Assessment
LEIA	Life Cycle Environmental Impact Assessment
LPA	Local Planning Authority (UK)
LPG	Liguidfield Petroleum Gas
LCI	Life Cycle Inventory
LOS	Level of Service
MER	EIA Commission (The Netherlands)
MRT	Mass Rapid Transit
MTOE	Million Tonnes Oil Equivalent
N	Nitrogen
NEPA	National Environmental Policy Act 1969 (USA)
NOI	Notice of Intent (USA)
NOx	Nitrogen Oxides
N_2O	Dinitrogen Oxide
NP	Nitrification Potential
NGOs	Non-Governmental Organizations
NIMBY	Not-In-My-Backyard
ND	Negative Declaration (US California)
NOP	Notice of Preparation (US California)
NOD	Notice of Determination (US California)
NAT	Notice of Action Taken (US Washington)
O	Oxygen
OECD	Organization for Economic Cooperation and Development
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substances
O_3	Ozone
P	phosphorus
P_b	Lead
PO_4^{3-}	phosphate
POCP	Photochemical Oxidant Creation Potential
POE	Post-Occupancy Evaluation
PPP	"Polluter Pays" Principle
PSI	Pollution Standard Index
ppb	Parts per billion
ppm	parts per million
PCU	Passenger car unit

RA	Responsible Authority (Canada)
ROD	Record of Decision (USA)
S	Sulphur
SEA	Strategic Environmental Assessment
SETAC	Society of Environmental Toxicology and Chemistry
SIA	Sustainable Impact Assessment
SOx	Sulfur Oxides
SEPA	Washington State Environmental Policy Act (USA)
TDR	Transfer Development Right
TFA	Total Floor Area
Three Ps(3PS)	Policy, Plan and programme
	Policy, Practice and Performance
TSP	Total Suspended Particulates
UNEP	United Nations Environment Programme
UNCED	United nations Conference on Environment and Development
UK	United Kingdom
USA	United State of America
μg	microgram
VAT	Value-Added Tax
VKT	Vehicle Kilometre traveled
VOCs	Volatile Organic Compound
VROM	Ministry of Housing, Physical Planning and the Environment (The Netherlands)
WCED	World Commission on Environment and Development
	World Conference on Environment and Development
WTO	World Trade Organization
Zn	Zinc

CHAPTER ONE: INTRODUCTION

The first Environmental Impact Assessment (EIA) was carried out in Taiwan in 1979 on a demonstration project. In the subsequent 20 years, the effectiveness of the EIA system has become a concern for many people since it has undergone many changes and transformations. This thesis will focus on high-rise buildings when assessing the effectiveness of the EIA system in Taiwan.

This chapter contains the following sections:

- Research Background
- Statement of the Central Problems
- Research Context
- Research Aims and Objectives
- Research Design
- Thesis Structure and Content

1.1 RESEARCH BACKGROUND

The Taiwanese EIA system has been in practice for 20 years since the pilot demonstration in 1979 with the number of EIA cases increasing from six annually prior to 1990, to over 100 today. The range of the EIA has also expanded from being applied to only large-scale development projects, to today where all projects likely to result in a significant environmental impact are subject to an EIA analysis. Hence, the effectiveness of an EIA is now of greater concern to the government and community.

The key features of an EIA are environmental protection and management. These concepts are used to scope, predict and assess what environmental impact is likely to result from a proposed project. They also establish what environmental management and mitigation measures might be necessary to

counter these effects, or to submit alternative programmes if appropriate. The ultimate aims are tc minimise environmental impact and to promote sustainable development. The more effective the EIA system, the closer these aims are to being reached. However, in Taiwan the effectiveness of an EIA tc date is subject to debate (Ni 1998, p. 9).

As a result of Taiwan's successful economic development in the last decade, many cities have moved towards intensive land use utilisation with a tremendous increase in high-rise building construction. There were only 149 high-rise buildings with 20 or more storeys prior to 1990, which increased to 663 by 1996. As well as being an effective and rational use of the limited land resource, high-rise buildings are also an example of how economic development can be achieved whilst maintaining some quality environmental space. However, high-rise buildings do produce negative environmenta impacts on society; minimisation of these adverse effects is one of the most challenging tasks being faced in Taiwan today.

Since 1990, all high-rise development proposals in Taiwan have been subjected to the EIA process in the hope of minimising any undesirable environmental impacts from these building projects allowing for sustainable development. In 1995, the EIA Act became law in Taiwan giving the EIA system legal status. Since the Act was promulgated, of all the project types under the remit of an EIA system high-rise building projects comprise 30% of all cases.

Although the Taiwanese EIA system has been in practice for 20 years and law for five years, with some 720 projects passing through the EIA process by 1998, some EIA cases are still highly controversial. For example, the fifth light oil refinery project received approval from the centra government on the basis of an EIA report, which was later denied the go-ahead by local government The central government had to request that the original EIA report be reviewed again by the Academy Another controversy was the Bayer project; after approval of the EIA report, the local governmen requested that a public referendum be held on the issue. Although some positive results have beer

achieved, such controversies highlight the problems still evident in implementing the EIA system in Taiwan.

As the Director General of the Building Management Department in the Bureau of Reconstruction and Bureau of Environmental Protection the author has had a long-term involvement in the Taiwanese EIA system. He believes there is a need for an evaluation to be conducted reviewing the effectiveness of how the EIA is enforced in Taiwan. The author expects that improvements can be introduced into the system and the decision-making process refined so the aim of sustainable development can be more effectively realised.

1.2 CENTRAL PROBLEMS

The motivation behind this research is to provide answers to the central problems apparent in the EIA, which are:

How effectively is the EIA system carried out on high-rise building projects in Taiwan?

Which aspects are be considered effective or non-effective?

How can the effectiveness of EIA system be increased when applied high-rise buildings?

Before answers to the central problem are sought, some general EIA concepts need to be developed. Firstly, it must be understood that when discussing the implementation of an EIA, it is not simply the practice of the system that is being expounded on as procedure, institution, structure, practice, and performance are also components. However, discussion of the assessment techniques is beyond the scope of this research as they have emerged from a very broad range of disciplines. Secondly, the 'effectiveness' of an EIA system is understood to be the extent to which the system meets its aim of sustainable development, and how decision-making can become more acceptable.

Based on the above, two hypotheses are outlined:

- The implementation of an EIA system can increase sustainability. This is because development projects, which undergo the EIA process, meet the requirements of sustainable development better than those that do not.
- The implementation of an EIA system increases public environmental awareness and recognition of the development project. These, together with public involvement in assessment and investigation, can make EIA-related decisions more acceptable.

The most important task when considering the central problems is to assess why implementation of the EIA is not always effective. Once assessed, analysis of how to improve the effectiveness of the system in those ineffective or weak areas can then be undertaken through the consideration of institution, procedure, practice and performance criteria.

1.3 RESEARCH CONTEXT

Since the first EIA demonstration case in 1979, and the EIA Act of 1995, it is now timely to carry out a full evaluation of the implementation of the EIA system in Taiwan. The first question to be asked is whether the EIA Act has made any difference to the implementation of the EIA system; is it more effective now? Secondly, have all EIA cases carried out to date complied with the original design and objectives? A further question of interest is whether any problems are encountered when the EIA system is applied specifically to high-rise building projects; can the EIA system achieve greater sustainable development?

There are many studies that have concentrated on the analysis of the effectiveness of the system (eg. Wood (1995) compared the EIA systems of the USA, Canada, Australia, New Zealand and the Netherlands). Some studies have focused on technical problem areas (eg. in 1998, a study by Buckley on the quality of Environmental Impact Statements and Li Wei's assessment of the EIA methods in China). However, the EIA system's institutional design, the quality of the EIA report, and methods of assessment cannot qualify as suitable overall criteria to assess EIA effectiveness. If the aims of the

EIA system are to be achieved, a good implementation process is required. To date, there has been no research specific to the evaluation of the effectiveness of the Taiwanese EIA system, although some preliminary studies include:

- A comparison of the EIA procedure in various countries (Lin, 1994) which includes a comparison of scoping in each country.
- An evaluation of consultancy firms that have conducted EIA cases (EPA, 1997d)
- EIA monitoring (Liao, 1995).

Due to the paucity of effectiveness evaluation research it is deemed appropriate to carry out a full assessment of the EIA system, both of the system's institutions and the method of implementation.

The author has been involved in the implementation of EIA cases since 1986 first as an official in a government organisation, then as chairman of an EIA committee before becoming a decision-maker for EIA project assessment. Therefore, he believes in the paramount importance of the complete evaluation of the effectiveness of EIA implementation.

In 1985, a European Directive on EIA was established (85/337/EEC). Its objectives were to provide all EU member states with a more consistent standard for environmental control measures so avoiding unfair competition. With these objectives in mind, there have been a number of studies to analyse and compare the EIA system operating within EU member states. Some of these analyses take the comparative institutional aspects of the system as a starting point. However, other analyses examine how the EIA is actually put into practice throughout the EU eg. Marr (1997) used this approach to compare the effectiveness of EIA implementation in Germany and the UK. Such studies are of use as a learning tool in Taiwan. However, attempts to directly apply these models without modification to Taiwan's' EIA system cannot work as the operational characteristics of a system differs across national boundaries. Therefore, the aim of this thesis is to form a set of evaluation criteria to assess the

effectiveness of EIA implementation in Taiwan. Although cross-national comparison is not an objective of this thesis, some overseas studies will be used when necessary.

As previously explained, the analysis of predictive techniques is outwith the scope of this study (Table 1-1), and will only be touched upon when required.

Table 1-1: Scope of This Research

Aspects of EIA system	Example of research objectives	Within the scope of this study?
Context	EIA development and application characteristics on high-rise buildings	Yes
System	What is the EIA procedure? What are the features at specific stages of the system?	Yes
Practice	What is the EIA implementation situation?	Yes
Substantive issues	What substantive issues are raised when high-rise building projects undergo an EIA process?	Yes
Performance	What is the sustainability performance when high-rise building projects undergo the EIA process?	Yes
Technique	What method is adopted to predict environmental influence of high-rise buildings?	No

1.4 RESEARCH AIMS AND OBJECTIVES

The three aims of this research are to:

- examine the development and implementation of the EIA system in Taiwan for high-rise building projects;
- To analyse potential factors that directly influence the EIA system
- conduct an overall evaluation of the effectiveness of the EIA system in Taiwan;
- Present suggestions for the improvement the effectiveness of EIA system in Taiwan for high-rise building projects in Taiwan.

The aims are derived from the institutional design and implementation of the EIA system in Taiwan. These will assess EIA effectiveness. They will analyse which variables influence EIA effectiveness determining which are and are not effective. All the above form the basis on which policies which

can improve the current situation can be suggested. In order to meet these aims, the following objectives must first be achieved:

- analysing and setting up an evaluation framework and criteria to assess the effectiveness of the EIA system in Taiwan
- Constructing a ideal model of sustainable impact assessment (SIA) to assess urban development action.
- analysing the development of the EIA system in Taiwan, and determining influential factors
- examining the context of the EIA system for high-rise buildings in Taiwan, and describing the environmental impacts resulting from such projects
- analysing the characteristics of how the EIA system is implemented in Taiwan
- using high-rise building projects as case studies to analyse and examine the EIA process, and the process of decision-making
- Forming an application model for the Life-cycle Environmental Impact Assessment (LEIA) system for high-rise buildings, and adopting a case study approach to implement the LEIA model
- evaluation of the effectiveness of the EIA system with respect to high-rise building projects in Taiwan, and the submission of suggestions on how to improve implementation of the system.

These objectives can be categorised into four sections - Formulation of an evaluation framework and ideal model; Implementation of an EIA; Case studies of the EIA system; Application of LEIA to high-rise buildings.

1.5 RESEARCH DESIGN

This section is composed of the following four parts:

1.5.1 Research Methods

1.5.2 Case Study Research Strategy

1.5.3 Type of Project Studied

1.5.4 Selection of Cases

1.5.1 Research Methods

A variety of research methods are adopted in this study. Case studies are used to test the effectiveness of the EIA system and an LEIA methodology is developed. The practical results of the case studies form the foundation of the research conclusions.

This research is closely related to practice, and drawn from interview based on the experience of government practitioners and consultants. Their quick and spontaneous co-operation has had a great influence on the progress of this research.

Research methods used in this study include; literature, case and field studies, and regression and impact analyses.

Literature studies

This research method focuses on comparisons of the effectiveness of various EIA systems. Relevant studies on sustainable development and the environmental impacts of high-rise buildings are cited as support in this thesis. Literature studies form the foundation for the development of a theoretical framework and an assessment model in this research.

Case studies

A multiple-case approach is used. This type of research method involves the reviewing of documents, conducting informal interviews, and participant observation.

Review of documents - Relevant documents have been reviewed eg. municipal documents, reports, and minutes (Table 1-2). Municipal documents from Taichung City Government are the main reference

source with those from the Environmental Protection Administration (EPA) taking a secondary role. EIA report documentation from 28 cases implemented in Taichung City are taken as examples. Other minutes include cases reviewed by the EPA, and Taichung City EIA cases.

Table 1-2 : Types of documents used to analyse EIA implementation

• EIA report • Minutes of EIA review committee • Minutes of public briefing • Records of public hearings • Scoping documents (cases that enter second stage assessment) • Business information of consulting companies • Documents of EIA decisions

Unstructured interviews - Interviews were conducted with the following organisations and parties:

- Personnel in charge at the Bureau of Reconstruction, Bureau of Public Works, Bureau of Environmental Protection of Taichung City, and the general planning office of EPA.
- Consultancy companies and Planning and Design Companies responsible for two EIA cases
- High-rise building management companies
- Local resident
- Members of the EIA committee.

Participant observation - Direct participation and participation observation (by observing meeting procedures) was undertaken for the So-Go and Formosa Building case studies. However, participant observation can produce potential bias.

Field studies

For the field studies, investigations and measurements were applied to the following situations:

- Investigation of building usage: This type of investigation is conducted to gauge reaction to environmental themes associated with the building's planned use. Examples of areas of investigation include energy consumption and the building management issues.
- To understand likely impacts on adjacent land, investigation into neighbouring land usage was carried out prior to building construction.

- Site surveillance during construction to monitor noise levels etc.
- To assess parking implications for the neighbouring areas, the parking situation in the building's vicinity was surveyed.
- To understand likely impacts of the building on the service quality of nearby public facilities, observations were carried out on nearby recreational facilities.
- To understand the likely impact on local road traffic, traffic flow on affected arteries after the completion of building was investigated.
- Surveillance by the monitoring of air quality during building construction is necessary to determine of air pollutant discharge levels.
- To understand the likely environmental impact resulting from building materials, investigation of their manufacture is recommended.
- To understand the related environmental management and energy consumption issues raised by the building project, post-occupancy evaluation (POE) was employed as an indicative investigation of the building[1].

Regression Analysis (RA)

This is used to analyse the correlation between the staffing levels and degree of business seniority of EIA consultancy firms and the number of EIA cases carried out. Regression analysis is used to find possible variables that fall into the study of the correlation analysis.

Impact Analysis

The concept of Life-cycle Environmental Impact Assessment (LEIA) is used to analyse the likelihood of an environmental impact at each stage of the building's life-cycle. These impacts include the prediction of air pollutants discharged, consumption of water resources, consumption of abiotic

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[1]POE is a systematic and rigorous evaluation of a building after a period of occupation. POE is generally used to assess the needs of the building occupant's but, at this point, the method is mainly used to assess the environmental performance of the building.

resources, environmental impact (eg. greenhouse effects and ozone layer damage etc.) and impacts on the social environment etc.

The combination of these research methods has enabled the thesis to study the implementation of the EIA system for high-rise building projects from both broad and detailed viewpoints. A flow chart has been designed to indicate this in-depth analysis (Figure 1-1).

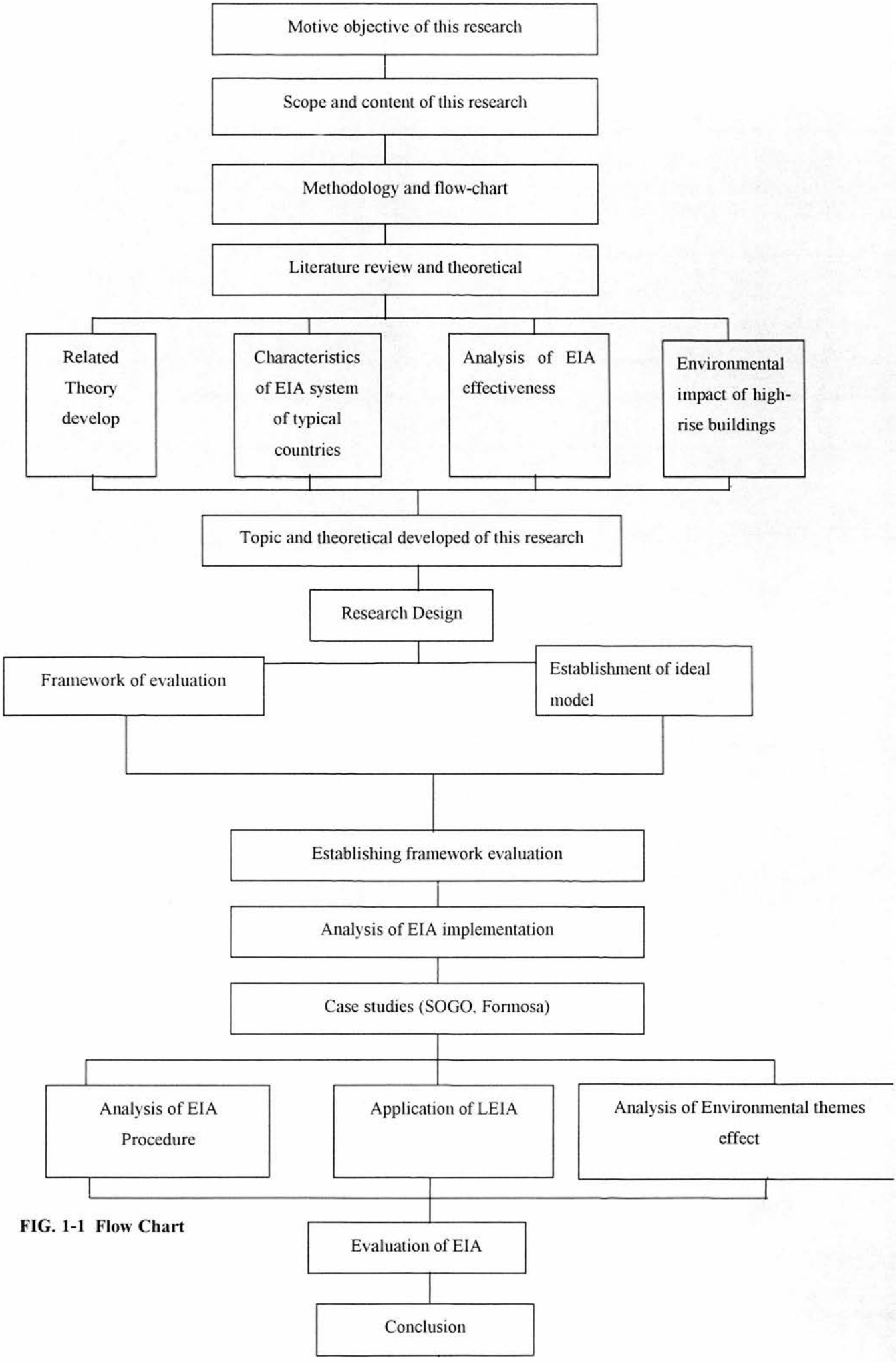


FIG. 1-1 Flow Chart

1.5.1 Case Study Research Strategy

Case studies are an empirical research method, and in general they serve exploratory, descriptive and explanatory purposes (Yin 1994, p.3). According to Yin (1994), a case study as an empirical inquiry is defined as one '*that investigates a contemporary phenomenon within its real life context, especially when boundaries between phenomenon and context are not clearly evident*' (Yin 1994, p.13). He states that the case study inquiry '*copes with the technically distinctive situation in which there will be many more variables of interest than data points and as a result, relies on multiple sources of evidence, with data needing to be converged in a triangulation fashion and as another result, benefits from the prior development of theoretical propositions to guide data collection and analysis*' (Yin 1994, p.13). In short, the case study as a research strategy is an all-encompassing method where the research design incorporates specific approaches to data collection and analysis.

Yin (1994) suggests that the formation of the type of research question (mainly 'what' and 'how' in this thesis) should be given priority (Section 1.2). These research questions ask (1) under what circumstances the EIA implementation can present its effectiveness in high-rise building projects, and (2) how to increase its effectiveness. As previously mentioned, a multiple-case strategy is adopted. Any cross-nation comparative studies are excluded from this research both due to the aforementioned problems, but also because few countries include high-rise buildings in their EIA remit.

Although case studies have exploratory, descriptive and explanatory purposes, they provide little basis for scientific generalisation. In response to the question 'How can you generalise from a single case study?" Yin (1994) claims that a single case study, like a single experiment, cannot represent a 'sample'. The investigator's goal is to expand and generalise theories (analytic generalisation), not to

enumerate frequencies (statistical generalisation). Statistical generalisation takes the form of statistically significant correlation, purely descriptive when using case studies (Mostert 1996, p.9). As the number of case studies is insufficient to obtain statistical significance, it makes no sense to aim at a statistical generalisation. Theoretical generalisation focuses on testing and developing theories, which is better applied in this research. Theories can be tested by experimentation, on the basis of the results of the case study, theories can be adopted in the same manner.

By using a multiple-case analysis for the purpose of 'theoretical generalisation' this research should result in the production of an assessment model that can be applied to the EIA process for high-rise building projects. Two high-rise building case studies are analysed in this research. Case chosen represent to regulatory region examine any possible differences arising from the 1994 EPA(see 1.5.3). In case selection, the objective is to pick a case that can serve the same purpose as a number of cases with similar results; literal replication.

1.5.2 Type of Project Studied

In Taiwan, the EIA system has been applied to a wide range of projects with the main procedural aspects of the system varying according to the type of development proposal as each type imposes a different degree of environmental impact. As a result, the research objective focuses on a single type of project. The reasons for choosing high-rise buildings as the central issue of this study are as follows:

(a) There has been a rapid increase in the volume of high-rise development, with associated widespread and serious environmental consequences, in all major Taiwanese cities. Since 1992 successive cities (initiated by Kaohsiung City) have enforced the EIA process on all

new high-rise building projects. Consequently, a study of the effectiveness of the implementation of the EIA system is especially worthwhile.

(b) Since 1995 and the promulgation of the EIA Act, it is now mandatory for high-rise building projects to undergo the EIA process. The high-rise building EIA has now been in practice for seven years in some cities. During this period, the system regulations have not been consistent with procedural requirements differing from one controlling authority to another. These changes have influenced the effective implementation of the EIA process on high-rise buildings, hence the need for an in-depth follow-up study.

(c) Although high-rise buildings can have a huge environmental impact on a city, their development is not as controversial as some project types eg. nuclear power stations or chemical plants. High-rise building projects are, therefore, more likely to obtain the necessary support, making it easier to conduct interviews with the relevant businesses and organisations.

(d) A long standing personal involvement in the administration of the EIA for high-rise buildings make it easier to gain access to information for the purposes of this research than for other project types.

(e) Environmental impacts resulting from high-rise building projects can be complicated, although their technical requirements are relatively simple when compared to other types of development project. Therefore, it is easier to formulate an in-depth assessment model to analyse these environmental impacts.

(f) As for waste water treatment plants, at present there is a paucity of research available for the implementation of the EIA with respect to high-rise building projects.

(g) As the pursuit of sustainable development is becoming ever more prevalent the planning of 'green' or sustainable building is now receiving more serious attention. The question of whether the EIA system can achieve such sustainability also requires thorough assessment.

For these reasons, high-rise development has been selected as the project type for this study. However as the local government oversees the EIA process for high-rise buildings, no comparison can be made between the effectiveness of central and local governments in implementing this process. This differs from the way eg. a garbage incinerator construction is assessed as this involves both central and local governments.

1.5.3 Selection of Cases

The multiple-case approach is adopted in the research design of this study. Two buildings, the So-Go department store (the So-Go Building) and the Formosa high-rise building (the Formosa Building) have been selected as case studies. Reasons behind this selection including the timing of the development, building usage, occupancy situation, location, and ease of data collection.

(a) Building for both the So-Go and Formosa Buildings was approved in 1993 before the promulgation of the EIA Act in 1994. However, in 1998 developers of the Formosa Building submitted a proposal to alter its use. These buildings have a representative value in this research as the So-Go Building represents an approved case prior to, and the Formosa Building is a case straddling, the enforcement of the EIA Act (Figure 1-2).

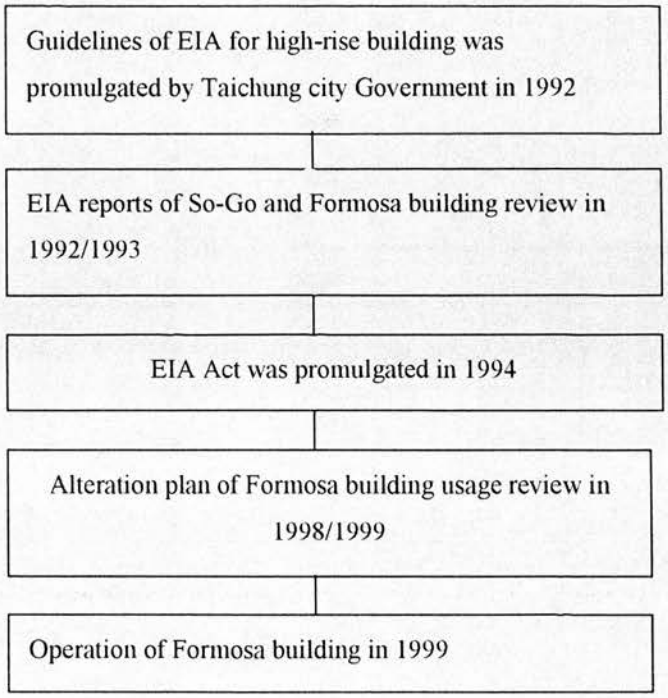


FIG. 1-2: Time sequence of selected case studies

(b) As both buildings have been completed they can be used in post-occupancy assessment issues. The level of sustainability achieved during building can be determined by establishing to what extent the objectives of the '3Ps' (policy, practice and performance) evaluation have been met.

(c) Seven of the 12 high-rise building projects undergoing the EIA process in Taichung City are being built for commercial purposes. These buildings tend to have a greater environmental impact on cities than residential (hence their exclusion from this research). The So-Go and Formosa Buildings are examples of commercial high-rise buildings. The So-Go Building is a department store selling an assortment of commercial goods, whilst the Formosa Building is

a mixed-use high-rise building combining hotel, restaurant, department store, and office facilities under one roof.

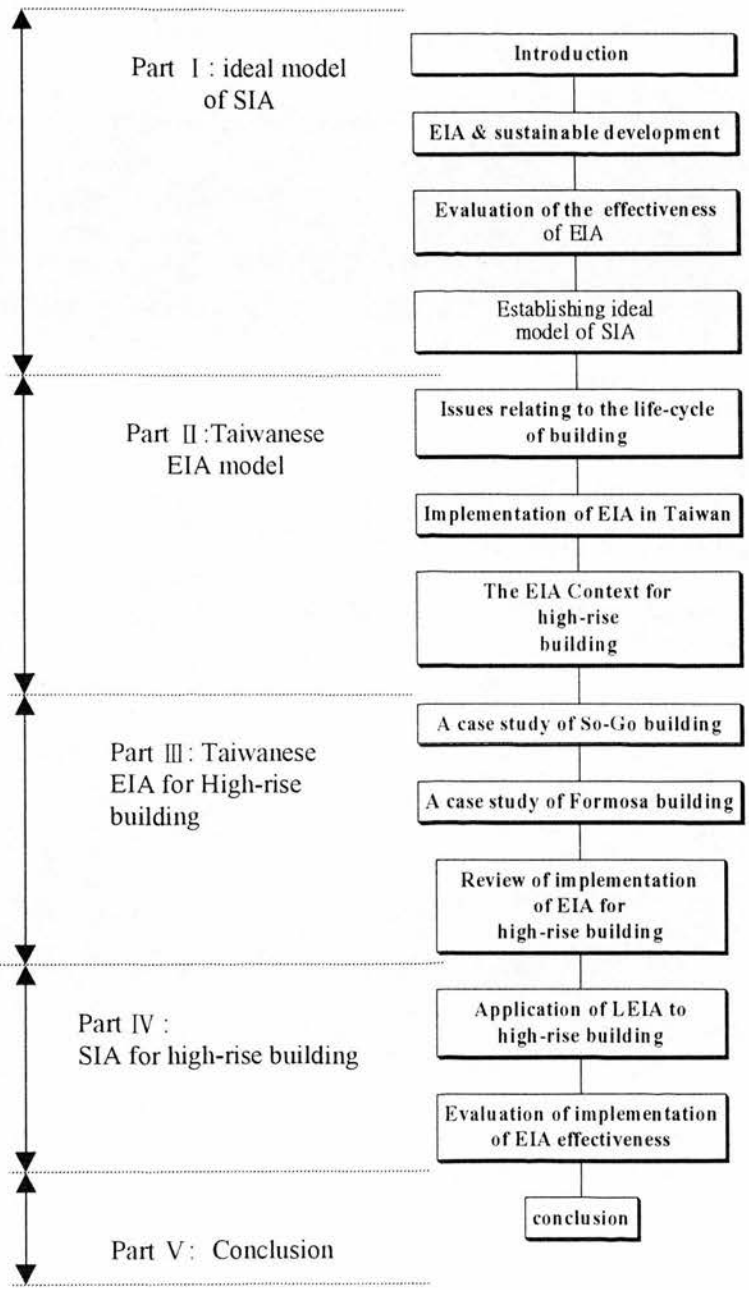
(d) As the EIA process for both buildings is virtually complete, each of the assessment stages (investigation, pre- and post-construction decision-making, monitoring and plan alterations) can be analysed. These buildings are both sufficiently advanced in the EIA process to be used as a standard for an overall assessment.

(e) The So-Go and Formosa Buildings are similar in their location in that they are both in the city area. They are, therefore, suitable cases for analytical comparison.

1.6 THESIS STRUCTURE AND CONTENT

The thesis is composed of five parts (Figure 1-3), the contents of which are discussed below.

FIG. 1-3: Structure of the research



Part One: Ideal model of SIA

This first section consists of three chapters: EIA and Sustainable Development, Evaluation of the Effectiveness of the EIA Process and establishing ideal model of SIA. The first of these chapters (Chapter Two) analyses the development of the EIA system by examining procedural and sequential issues, and describes the relationship between the EIA system and sustainable development. Chapter Three draws on the theories of sustainable development to formulate a framework evaluating the effectiveness of the EIA system using the '3Ps' concept to set up assessment criteria. After the formation of the evaluation framework, it will be used as an operational tool throughout the rest of this study. Chapter four focuses on ideal model of SIA.

Part Two: Taiwanese EIA model

This second part consists of four chapter (chapter Four to Eight); Issues relating to the life-cycle of building; The development of the EIA in Taiwan, The overview of the Taiwanese EIA model; and the EIA context for high-rise building. This part focus on the formation and implementation of the EIA system in Taiwan. Analysis of issues relating to the life-cycle of building, and context of EIA for high-rise building in Taiwan. Analysis of issues relating to the life-cycle of building.

Part Three: Taiwanese EIA System for High-Rise Buildings

This three part is split into three chapters (Chapter Nine to Eleven):A case study of So-Go Building, A case study of Formosa building, and A Review of the Implementation of the EIA Process on High-Rise Projects. This section focuses on the implementation of the EIA system for high-rise building in Taiwan. Analysis of how the EIA is applied to high-rise projects is accomplished using the multiple-case approach. The review of the implementation of the EIA process, together with an in-depth analysis of the investigation and decision-making processes, can be used later when assessing the

effectiveness of the EIA system as a whole. This section provides a practice basis used for evaluating the effectiveness of the EIA system, which is the overall aim of this thesis.

Part Four: SIA for High-Rise Projects

There are two chapters in Part Four: The Application of SIA to High-Rise Projects (Chapter Twelve), and evaluation of implementation of EIA effectiveness (Chapter Thirteen). This section aims to apply SIA approach for high-rise building. The SIA approach is used to determine the main environmental themes from all stages of a building's life-cycle, and to then analyse the impacts derived directly from the building sector; this is applied to the So-Go and Formosa Buildings in Chapter Twelve. Initially, the life-cycle of both buildings is defined from the 'cradle' to the 'grave'. Then, to fully understand the likely environmental impacts, revealed by the application of LEIA and EIA to high-rise buildings, a comparison is made of the likely impacts at each stage of the building's life-cycle. This section considers high-rise assessment issues from an environmental effect perspective. Chapter Thirteen uses the evaluation framework from Part One to assess the effectiveness of the EIA system on high-rise building projects in Taiwan. An overall assessment is carried out in terms of policy, practice and the degree of sustainable development (performance) criteria.

Part Five: Conclusion

This final part and chapter answers the questions addressing the central problems (Section 1.2) and provides suggestions on ways to improve the effectiveness of the EIA system in Taiwan. The problems and defects encountered when the EIA system is applied to high-rise building projects is summarised with specific improvement recommendations made (eg. improvements to the system and methods of implementation, and the pursuit of sustainable development).

In summary, aside from this Introduction, the thesis is composed of five parts. The first provides a theoretical framework , and the second analysis of Taiwanese EIA model whilst the third and fourth parts focus on the case studies using the EIA and SIA approaches. Conclusions are made in the fifth and final part. The relationship between the seven objectives encountered in the five part framework of this research is illustrated in Figure 1-4.

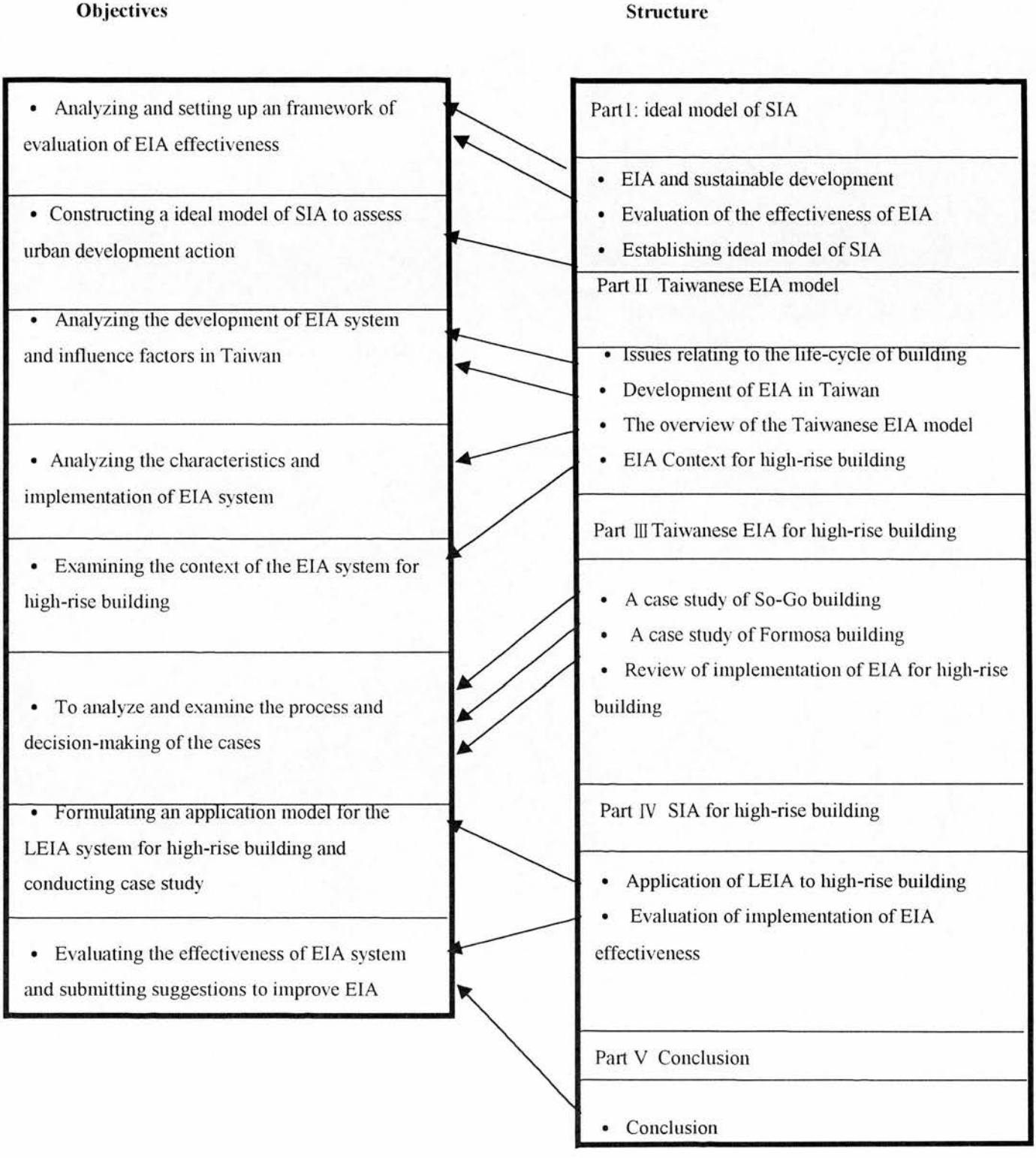


FIG. 1-4: Research Objectives and Thesis Structure

CHEAPTER TWO: EIA AND SUSTAINABLE DEVELOPMENT

2.1 ENVIRONMENTAL PROBLEMS AND CAUSES

Although humans have been aware of their impact on the environment for centuries, little was done to reduce environmental degradation caused by the implementation of public policies and private activities (Ortoland 1997, p.6). However, in the 1960s when the general public became increasingly more concerned about this deterioration, countries began to reinforce the planning and management of policies to maintain and enhance the environmental quality (Doyle *et al.* 1998, p.1).

In the 1960s the "Environmentalism" movement largely reflected European and American white, middle-class concerns with action groups campaigning on issues such as air pollution and whaling. At this time the negative effects of industrial development were beginning to be noticed, causing concern amongst people about how this may affect their health and lifestyles. In addition, these action groups articulated disquiet regarding population expansion in developing countries, and the threat that this posed to the environment through a rising demand on a finite global resource base, considered to be. This environmental movement, however, found little support in the developing world as development and environmental conservation was regarded as incompatible. As resources were thought to be finite, environmental deterioration was simply considered to be an inevitable consequence of industrial development. The developing world feared the negative economic effects in the enforcement of environmental policies. By the 1972, at the UN Conference on the Human Environment in Stockholm, the term 'pollution of poverty' was first coined. This referred to environmental aspects such as a shortage of clean water or sanitation threatening the lives of millions in the developing world (Elliott 1994, p.10). By the late 1970s a paradigm shift in thinking recognised environmental and developmental aspects as being interdependent concerns rather than two separate issues. As a result of this, the interdependence of the developed with the developing world was also acknowledged. By 1992, the interdependence of environment and development were realised to be of sufficient global concern to justify the largest

gathering ever of Heads of Government, namely UN Conference on Environment and Development (T
Earth Summit) in Rio de Janeiro.

2.1.1 A Review of Environmental Problems

Environmental problems can also be a result of deviant human behaviour, or those at a metaphysical lev
through the upholding of different beliefs, faiths, and/or ideologies. After the Industrial Revolutio
environmental problems have become a global issue through the promotion of technology, as well as
increase in human desire for material progress and possessions.

Environmental problems are inextricably connected with rapid increases in the global population.
1650 the worldwide population was estimated to be about 0.5 billion with an annual growth rate of 0.3
By 1900, it had increased to 1.6 billion with a growth rate of 0.5%: in 1950, 3.5 billion; in 1980, 4
billion and over 6 billion by 1999 (as at 12 October) with an annual growth rate of about 1.6% against
increase of 0.8% in 1950 (see Table 2-1). It has been estimated that the population could reach 8.3 billi
by 2025 (Jacobs 1996, p. 28). UN estimates indicate that if the annual rate of growth could be reduced
replacement levels by 2010, the population could stabilise to 7.7 billion by the year 2060. If t
replacement level were not reached until 2035 however, the population would eventually stabilise at 1(
billion in 2095. The Environmental Institute of Applied Systems Analysis (EIASA) predict a mid-ran
scenario is likely resulting in a world population of 12.5 billion by 2100 (Clayton *et al.* 1996, p. 75).

An escalating population will require a concomitant boost in economic activity, resulting in increas
both in the demand for resources, and in pollution levels. One of the first environmental impacts to be f
would be a shortage of food, which could be resolved by the development of agrarian and/or farmi
lands. However, this not only negatively affects the natural environment, but also destroys local natu
ecology through the application of fertilisers to enable intensive production.

It is a fact that there is extreme inequality in the distribution of the world's population. Of the 100 milli

babies born each year, some 80% occur in developing countries. By 2030, it is predicted that developing counties will represent 85-87% of the world's population (Clayton *et al.* 1996, p. 76). The current ability of the governments of these developing countries to provide the basic needs for their people (shelter, food, water, employment) is already over-stretched. With ever increasing numbers the shortcomings from the government will ultimately force people onto the land, to degrade and destroy the resource base on which their future livelihoods depend.

Table 2-1 : Global Population Statistics

	1650	1830	1900	1930	1950	1960	1970	1980	1990	1999 (12 Oct)
Total Population (billion)	0.5	1.0	1.6	2.0	2.5	3.0	3.7	4.4	4.8	6.0
Annual Growth Rate (%)	0.3	0.4	0.5	0.7	0.8	1.8	2.0	1.9	1.7	1.6

The growth rate in the production of forestry goods, such as paper, logs, and other wood products reached a maximum in 1967. However, the concurrent growth rate of individual consumption for these products decreased by 10% due to a reduction in forest area through felling rather than a decrease in demand. Sage (1996, p. 101) indicated that 148,000 km^2 of tropical moist forest was removed in 1991, this area represents 2% of the worldwide total of 7.5 million km^2. According to the World Commission on Environment and Development (WCED) report, between 7.6-10 million acres of rainforest has disappeared, and is continuing to disappear at a rate of 10 million acres yr^{-1}. Many developing countries, which depend on wood and charcoal for cooking, warmth, and light, felled more trees than were planted. According to estimations from the Food and Agriculture Organisation (FAO), in 1980 1.3 billion people lived in areas that were once under forest. It is speculated that if the current pace of felling is maintained, up to 2.4 billion people could be living in previously forested areas, and would be needing to import wood to supplement day to day needs (Lee 1995, p. 8).

Although the volume of fish caught each year has been steadily increasing since World War II, and since 1970 it has been doing so at an average annual rate of about 1%. If this situation is maintained, fish stocks

will eventually be eradicated. Abuse catching is already threatening stocking, and local economies.

Shortsighted agricultural policies are ineffective in that they actually deplete the agricultural resource. I some areas sensitive marginal land has been converted to agriculture to keep up with the demands of a increasing population. However this has resulted in environmental and ecological degradation e.g. i North America high soil losses, and sometimes desertification, have occurred though increased erosion in Asia, Africa and areas of Latin America the shallow soils of previously forested areas are unable t support long-term agricultural needs.

Air pollution, a reduction in forest area, and ecological destruction all contribute to global climate change Climatic abnormalities will further reduce agricultural outputs. According to the FAO, about 22% of th earth's surface (and about 11% of the population) are currently located in areas that experience a aberrant climate (Houghton 1996, p.3). During 1987 and 1988, the stocking volume of wheat and coarse grain, according to the FAO, decreased from 353 million tons for 78 days stocking to 248 tonnes for 5 days stocking. This corresponded with drought and heat waves of the Corn Belt and Great Plains o America, in 1988 (Lee 1995, p.9).

Furthermore, pollution also plays an important role in environmental degradation. Some gaseou emissions (CO_2, CH_4, and N_2O) are responsible for the greenhouse effect, which is causing the rise i global temperatures. Predictions by the IPCC state that global temperatures are likely to rise at a rate o around 0.3℃ per decade with mean temperatures rising by about 1℃ by 2025 and 3℃ before the end o the this century. Sea level could rise by approximately 65cm by 2100 (Jacobs 1996, p.15) putting th lives of a third of coastal dwellers in jeopardy. Through the global warming of the planet, it is predicte that the winters in the Northern Hemisphere will be shorter, colder, and wetter. The summer season wi be longer, hotter, and drier; evaporation rates will be expedited resulting in poorer soil quality, reduce growth periods for crops, and the destruction of a balanced ecology.

Other issues of concern include the condition of endangered species, the disposal of chemicals, the extensive application of insect pesticide, the destruction of the ozone layer, the treatment of hazardous wastes, and the degradation of marine ecosystems. Hazardous waste, greenhouse gases and other atmospheric pollutants all contribute to environmental pollution. In general, environmental issues can be grouped into three major categories:

- environmental pollution
- ecological destruction and crisis
- excessive depletion of natural resources

The destruction of a fragile ecosystem occurs through a loss of species and habitat specific to that environment, due to unsuitable changes to the ecological system. This could be through the mis-use of non-renewable resources, or the depletion of a renewable resource if not used optimally or sustainably; resources will be irreversibly exhausted if used to excess. The three categories mentioned above are closely interrelated; they are not independent issues. For example, the burning of fossil fuels emits greenhouse gases, which as well as producing an environment pollutant, is also depleting a non-renewable resource.

The problems of ecological degradation, environmental, and sustainable development, are receiving worldwide recognition and are of international concern. In the United Kingdom, Agenda 21 clearly describes all-important issues and follows on from the earlier Brundtland Report. Global environmental pollution and depletion of resources have become critical issues as indicated in Table 2-2.

Table 2-2 : Environmental Concerns and Sustainable Development in Various Research Reports

	Issues of Environmental Pollution	**Issues of Resource Depletion**
Brundtland Report	• control of climatic change • 3 types of pollution from burning fossil fuels: greenhouse, acidification, & industrial pollution • far-range spread of air • pollution • reducing urban industrial pollution; • risk of chemical product • industrial hazards: chemicals, hazardous wastes, nuclear wastes	• basic degradation of resource: loss of-soils • food shortage • decreasing forestry areas • expansion of deserts • woods: disappearing resource • renewable resources
Agenda 21	• protection of atmosphere • management of poisonous chemicals • management of hazardous waste • management of solid waste & waste water • management of radioactive waste	• management and planning of land resources • sustainable agriculture • sustainable countryside development • control of deforestation • prevention of drought • protection of marine resources • protection & management of fresh-water resources
Indicators of Sustainable Development in the UK	• climate change • ozone layer depletion • air quality • fresh water quality • soil • acid deposition • waste	• energy depletion • marine • land use • water resource • forestry • fish resource • mineral extraction • transport use • leisure and tourism
Toward European Sustainable Development	emission of CO_2	• resource use • use of renewable resources • use of fossil fuels • use of non-renewable raw materials (cement, raw iron, aluminium, chloride) • degraded soil areas • wood use • use of water resources
Global Environment Outlook 2000	• climate Change • stratosphere ozone depletion • nitrogen loading • toxichemical & hazardous waste • atmospheric • water	• natural disaster • forest fires & biomass burning • land & food • forest • biodiversity • freshwater • marine & coastal areas • urban area

2.2 SUSTAINABLE DEVELOPMENT

Since the Industrial Revolution growing demand on scarce resources and pollution generated by increasing living standards has resulted in environmental stress. Ecological imbalances, as a consequence of chemical and pesticide abuse, have attracted the public's attention re-evaluating the interactive relationship between humans and the earth. Environmental protection issues, such as global warming and the depleting of the ozone layer in Antarctica, spotlights the global nature of the problem, and the urgency with which they need to be acted on. Hence the development of the concept of 'sustainable development'.

Sustainable development is not limited to environmental issues alone. It is also relevant when applied to e.g. economic, social, ecological, and marine aspects. A definition of sustainable development depends on the viewpoint from which the concept is taken; this will discussed later.

2.2.1 Concept of Sustainable Development

Prior to 1980 thinking in the field of development centred on increasing prosperity in developing countries through economic growth and the application of scientific and technical knowledge. During the 1980s 'development' became a multidimensional concept encapsulating social, as well as material, improvements in society. In the 1980s, many developing countries have a debt outweighing their Gross National Product (GDP). Income inequalities across the world have also increased. In the latter part of the 1980s the concept of 'development' has broadened to encompass the genuine needs of society although many people in developing countries still have limited choices in their daily lives (Elliott 1999, p. 13).

Through continued deterioration of the global environment (both visible and hidden) the World Commission on Environment and Development (WCED) was established at the 38th UN meeting in 1983, and Gro Harlem Brundtland was appointed chairman. Its purpose was to re-examine global

environmental issues and 'development', to set up a global agenda for change, to propose long-term environmental measures for sustainable development, and to assist all countries and their people to establish a common knowledge. The Commission published the 'Brundtland Report' in April 1987 titled *Our Common Future* and included common concerns, challenges and endeavours. The report outlined the concept and implementation procedures for sustainable development, which was defined as:

> "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own need.*"
>
> (WCED 1987, p.43)

There are two key concepts within this definition:

- the concept of need, especially the essential need of the world's poor, to which overriding priority should be given
- the concept of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs (WCED 1987, p. 43)

The Brundtland Report covered issues of improving social behaviour and ethnic interaction with an overview to sustainable living for humans. Issues concerning 'people' and 'meeting mankind's demands' were given the highest priority with environmental issues considered from this perspective. It implies adjustments are necessary to human life styles, and the application of resources to satisfy a environmental carrying capacity; 'how to maintain environmental productivity to ensure long-term development of social economy' (WCED 1987, pp.118-145). One criteria of sustainable development is the aim for 'economy' and 'environmental protection' to be compatible, rather than contradictory i.e. environmental protection must not impede economical development. In fact, unless environmental policy is deemed a part of economic development, social and economical achievements cannot be sustained in the long-term. Thus, current environmental challenges arise from both the lack of development, and from the consequences of some forms of economic growth.

In 1992, the United Nations Conference on Environment and Development (the 'Earth Summit') took

place in Rio de Janeiro, Brazil. It was the largest international conference with a central aim of identifying the principle actions needed towards the implementation of sustainable development in the future. The challenge required the consensus from the highest level; hence this first, unique gathering of the heads of state brought together to consider the environment (Elliott 1999, p. 5).

Various agreements were reached, including Agenda 21, which provided the blueprint for the implementation of sustainable development. It included global, social, and economical issues, the preservation and management of resources, the enhancement of functions of every important organisation and implementation project. These issues are specific to the application, efficiency, and sustainability of natural resources, pollution management, treatment of waste, and the maintenance of a basic living standard for human beings. Therefore, this agreement of Agenda 21 was a milestone in promoting the idea of sustainable development after the initial proposition by the Brundtland Report.

As the concept of sustainable development was accepted throughout the international community, each country drafted a strategy for sustainable development. Although there are over seventy definitions of sustainable development currently in circulation (Elliott 1999, p. 6) most countries still use the definition detailed in the Brundtland Report. The definition used in the UK Environmental White Paper (1990) states that

> *Sustainable development means living on the earth's income rather than eroding its capital. It means keeping the consumption of renewable natural resources within the limits of their replenishment. It means handing down to successive generations not only man-made wealth, but also natural wealth, such as clean and adequate water supplies, good arable land, a wealth of wildlife, and ample forest.* (DOE 1996, p.1)

Sustainable development is a complex concept as environmental issues are interwoven with socio-economic activity. As the needs of future generations cannot be predicted, or how technological advances will affect resource utilisation, sustainable development has become a primary concern for environmental groups and politicians (Giddens 1998, p. 56).

2.2.2 Sustainable Development Goals

Since the publication of the Brundtland Report in 1987 sustainable development has achieved international recognition. However, development is often confused with growth. Growth conveys an idea of a physical or quantitative concept incorporating a notion of improvement and progress, and includes a cultural, social, and economic dimension. Nonetheless, sustainable development also encompasses the earth's regenerative capacity, and ability to recuperate and maintain productivity. The conservation of resources is, therefore, an underlying element to sustainable development (Blowers 1993a, p. 5).

The British Department of the Environment (DOE) states four aims for sustainable development;

(a) a healthy economy should be maintained to promote quality of life while at the same time protecting human health and the environment, in the UK and overseas, with all participants in all sectors paying the full social and environmental costs of their decisions;

(b) non-renewable resources should be used optimally;

(c) renewable resources should be used sustainably;

(d) damage to the carrying capacity of the environment and the risk to human health and diversity from the effects of economic activity should be minimised (DOE 1996, p. 9).

According to these goals, the premise of sustainable development is the efficient management of resources. It aims to ensure future generations can make use of the current environment and resources whilst also improving the standard of living for human beings within the environment's natural carrying capacity.

Blowers (1993a, p. 6) stated there are actually five goals of sustainable development:

(a) resource conservation

(b) built development

(c) environmental quality

(d) social equality

(e) political participation.

This includes social equality and political participation as being goals for sustainable development.

For development to be sustainable, the goals can be categorised into four levels.

(a) Maintaining the potential of species and the protection of biological diversity.

(b) Sustaining the economic welfare of each generation, and pursue intrageneration and intergeneration equality.

(c) Economic and development activities should comply with the sustainable development concept i.e. renewable and non-renewable resources should be used optimally and sustainably

(d) Maintain the sustainability of the community and improve the development of the standard of living for human well being.

Sustainable, or Optimal, Development

Sustainable development aims to strike a balance between the use of natural resources whilst ensuring an acceptable standard of living for this and future generations. Are the goals of sustainable development and optimal development consistent?

Simply, optimal development refers to the best development. It is defined as that path of economic development, which over time makes potential human well-being as large as possible (Pearce 1993, p. 8); i.e. it is the pursuit of greatest potential development. However, a basic assumption is made that cost of well-being will be higher in future generations i.e. future generations will be better off than today's generation. Consequently, the current generation ought to seek as high as well-being as possible. However, the meaning of sustainable development is not the pursuit of the best for just this present generation, but for all future generations. Figure 2-1, highlights the differences between sustainable and optimal development. Comparison of these two development methods clearly shows that sustainable development seeks for a greater well-being for future generations.

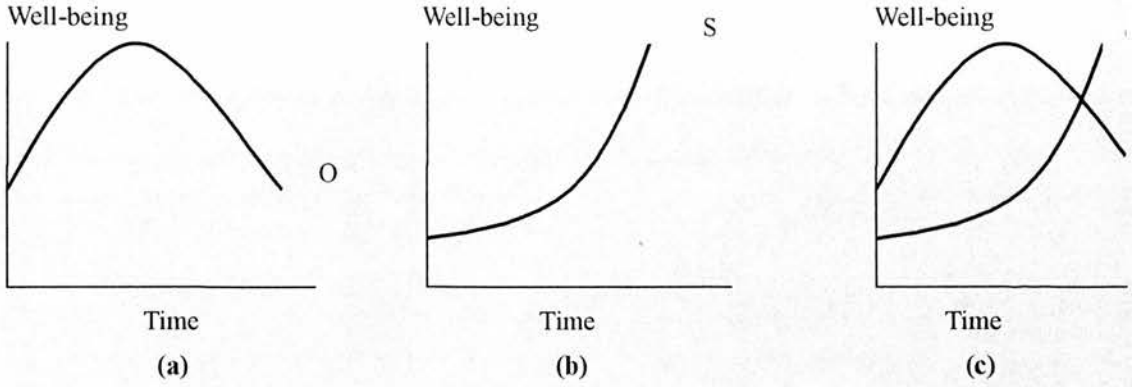


FIG. 2-1: Optimal and Sustainable Development

Note: Figure (a) optimal development. Figure (b) sustainable development. Figure (c) compares the two paths and shows a situation where the sustainable path makes future rather than current generations better off.

Data source: Pearce, 1993, p. 9, Figure 1.1

2.2.3 The Concept of Sustainable City

On examination of the evolution of the meaning of sustainable development, it is clear that the direction of the concept has changed. It has gone from being national policy to a practical task under the responsibility of local governments and organisations and the practice of 'think globally, act locally.' World population reached six billion on 12 October 1999. According to UNEP (1999, p.47) estimations almost 3,000 million people, about half of the world's population, live in urban areas and about 160,000 more join them every day, and that the 21st century will be a large-scaled urban world. Together with an increasing city population, urban problems are likely to be the leading global environmental and ecological issues. In facing expected environmental deterioration from this rapid population growth WCED (1987) have proposed that local-level organisations should co-operate with the global action project for sustainable development in order to cope with global environmental changes.

City planners see cities as organic bodies, and that the growth process of a city is a function of time. However, this growth process is mainly attributed to an infinite increase in population size, rather than the more finite expansion of area. In the early stages of city development, population size and area are both small. With time, the various stages follow; city growth, city ageing, city declination, and city destruction. During the growth phase, as city plans alone cannot maintain the functions of the city,

planners supplement and increase city functions through urban renewal projects to try and prolong the life of city. So-called 'City Renewal Projects' apply to opportune projects in older city areas where large-scaled adjustments (e.g. public facilities, removal of bad environmental areas) are carried out. These renewal projects are designed to substantially change the social and economical environment of the city, to restore its performance, to halt the ageing process, and to give new opportunities to the city. Traditional city planners tried to uphold the life of the city by re-building existing infrastructures. Nevertheless, city renewal overlooks the ecological elements, and the impact of industrial economy. Excessive development will deplete city resources, making the practice of sustainable development impossible.

According to the Seattle Comprehensive Plan (1994), a sustainable city needs to use resources in an efficient manner. It states that resources should be recycled, that local resources for development with minimum environmental impact should be utilised. An environment to ensure the safe and fair distribution of resources and profits should be provided, and a balance should be met between the demands of growth and recoverability (Cheng 1996, pp. 2-5).

The concept of sustainable development, when applied to cities, was stated by Elliott (1999) as:

Meeting the needs of the present

- economic needs include access to an adequate livelihood or productive asset
- social, cultural, and health needs: include a shelter which is healthy, safe, affordable and secure
- political needs: includes the freedom to participate in national and local politics, and in decisions regarding management and development of one's home and neighbourhood.

Without compromising the ability of future generations to meet their needs

- minimising use or waste of non-renewable resources: including minimising the consumption of fossil fuels
- sustainable use of renewable resources

- waste from cities keeping within the absorptive capacity of local and global sinks (Elliott 1999, p 162).

The prospects of sustainable urban development are inextricably linked to those of securing a sustainable rural livelihood. Rural-to-urban migration is still an important factor in current urban growth Challenges and opportunities of sustainable development include providing security and meeting of basic needs of individuals in urban and rural areas. Once this is achieved, a long-term view of development and the environment can be taken.

Practice of Sustainable City

WCED stated that for a city to be sustainable, policymakers should work towards the following goals:

- to experience and consider the concept of city and global sustainable development from the individual experience of city development
- to affirm and spread representative environmental information being a sustainable city
- to implement city development in compliance with the concept of global sustainable development
- to review and improve co-operation agreements between local governments, private organisations and individuals.

Lancashire County Council (England) proposed several items for sustainable city development (Selman 1996, p. 64). They were:

(a) more efficient use of resources, and less waste;

(b) lower levels of pollution;

(c) a more diverse natural environment;

(d) locally met basic needs for all;

(e) more work opportunities in a more diverse economy;

(f) improvements in health;

(g) access to facilities, goods, services, and people whilst protecting the environment;

(h) less fear of crime and persecution;

(i) access to education, training, and information;

(j) public having a say in decision-making;

(k) people valuing the neighbourhood and community in which they live.

This list includes public participation in governmental policies, and the efficient use of resources. From the principles set out by Lancashire County Council, it is noted that public participation can make the concept of sustainable city a reality. The principles of preservation and conservation of the natural environment, establishment of a sound economic system, support of a regional agriculture, business and service systems, efficient promotion of transportation, communication and production systems, development of renewable resources, and the building of a recycling material industry, must be focused on and given special emphasis to.

Breheny & Rookwood (1993, p. 163) proposed the fundamentals for a sustainable city to be[1]:

(a) more attractive for living as well as working

(b) less dependence on long journeys to work

(c) increased amount of affordable housing relative to total employment

(d) selection and decentralisation of employment

(e) improved quality of housing through, for example, reduction of excessive densities and redesigning for 'defensible space'

(f) greener, with more natural features, especially trees and water

(g) augmenting local open spaces to meet shortages

(h) exclusion of non-essential road vehicles

(i) improved access by high-quality public transport

(j) reduced car parking with priority for essential users

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[1]Breheny & Rookwood divided the social city region into six categories: city centre; city-inner area; city-suburbs; small town and new communities; mixed urban-rural; remote rural areas. They also presented strategies and monitoring processes (Breheny et al., 1993, pp. 150-189).

(k) progressive reduction in road congestion and traffic delays

(l) greater self-sufficiency of local areas for daily servicing

(m) increasing provision of more continuous and attractive cycle and pedestrian routes

(n) increasing pedestrian-only and pedestrian-priority areas

(o) better energy-efficiency standards in all buildings; greater use of solar gain

(p) reduced consumption of fossil fuels; more use of CHP (combined heat and power)

(q) reduction of total waste stream and greater percentage recycled.

The principles of sustainable city occur at four levels, namely:

- **consumption of natural resources:** The economic system depends on raw materials, food, and energy required for production that is provided in nature. Use of renewable resources cannot exceed their renewing capacity if the resource volume balance is to be maintained. Sustainable providence of required resources for the economic system, efficient applications, and recycling of non-renewable resources.
- **land use & traffic:** In the utilisation of urban land, the distance of workplace and convenience facilities should be as short as possible. Mass transportation ought to be used to reduce energy consumption. Moreover, a sustainable city also needs to be self-sufficient with respect to food, goods, services etc.
- **carrying capacity of city:** From the standpoint of resource supply, the carrying capacity of a city will limit the growth of said city. To enable the sustainable development of a city, the economic scale should not surpass the carrying capacity of the city. As for the carrying capacity of a city, the living standards and resource supply quantities should be taken into consideration.
- **by-products of city life:** The by-products from e.g. manufacturing in the city will become waste if not utilised. The treatment of waste is costly both on capital and resources, but will be released back into the environment after disposal. Once released wastes overtake the environmental assimilation capacity in a city, the environmental system will deteriorate affecting the life-supporting capabilities of the city. Therefore reductions in the emissions of pollutants, an improvement in water, air and soil

quality, and the recycling of waste materials will enhance the sustainability of a city.

In a broad sense, the strategy for a sustainable city aims to promote harmony between humanity and nature. The concept of a sustainable city is multi-faceted. Each individual city will have particular characteristics promoting sustainable development. Agenda 21 has identified the major physical environmental issues facing urban settlement worldwide. These issues include improved planning and management, integrated provision of environmental infrastructure (basic water supply and sanitation), the promotion of a sustainable intra-urban energy and transport system, anticipatory planning in disaster-prone areas, and urban health. It is acknowledged that any effective attempt to address these issues must be accompanied by participatory approaches through enhanced capacities within the local government. Sustainability plans and programmes should be implemented at the city level in order to promote a sustainable city whilst local sustainability requires the integration of environmental, social, and economic consideration. This shift of the sustainability agenda away from traditional 'green' issues (Selman 1996, p. 40) into the mainstream concern of economy and society has been the fundamental characteristic of the Agenda 21 process.

2.3 THE NATURE AND DEVELOPMENT OF ENVIRONMENTAL IMPACT ASSESSMENTS

The Environmental Impact Assessment (EIA) system was established in the United States in 1969 and was first implemented in 1970 (Weston 1997, p. 1). A number of countries have since set up their own EIA systems. Some countries have made it law to specify EIA issues through incorporation into related, currently existing, legal regulations such as environmental protection, land planning, and urban development law.

The EIA is a reference point necessary in the overall planning of any development project, with a view to balancing the needs of economical growth with the demands of environmental protection. It helps policymakers make objective decisions whilst taking the economic, sound environment practice, and

technical aspects of a project into consideration. It allows policymakers to be compliant to all possibl direct and indirect environmental impacts, and to make the appropriate decisions through Environmenta Impact Statements (EIS). In the remainder of section 2-3 we will discuss the origin, concept, an procedures for the EIA system.

2.3.1 Origin and Development of EIA

As previously stated, the EIA concept originated in the United States to balance economical developmen with environmental protection requirements. On the presentation of an EIS, the American governmer was in a position to determine and assess all likely environmental impacts of a project. In this way irreversible destruction to the environment could be avoided (Chang 1993, p. 5).

On examination of the history of environmental protection policies in the USA, the establishment of th EIA was a natural development. Environmental protection policy, in America, can be divided into thre broad periods:

1. **1950 to 1969** - Environmental protection and ecological maintenance issues were the responsibilit of local governments. Federal government only assisted in environmental protection (taking n leading role in any policymaking), and provided financial support for pollution control.
2. **1970 to 1979** - This period was known as the 'Environmental Golden Decade'. Environmentalis was actively promoted with environmental movements developing rapidly throughout America. T cope with social trends and demand, President Nixon established the Environmental Protectio Agency (EPA) and the Council on Environmental Quality (CEQ). During this period policymakin was transferred from local to the federal government, and were of the 'typical command' and 'contr regulatory' type of statutes.
3. **Since 1980** - Due to the economic recession of the federal government, the budget for environmenta protection policy was cut. In this period, the era of deregulation, environmental issues became shared responsibility of the government and the economic market (Chu 1995b, pp. 38-48).

Prior to 1970, environmental issues were managed locally although the control of regulatory statute

came from the government. Both the economic inefficiency of this scheme, and a number of pollution events which aroused the attention of the public[2], motivated the federal government into reviewing, examining, and centralising environmental policy. Large-scale environmental protection movements also encouraged this change (Chu 1995b, p.39) getting environmental policies onto the agenda for National Affairs. Thus, in 1969, the government regulated and published the National Environmental Policy Act (NEPA 1969) and established the EIA system (Petts *et al.* 1994, p. 36).

The implementation of the EIA moved environmental protection policies away from command and control regulatory statutes; the model was transformed from 'ex-post end-of-pipe control' to 'ex-ante prevention'.

In NEPA, Section 102, the Detailed Statement, is the legal reference for the EIA. In NEPA there are 2 chapters and 13 clauses that can be categorised to three major parts: the description of national environmental policies; actions forcing provision of the CEQ; and the establishment of the CEQ. The CEQ is the Advisor to the President on environmental issues and assists in the preparation of the Annual Environmental Quality Report.

According to regulations set out by the NEPA (section 102), the environmental impact report must include:

(i) the environmental impact of the proposed action

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented

(iii) alternatives to the proposed action

(iv) the relationship between local short-term uses of the human environment, and the maintenance and enhancement of long-term productively

(v) any irreversible and irretrievable commitments of resources which would be involved in the

[2] For example, a petroleum exploration drilling ship spilled 200 million and 5 thousand of crude oil in the sea near Santa Barbara, California in 1969. This resulted in 800 square miles of polluted sea, and killed thousands of sea birds.

proposed action should it be implemented.

From the above list, the US EIA aims for a proposed development project assesses both positive an negative impacts, and considers the feasibility of any alternatives. It also assesses the impact of resourc conservation with long-term developments. Under the US EIA system, any development authorit cannot only use the Cost-Benefit Evaluation method but has to take the irreversibility and irretrievabilit of resources on board when policymaking.

EIA, published by the NEPA, generally refers to federal organisations subject to NEPA specification However, each American state has its own regulations for EIA with different methods of implementatio some states require the state government to perform the EIA for every project whilst others states emplo local institutes (with state subsidy) or private individuals and companies (e.g. California an Massachusetts).

Since the establishment of the EIA in America many countries have followed suit in the setting up an implementation of an EIA system (Table 2-3). Although differences in methods and name occur betwee nations (e.g. Environmental Assessment in Canada and UK), in essence they are the same. Main points i the development of the EIA system are:

- EIA processes are clearly prescribed in law, which not only avoids ambiguous application, but als supervises the relevant agency in charge
- the implementation range of the EIA has extended from development project to governmental polic plan and programme
- scope of the EIA has been enlarged from direct and indirect environmental impact to the assessme of life cycle
- to encourage and ensure the participation of the general public, the process of the EIA syste includes public meetings, hearings and public inquiries etc.
- the public can file their complaints on unreasonable policies or illegal-processed assessments to th appeals and assistance channel, which includes administrative complaints or juridical litigation.

There are two methods for the establishment of an EIA system (Table 2-4):

- in Germany, Sweden, Denmark and the UK (for example) it is incorporated into the current land planning procedures, or
- as a new EIA legal statute, such as USA (NEPA), Australia (in Victoria, Environment Effects Act, 1978), Canada (Canadian Environmental Assessment Act, 1992), and Taiwan (EIA Act, 1994).

Table 2-3 : Introduction of Formal EIA Requirements

Country	Year
United States of America	1969
Hong Kong	1972
Japan	1972
Singapore	1972
Canada	1973
Australia	1974
Germany	1975
France	1976
Philippines, The	1977
China	1979
Taiwan	1979
Korea, South	1981
Indonesia	1982
Pakistan	1983
Switzerland	1983
Thailand	1984
Belgium	1985
Malaysia	1985
Greece	1986
Netherlands, The	1986
Spain	1986
Portugal	1987
Sweden	1987
Britain	1988
Ireland	1988
Italy	1988
Denmark	1989
Norway	1989
Poland	1989
Luxembourg	1990
Czechoslovakia (Czech and Slovak republics, 1992)	1991
New Zealand	1991

Data source: Gilpin, 1995, 0.3

2.3.2 The Purpose of the EIA System

The EIA system informs decision-makers of potential environmental impacts caused by development proposals. The EIA process has a number of important purposes, including:

An aid to decision-making

It provides a systematic examination of the environmental implications of a proposed developmer project (and sometimes alternative and mitigation measures). The EIA report can be considered by th competent authority and decision-maker together with other relevant documentation related to th development activity. The EIA report contains a non-technical summary. However, it does not clarif trade-offs associated with a proposed development project, which would lead to more rational an acceptable decision-making. The EIA process can be a basis for negotiation between the proponen stockholders, environmental NGOs, and the government (Glasson 1994, p. 8). This can result in a mor balanced conclusion between the project and the environment.

An instrument for sustainable development

Environmental protection and EIA are often regarded as being either a secondary objective in resourc management, or as obstacle to development. However, as previously discussed the concept c sustainable development offers opportunities for the bringing together of environmental, social, an economic planning and management. The EIA is a means of achieving such a synthesis (Barrow 1997, p 8) through its preventive, systematic, and holistic (i.e. multidisciplinary) approach to sustainab development. It also ensures inter-generational equity. It informs decision-makers of the limits of th environmental by establishing carrying capacities. Since 1992 the European Union has stressed the valu of EIA as a route to sustainable development (Barrow 1997, p. 9).

An aid to the development of projects

Developers, undoubtedly, see the EIA as a hurdle stalling the commencement of development project yet another costly and time-consuming bureaucratic process. However, the EIA is actually of benefit as provides a framework for considering location, design issues, and environmental issues (Glasson 1994, 8). The EIA can help achieve the ideal concept, whilst reducing both the need for modification during th project, and eliminate environmental impacts early in the planning phase. It can assist in smoothir consent procedure, reduce local opposition, and avoid costly public inquires.

However, the purpose of an EIA is not to force the hand of a decision-maker into adopting the least environmentally damaging alternative but to indicate the balance between the demand of development and the protection of the environment. In the past, the decision-maker just had to ensure that the economic benefit was larger than the cost of development generally using Cost-Benefit Analysis (CBA).

When decision-making information from various aspects must be considered. However, the manner in which this information is organised presents a further problem. Moreover, economic and environmental analyses, although interrelated, are often dealt with separately. The objective of the EIA system is to fully inform the decision-maker on all aspects of the environmental impacts, and to suggest alternatives.

Table 2-4 : Comparison of EIA coverage

Item	US	UK	Canada	Netherlands	Taiwan
Legal basis	Separate law (National Environmental Policy Act, 1969)	Amendment to existing act (Town and Country Planning Requirements, 1988)	Separate law (Canadian Environmental Assessment Act, 1992)	Amendment to existing Act (Environmental Management, 1994)	Separate l (EIA Act
Compliance with EIA process	Mandatory	Mandatory	Mandatory	Mandatory	Mandator
Introduction of formal EIA	1969	1988	1973	1986	1979
Scope of EIA application	Federal action, require federal permit for private project	Private sector and government initiatives	Private sector and government initiatives	Private sector and government initiatives	Private se and governme initiatives
Type of activity	Only those activities likely to significantly affect the environment	Only those activities likely to significantly affect the environment	All activities likely to affect the environment	Only those activities likely to significantly affect the environment	Only thos activities to signifi affect the environn
Coverage of impacts	Physical environment, socio-economic factor health, global climate change, global loss of biodiversity	Physical environment, material assets, cultural heritage	Physical environment, health risk, cultural historical factor, socio-economic factor, historical factor	Physical environment, health risk, cultural and historical factor	Physical environn socio-economic factor, he cultural heritage
Type of effects	Direct indirect, cumulative large scale (regional/global) biodiversity effects, sustainability consideration	Direct, secondary, cumulative, short, medium and long term, permanent, temporary, positive and negative effects	Direct, indirect, cumulative, large scale (regional/global) biodiversity effects, sustainability	Direct, indirect, cumulative, large scale (regional/global) biodiversity effects, sustainability	Direct, ir large scale(nat biodivers effects
Scope of assessment	Justification of proposal alternatives, project redesign, impact mitigation, environmental and financial compensation	Alternatives project redesign, impact mitigation, environmental compensation	Justification of proposal alternatives, project redesign, impact mitigation, environmental and financial compensation	Justification of proposal alternatives, project redesign, impact mitigation, environmental compensation	Justificat proposal alternativ project redesign, impact mitigatio

2.3.3 : The Operation of the EIA System

EIA system assesses the likely environmental impacts of a proposed project, and acts as a Competent Authority in policymaking. The content of an EIA is, therefore, extensive, complicated, and includes a number of assessment techniques. A series of specialised subjects are employed in an EIA, including the carrying out of surveys, observations, and analyses that are conducted frequently during the assessment process. The implementation of an EIA is time-consuming and costly, hence a number of small businesses either avoid, or only carry out perfunctory assessments. Often competent authorities do not take assessment results seriously not deeming them important in policymaking. However, a reasonable, appropriate and effective EIA is a critical tool in environment management.

To follow are discussion and explanations of some basic concepts of the implementation of the EIA system

A. EIA, Definition

Although many countries internationally have adopted the EIA system, as previously mentioned, the term 'EIA' differs between nations. Wood (1995, p. 1) believes that *"EIA is the evaluation of the effects likely to arise from a major project (or other action) significantly affecting the natural and man-made environment"*. Based on this definition, it could be concluded that the EIA is an assessment of natural and man-made environmental impacts of a proposed development project. However, Mostert (1995, p. 17) states that *"EIA is the process in which the environmental effects of a specific activity are studied and communicated"*. Mostert emphasises the essence of an EIA is its process, which differs from the EIA procedure. He considers that the EIA process is what actually happens and can, in principle, be observed in reality, and that the EIA procedure is what is prescribed by law and is found in legal regulations. The EIA process is the result of a number of overlapped, feedback steps whilst the EIA procedure consists of a combination of many different steps. Different definitions imply different underlying aspects. It has been 30 years since the EIA was implemented in 1969. The EIA process not only stresses the importance of ex-ante EIA, but also puts emphasis on the monitoring and supervision of the execution of the EIS.

Consequently, the definition of an EIA is the process of predicting and assessing likely impacts on the environment of proposed development actions and its alternatives; findings are used in publicly accountable decision-making, follow-up monitoring, and auditing are implemented as an on-going action. It aims to prevent environmental degradation by giving decision-makers better information about the consequences that development actions could have on the environment. Briefly, EIA involves public reviews of the existing environmental state, and the likely impacts of the future environment with or without action. After a decision is made, monitoring of the actual impacts should be implemented

B. EIA, Application

EIA application is aimed at those development projects that have a significant environmental impact. Generally speaking, EIA applications cover both public and private development projects. Nevertheless, many development projects may not require a license application, or need to adhere to government policies, but will make a significant impact to the environment. As a result, some countries extend the area of an EIA application to the level of policies, plans and programmes. This is known as the 3P's EIA, or the Strategic Environmental Assessment (SEA), or the Programme of Environmental Impact Assessment (PEIA).

There are two methods within an EIA application: generalism and itemisism. Generalism prescribes abstractly, e.g. the NEPA states that an EIA process should be conducted according to development activities, whether with significant impacts on the environment or not. Itemisism lists all the required development activities for which the EIA is being applied to e.g. the EIA Act in Taiwan. Itemisism however, is rather inflexible. Generalism prescribes that an 'EIA should be conducted if a proposed development project has significant impacts on the environment.' Following this, every development case needs to have an initial review conducted, resulting in further time delays. Moreover, 'significant impact' is difficult to define. Thus, most countries take these two methods, generalism and itemisism simultaneously i.e. listed categories and a general discretion approach are incorporated. There are criteria and thresholds needed during the screening process to decide whether a proposed project should be

subject to an EIA process.

C. Coverage of Assessment

The target of the EIA is to determine the likely environmental effects caused by a development proposal. There are two aspects to the assessment; environment, and effects.

The environment includes the natural, social, and human environment. The definition of 'environment' in the EIA differs between countries e.g. in Japan 'environment' refers to public nuisance and the natural environment whereas in Taiwan it more broadly refers to the living, natural and social environment (Table 2-4).

The 'effects' are discussed below.

(a) Direct effects and indirect effects

Occurs where a proposed project was likely to cause impacts at the same time and place that the project is sited. Direct effects refer to e.g. air pollution. Indirect effects refer to such impacts as new power requirements due to the establishment of a factory.

(b) First order effects, second order effects and higher order effects

First order effects are the immediate impacts resulting from a proposed development project. Second order effects are the knock-on effect from first order effects (e.g. change of river water quality) (Mostert 1995, p. 19).

(c) Cumulative effects

These refer to the impacts from a combination of a number of development projects. Some of the cumulatic effects can be obtained by directly adding the effects of one development with those from other developments, termed additive effects. However, where the cumulative impact of several projects exceed the sum of an individual impact a magnified cumulative effect results, termed *synthetic effects* (Therivel *et al.* 1992, p. 20). Most of the criticism of an EIA is the neglect of these cumulate effects; and the use of multiplied rather than additive effects.

(d) Short- and long-term effects

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Short- and long-term effects are usually evaluated during the EIA process. Short-term effects refer to the immediate impact after implementation of development projects e.g. a filled in swamp, the disappearance of the wetland is a short-term effect. Long-term effects refer to environmental impacts after a long period of development e.g. after the removal of the wetland the original ecological system has been altered which may lead to the disappearance of unique fauna and flora.

(e) Temporary and permanent effects

Temporary effects refer to those that may disappear after a short time e.g. noise pollution during construction. Permanent effects are those with a longer lasting impact whilst development activities are still in operation e.g. air pollution from a factory. Fundamentally, the importance of permanent effects outweighs temporary effects.

(f) Reversible and irreversible effects

Reversible effects are those that can be retrieved after the completion of the period of activity e.g. the aesthetics lost whilst temporary facilities are installed during construction. Irreversible effects are impacts that cannot be restored using artificial methods.

(g) Scale of effects

Development impact on the environment can be split into indoor (or site) effects, local effects, regional effects, national effects, and global effects. Indoor effects occur on site e.g. the impact of additional installation to the original plant. Local effects only affect a certain area whilst regional effects have an impact over a region e.g. air pollution. National effects affect a country e.g. social or economical impacts. Influences with no boundary such as climate change or ozone layer depletion are examples of global effects.

(h) International effects

Aside from global effects, any further impact to the human environment can be termed as an international effect. However scale cannot be the only standard for definition i.e. air pollution from development activities (e.g. SO_2) can affect a series of countries through long distance transmission. A further example is that of endangered flora and fauna which is part of the natural and cultural heritage of the world.

(i) Significant and insignificant effects

Many countries state that an EIA must be carried out if a significant effect occurs during development activities. NEPA (USA) and 85/337/EEC (EC) both contain the word 'significant'. As the determination of significant effects is subjective five factors must be looked at. The first element is the scope or level of effects; even if minor, it may become a 'significant effects'. The second factor is intensity; the seriousness of the effect e.g. a higher concentration of emissions is more 'significant' than lower concentration levels. The third point is the history of the area; the same pollution situation in a high-quality environment would be considered a 'significant effect' but not so in an area of low environmental quality such as an industrial zone. The fourth factor is certainty; whether a pollutant is of unknown risk then it might be classified as a 'significant effect'. The final factor is the effect to human health.

(j) Positive & negative effects

Positive and negative effects, again, are subjective. A specific effect may be positive to one group but negative to another e.g. a development project attracting visitors may negatively influence the living quality of nearby residents but may positively bring business opportunities to local stores, and employment.

(k) Certain and uncertain effects

Certain effects can be predicted and specific, but uncertain effects are not guaranteed and are hard to predict. In general, indirect effects, higher order effects, cumulative effects, and long-term effects are uncertain (Mostert 1995, p. 21).

D. Alternatives

The idea of alternatives comes from the American NEPA. Negative effects on the environment can only be lessened or prevented through analysis with choices necessary to allow alternative actions. In the NEPA, there are six types of alternative actions:

(a) no action: 'shelving' a development project

(b) postponed action: putting off the implementation of a development project; e.g. a proposed development project may be delayed to take into account the seasonal requirements of a local

endangered species

(c) **equivalent profit action:** utilising different ways to achieve the same result; e.g. construction of a super-highway being substituted by public transport

(d) **action of alternative designs:** a number of design actions can achieve the goal of project; e.g. different operational processes for wastewater treatment as a replacement

(e) **action of compensation:** losses at a specific area must be compensated for; e.g. if the underground water supply at a certain site is drawn, then an equivalent amount should be replaced to maintain the underground ecology

(f) **site alternative:** an alternative installation site.

Proponents can evaluate all possible alternative actions and present each alternative to the policymakers allowing informed decisions to be made.

E. Timing of Evaluation

With any type of development, there are four stages; conception, planning, design, and implementation. It is generally agreed that it is best to conduct the EIA process at earlier stage; some advocate for during the stage of conception (Wu 1990, p.22). In the early years of EIA it was carried out between the planning and design stages. However, as much was already tied up in the project by this stage (manpower capital invested), it was very difficult to propose alternatives with amendments often resulting in the loss of the proponent.

It is therefore best to conduct an EIA during the earlier phases, either conception or planning. The main aim of an EIA is to determine the environmental impact of a new development project through assessment and review procedures, and to outline all likely alternatives. In conducting an EIA early, any environmental effects will be noted in advance, allowing findings to become part of the policy. However if it is carried out too early, re-evaluation may be necessary at a later date due to insufficient information or changes in ideas and the environment, which will be as wasteful to proponents

Consequently, the ideal timing to conduct an EIA should be between the conception and planning stages

F. Public Participation

Public participation is indispensable to EIA. However, there are differences in both the timing and ways of public participation. With regards timing, notification to the public should be as early as possible to allow public opinion to be incorporated into the plan; the sooner the public makes a stand in policymaking, the greater their influence on the final result. As for participation, there are four occasions for the public to input into the EIA process:

(a) preparation phase: public consultation before the scoping process of the development action is conducted

(b) scoping phase: assessing items are confirmed in public

(c) preparation of EIA report phase: relevant organisations and public opinion must be examined by the proponents before the submission of an EIA

(d) review phase: to ensure that public opinion has been noted by the proponents and have been reflected in the EIA report, the report must be distributed to all appropriate organisation and the public for review.

Thus, the methods for public participation differ at every stage. The most common ways the public can participate are through public hearings, general public presentations, leafleting, advertisements, questionnaires and surveys, exhibitions, telephone 'hot lines', briefings, responses to public inquiry, consultation committee, and informal group meetings.

Aside from consultation to collect public opinion, and utilising the right to be informed, public participation is also a form of intelligence collection. It is therefore in the interests of proponents to respond to the opinions of public participation through the EIA reports.

G. Review Agency

A review agency does review the EIA reports in compliance with justice and objectiveness. Each nation has its own rationale regarding the role and constitution of the review agency e.g. the EIA committee is responsible for reviewing EIA reports in the Netherlands and Canada whereas in America the review agency is divided into a lead agency (or competent authority) and public reviewer (which could be individuals, organisations, companies, and other institutions made up of Indian tribes). If there were no

appropriate agency to review the EIA report, then the investigation and prediction of environmental impacts, the analyses of evaluations, and the treatment of public participation would be an invalid and meaningless process. As such, for an EIA to be justly implemented a third-party group must take charge of the review or, as is the case in the US, a public reviewer together with the judicial review system.

H. Other Types of Impact Assessments

There are other impact assessment systems in addition to the EIA such as Ecological Impact Assessment, Social Impact Assessment, Economic Impact Assessment, Hazard and Risk Assessment, and Aesthetic Impact Assessment. These assessment types are specific to a particular purpose namely ecology, society, economy, risk etc. Assessment techniques used in these systems are also employed when conducting an EIA.

I. Characteristics and Types of the EIA System

Though the EIA system has been adopted around the world, each nation differs in its method and purpose for implementation. There are three types, rationalised according to the characteristics of each system (Wu 1990, p. 30-31):

(a) ex-ante investigation of public nuisance: this requires the developer to investigate and predict al potential environmental effects resulting from the development, and to propose resolution measures for approval. This type falls short of a true EIA as there is no public participation or reviews

(b) simple procedure type: this necessitates proponents to investigate, predict and assess al environmental impacts of the project. The opinions of residents are requested through public participation with published data available for policymaking. Although this EIA system includes public participation and published information, resident opinions and those from environmenta protection organisations are not emphasised.

(c) rational type: the proponent is required to process an environmental assessment before the development activity is approved, and to present alternatives through published information and public participation. This model also deals with the compensation system after the event, penalty regulations, and continued monitoring and supervision. This is considered to be the ideal model and is implemented in the Netherlands.

Table 2-5: Comparison of EIA process

Item	US	UK	Canada	Netherlands	Taiwan
Parties involved at screening	Competent (lead agency) authority initiator	Competent authority initiator	Competent (Responsible Authority RA) authority initiator	Competent authority initiator	Environmental authority initiator
Parties involved at scoping	Competent (lead) environmental authorities public initiator	Initiator	RA, environmental authorities, Federal Authority (FA) public expert committee (panel) initiator	Competent environmental authorities public expert committee initiator	Competent environmental authorities public expert committee initiator
Final responsibility for scoping	Competent authority(lead agency)	Initiator	RA, expert committee (panel) environmental authority (Expert FA) initiator	Competent authority	Environmental authority
Reviewing EIA	Competent authority (lead agency)	Competent authority	Expert committee (Panel)	Expert committee (mer)	Expert committee
Final decision	Competent authority	Competent authority	Competent authority	Competent authority	Competent authority
Screening undertaken	List of categorically excluded step by step screening mechanism	Case by case screening mechanism and use of list of activities with threshold values	Use of activities with threshold values, case by case screening mechanism, general criteria list of resource or area or sensitivity	Case by case screening mechanism and general criteria threshold values	General criteria threshold values list of resource or area or sensitivity
Administering EIA procedure	Competent authority	Competent authority	Competent authority	Competent authority	Competent authority
Aspects identified in scoping phase	Key issues, significant impacts, alternatives affected and interested population, group guideline for preparing a EIA	Key issues, significant impacts, alternatives affected and interested population, group guideline for preparing a EIA	Key issues significant impacts alternatives affected and interested population group guideline for preparing a EIA	Key issues significant impacts alternatives to guideline for preparing a EIA	Key issues significant impacts alternatives to guideline for preparing a EIA
Assessment related to decision making	Linked to approval process	Linked to approval process	Linked to approval process	Linked to approval process	Formal binding approval process
Application of SEA	Yes	Yes	Yes	Yes	Yes
Public participation	Throughout the process	Only at particular stages	Throughout the process	Only at particular stages	Only at particular stages
Number of EIA undertaken in 1994	NA	100-499	More than 1000	83	67

2.3.4 The EIA Process

Integrity requires that an EIA procedure must include all the main related issues. Wood (1995, p. 5) pointed out that an EIA should include a series of steps:

- *consideration of alternative means of achieving objectives*
- *designing the selected proposal*
- *determining whether an EIA is necessary in a particular case (screening)*
- *deciding on the topics to be covered in the EIA (scoping)*
- *preparing the EIA report (i.e. Inter alia, describing the proposal and the environmental affected by it, and assessing the magnitude and significance of impacts)*
- *reviewing the EIA report to check its adequacy*
- *making a decision on the proposal, using the EIA report and opinions expressed about it*
- *monitors the impacts of the proposal if it is implemented.*

These steps take alternatives into account. The procedure of screening decides the necessity of the EIA process, whilst the procedure of scoping determines the coverage of investigation. Apart from that, the preparation of EIA report incorporates the reviewing, decision-making, and following-up processes. However, Barrow (1997, pp. 105-123) noted that the EIA procedure should include screening, scoping, consideration of alternatives, identification and measurement of impact, mitigation and avoidance of impacts, recommendations, communication of impact assessment, review of impact assessment, making use of impact assessment, auditing (evaluating whether the impact assessment has worked), and monitoring.

General speaking, the EIA process is composed of various elements and steps. The most important include alternatives, screening, scoping, preparation of the EIA reports, public review, decision-making and monitoring.

A. Consideration of Alternatives

The consideration of alternatives to any development proposal is the first step in the EIA process. The proponent of a project has a set of aims, which can normally be satisfied by a number of alternatives, each of which has a different impact on the environment. The choice of alternatives minimising the environmental impact of a project will be an important determinant when decision-making.

Alternatives for all projects are evaluated individually and should be drawn up during the planning stage. Most EIA systems also expect proposed alternatives to be explained in detail in the EIA report. For instance, in America alternative ways to meet the objective are required; the no-action alternative, and alternatives outside the lead agency's jurisdiction (Wood 1995, p. 105). Each alternative is must to be individually evaluated, and compared.

B. Screening

Screening is necessary to determine whether a development activity needs to be subjected to an EIA process. In America the NEPA states that the EIA applies to "major actions significantly affecting the quality of the human environment". This screening process determines the 'significant effects' of development on the environment.

One type of screening process, the 'categorical approach', is to list all the development actions applicable to the EIA, and give criteria. The other type is to 'regulate generally' i.e. to only list principle regulations. Consequently, whether a development action requires the EIA process or not is determined by a set of procedures, called the 'discretionary approach' (Mostert 1995, p. 24).

The categorical approach relies on criteria and thresholds. In addition to the aforementioned category listing, it can also be based upon scale and location e.g. the development of an industrial park over 10 acres with 2 acres of protected land will be required to conduct an EIA. The merits of the categorical approach are that it is clear, incontestable, and time- and cost-effective; a shortcoming is its inflexibility.

To avoid the EIA process, proponents sometimes readjust the apparent scale of the development.

The screening process is more complicated when using the discretionary approach. In America an initia environmental assessment has to be carried out by the government to determine the criteria and characteristics of the project. If an EIA is not required, a notice of 'Finding Of No Significant Impact (FONSI) will be filed.

The screening process plays an important part in the EIA system. It can be utilised to confirm if any significantly negative environmental effects could be expected from the development actions and whether an EIA would be required. It can also expose unnecessary development actions so avoidin wasted time and costs.

C. Scoping

The purpose of scoping is to determine the range of issues to be addressed in the EIA report. Scopin identifies the significant issues related to a proposed project, decides and provides a communication lin between environmental protection groups, individuals and relevant organisations to help promote th quality and credibility of the EIA report. Its main goals are:

- to determine the range of issues required in an EIA report and deciding methods of investigatio prediction, analysis, and evaluation
- confirm all reasonable alternatives.

The scoping process is not the same for every country. The purpose of scoping within the US EIA syste is to list and confirm all the important environmental issues, to evaluate scoping, and to determine th significant effects of the project. The scoping process is:

1. the lead agency invites the affected federal, state or local government, local residents of the affecte region, proponents, and stockholders to take part in a scoping meeting
2. determine the important issues from the EIA reports, the range of assessment, and analyse the dep

3. delete or eliminate insignificant assessment items
4. the lead agency and sponsoring organisations must work together to co-ordinate, co-operate, and discuss the schedule and progress of the assessment.

In many countries scoping is a distinct phase in the EIA, prescribed by law. However, scoping can take place before this formal phase, often needing public participation. Scoping can enhance the relevance and scientific quality of the EIS so preventing possible bias in the outcome. In addition, scoping can promote the public to put forward their concerns, and for these concerns to be properly addressed in the EIA report. Scoping can give the proponent more certainty.

D. Preparation of EIA Report

The environmental impacts of development activities, alternatives, and mitigation measures are presented as an EIA report. In the US and the Netherlands this report is an Environmental Impact Statement (EIS), Environmental Statement (ES) in the UK, Environmental Impact Report (EIR) in California, Environmental Assessment Report (EA Report) in Canada, and Environmental Impact Assessment Report (EIA Report) in New Zealand. Aside from the variety of names, some countries also divide the EIA report to a draft and final versions. The draft is prepared by the proponents and presented to institutions, interest groups and individuals for review. The final version is an amendment of the draft and includes questions, discussions, and opinions of the reviewers. In Australia an EIS is not required as a Public Environmental Report (PER) is produced which can be regarded as being a simplified EIS. The term EIA report will be used throughout this work.

Prior to making an EIA report, consultation to related organisations and groups, and public participation to reflect the opinion of residents is required. Alternative and mitigation measures should also take public opinion into account.

The content of the EIA report is similar between countries although there are some differences regarding

the range and definition of environmental impacts. Essentially, the EIA system provides a reference guideline for proponents.

The content of an EIA report, according to the NEPA regulations, is composed of the following items (Wood 1995, p. 150):

- cover sheet
- summary (not normally exceeding 15 pages in length)
- table of contents
- statement of purpose and need
- alternative, including the proposed action
- affected environment
- environmental consequences, including mitigation measures
- list of preparers
- list of agencies and organisations consulted
- list of all federal permits
- appendices
- index

In addition to the federal regulations in the US, each state also has its own ordinance (Table 2-6). A basi EIA report must not exceed 150 pages whilst a complicated proposal is limited to 300 pages with summary of not more than 15 pages. The contents and regulations of an EIA report in the Netherlands ar (Mostert 1995, p. 23):

- aim of the pertinent activity and discussion of project aim
- description of the pertinent activity
- 'reasonable' alternatives (technology, location etc.), including the 'most environmentally friendly alternatives
- indication of the decision on the pertinent activity for which the EIA is being conducted e.g.

specific permit. A description of earlier decisions taken on the pertinent activity, and the policy framework (pertinent plans and policies, future policy, relevant legal standards)

- existing environment
- development of the environment if the pertinent activity was not to go ahead ('zero alternative')
- prediction of the environmental effects of the pertinent activity and its alternatives in case of normal operation, including the effects during construction and after decommissioning
- prediction of the environmental effects of the pertinent activity, and its alternatives in case of calamities; prediction of risks
- estimation of the significance of the environmental effects
- identification of mitigation measures
- possibilities for compensation
- comparison of the environmental effects of the pertinent activity and its alternatives
- overview of the gaps in knowledge and indication of uncertainties
- outline programs for ordinary management, crisis management, monitoring and evaluation of the EIS and the EIA process
- a summary in a non-technical language

Table 2-6: EIS/EIR contents (regulations allowing flexibility in EIS and EIR formats)

Federal (NEPA)

Cover sheet
Summary
Table of Contents
Purpose of and Need for Action
Alternatives including the Proposed Action
Affected Environment
Environmental Consequences including mitigation measures, unavoidable adverse impacts, short-term uses vs. long-term productivity, irreversible and irretrievable commitment of resources, growth-inducing impacts, cumulative impacts
List of Preparers
List of Agencies, Organisations and Personnel to whom copies of EIS were sent to
Index
Appendices

California (CEQA)

Table of Contents, or Index
Summary
Project Description
Environmental Setting
Environmental Impacts including alternatives, significant environmental effects which cannot be avoided, irreversible environmental changes*
Mitigation Measures
Growth-Inducing Impacts
Cumulative Impacts
Effects not found to be Significant
Organisations and Personnel consulted
Economic and Social Effects (not treated as significant effects on the environment)

*Only required for agency plans, policies, or ordinances, or resolution of local agency formatio commission.

Washington (SEPA)

Cover Letter, or Memo
Fact Sheet
Table of Contents
Summary
Alternatives including the Proposed Action
Affected Environment, Significant Impacts, and Mitigation Measures (includes similar contents as NEPA, but does not require discussion of short-term use vs. long-term productivity, or irreversible commitment of resources)
Distribution List
Appendices

Data source: Kreske, D. 1996, p. 139

As a guide, the main components of an EIA report includes the following seven items.

(a) summary: in a non-technical language, and a limit of 15 pages

(b) description of development activities and current environmental background: as this item is the basi of the EIA report, aspects of the development actions, designated resources, and descriptions of the current natural, social, and economic characteristics have to be described clearly. Table 2-7 show

detail of a checklist.

(c) prediction and assessment of environmental impacts: this section is one of the most important in the EIA report. Its information will be the basis for drawing up alternatives and mitigation measures. It includes the assessment of impacts to individual environmental factors resulting from development actions as well as cumulative or synthetic effects. Aside from the significant environmental impacts in California, America consists of direct, indirect, short-term, long-term, cumulative and unavoidable effects.

(d) alternatives and its' impacts: reasonable alternatives to development activities must be drafted to ensure the development aims are reached. In addition to depicting alternatives in an EIA report, a comprehensive analysis of costs and environmental impacts of each alternative is also required.

(e) mitigation measures to proposals: it is necessary to describe every mitigation measure as either a construction or operation period. Impact preventing, and mitigating methods are drawn up separately according to affected range and items.

(f) treatment of opinions from related organisations, groups and people: contents and the treatment of each opinion must be included

(g) assessor: assessment personnel and their related documents.

As the treatment of alternatives is at the heart of the EIA report, it follows that the EIA report itself is at the heart of the EIA process (Wood 1995, p. 143). Most EIA systems have a requirement that each EIA report must describe the proposed projects, forecast the significant impacts, and contain a non-technical summary.

Table 2-7 : Checklist for Project Description

NATURE AND PURPOSE OF THE DEVELOPMENT

- Function of the proposal, with economic and operational context
- Demand and need for the development (if appropriate)
- Alternatives considered (if appropriate)

CHARACTERISTICS OF THE PROPOSED SITE

- Location
- Size
- Summary of topography, landscape, and natural or manmade features

CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

- Size
- Site layout
- Shape
- Character
- Landscape proposals (including grading)
- Car parking
- Entrances and exits
- Access to public transport
- Provision for pedestrians and cyclists
- Provision for utilities
- Any other relevant information (emissions to air, water and land)

PHASING OF THE DEVELOPMENT

Construction phase

- Nature and phasing of construction
- Frequency, duration, and location of intrusive operations
- Timing, location, and extent of mitigation measures
- Use and transport of raw materials
- Number of workers or visitors

Operational phase

- Processes, raw materials
- Emissions (e.g. air, water, noise, vibration, lighting)
- Number of employees or other users
- Traffic generation

Likely expansion or secondary development

- To be covered so far as the effects of such development can be anticipated at the time the ES (EIS) i prepared.

Data source: Wood, 1995, p. 145

E. EIA Review

This stage also is known as the 'public review' stage in some countries due to the formal consultation and the public participation, which take place during the review process. The formal review of EIA reports is handled differently in different countries. In the US, the draft EIS is used as the basis for consultation and participation, after which a final EIS is produced. The EPA review and publish all EISs. A difficulty with the review process is to ensure objectivity as the reviewing organisation may have a vested interest in the ultimate decision. Methods to try and ensure objectivity include the use of criteria, the accreditation of EIA report review consultants, the setting up an independent review body, the publication of the review results, and the involvement of consultants and the public (Wood 1995, p. 162). The production of the EIA report follows the EIA report review.

The public review method is the most commonly adopted reviewing process for an EIA report that requires comments and opinions from the general public, groups, and pertinent organisations. In America, for example, after an internal review, an EIS draft has to be published and circulated for comment to all relevant groups and individuals. Additionally, the lead agency must hold hearings for argumentative development actions. Comments from the public must be included in the final version of an EIA report.

In the US, an EIA report has to be reviewed by the EPA, which then develops a grading system in order to evaluate the environmental impacts of each development project, and the completeness of an EIA report. There are four levels of environmental impact; Lack of Objections (LO), Environmental Concerns (EC), Environmental Objections (EO), and Environmentally Unsatisfactory (EU). Three categories for the integrity of an EIA report are; Adequate (Category 1), Insufficient Information (Category 2), and Inadequate (Category 3). If the EPA assesses the final EIA report as 'EU', and there are no new channels for co-ordination, then the project, along with the EIA report, have to be submitted to the CEQ for a final response.

Although there are differences on acceptance comments with different EIA systems, quintessentially the purpose is the same; to collect information and to create a channel for communication. Groups overseeing the reviewing methods also differ from country to country; in America it is down to the environmental authorities, in Canada committees such as the Environmental Assessment Panel and in the Netherlands it is the Commission for the EIA(mer).

F. Decision-making

Following the review phase, the 'final decision' on what action to take is made[3]. This takes into account all findings revealed throughout the whole EIA process. The final decision can take on one of a number of forms, such as the issue of a permit, the granting of a subsidy, or the approval of a project. However, the final decision of the EIA process as to whether a proposal can proceed occurs in the public domain. At this stage, the final decision is not usually a choice between alternatives, but between authorisation and refusal (Wood 1995, p. 182). Decision-making is seldom straightforward as it is dependent not only on the merits of the proposal, but also on political circumstances. The environmental impact of the proposed project will usually be just one of many factors considered by the decision-maker. Any decision will involve a number of trade-offs between the information available, the urgency of the decision, and the need for further information, as well as between certainty and uncertainty. The personnel involved in making the decision on a proposed project involving an EIA are usually elected government politicians, people who seldom have time to read EIA reports so are dependent on official for a summary evaluation of the earlier phase of the EIA process.

The main function of an EIA report is to provide environmental information. Conclusions drawn from the EIA report do not have a controlling power over policymakers; some EIA regulate allow parties the right to vetoed. They can only inform, and motivate the policymakers into considering the value of the

[3] Decision-making takes place throughout the EIA process. Many decisions are made by the proponent (e.g. choices between various alternatives). Other decisions may be made jointly by the proponent and decision-making and environmental authorities (e.g. screening). However, in this dissertation decision-making refers to the final decision made by the competent authority.

environment through a series of procedures and arrangements. However, an EIA report cannot prevent or reduce environmental damage caused by development activities. However, if policies are very different from the results of the EIA, as well as much wasted time and resources, any considered environmental issues might possibly become the obstacle of policy implementation. To avoid such situations, the simplest way would be to reflect EIA results in policy, which can be achieved through the process of decision making and publicising.

Most EIA systems require the competent authority to publish the decision summary. It must include a description of the alternatives considered and detail of each factor examined by the competent authorities during the decision-making process. When the outcome is an alternative with a negative impact on the environment, it must be justified. The publication of the decision-making process will put the policymaker under some public pressure, hence the benefit of publicising the results of the EIA reports.

A further reason to publish the decision-making records is to ensure that the proponents comply with, and carry out, mitigation measures, monitoring programmes and environmental management. In this light, the EIA report becomes a legal document and may become a target for litigation by the public.

To ensure an informed outcome is reached, most countries do not allow the decision-making process to begin until the EIA report has been completed and thoroughly reviewed.

G. Monitoring and Auditing

Although this is the last procedure in the EIA process, it is not necessarily started last. In fact, it is best to implement monitoring programmes as early as possible i.e. as soon as a specific goal or aim has been identified in the planning stage. Monitoring involves verifying the project is executed as approved, that mitigation measures correspond with those required, and that additional conditions imposed on the project have been met. The EIA report is a record of the forecast environmental impacts likely to be caused by the proposed project. This allows the design of the monitoring programme to be modified on

publication of the final decision (or at any stage if unexpected problems are encountered). However, the area of surveillance and monitoring has tended to be neglected within the EIA although monitoring results is the basis of both an EIA and auditing.

Impact auditing is a comparison of the results of the implementation of the project, and impact monitoring. The underlying purpose of impact auditing is to determine the effectiveness of particular predicting techniques, and to use the results to improve future practice; an differential analysis between predicted and actual impacts. These results are part of a feedback mechanism linking amendment evaluation, prediction, and analysis methods.

Another purpose of monitoring and auditing is to establish if actual impacts exceed predicted impacts. I they are, compensatory, or mitigation measures, can be initiated to avoid an environmental disaster However, it is difficult to predict and assess any impacts to the future environment during the planning phase, further highlighting the importance of continuous monitoring and auditing.

Although EIA processes vary from country to country, they are all quintessentially the same. Figures 2 2, 2-3, and 2-4 outline EIA processes for America, the Netherlands and the UK.

In summary, the proponents initiate the EIA process with a proposed design for a development action o project. This is followed by a screening phase. In America, the lead agency determines whether th development action belongs to a categorical exclusion (or categorical exemption). If this is the case n EIA is required as no significant effects are likely to occur[4]. If not, the lead agency must establish 'threshold determination' to decide if the project will culminate in any significant effects resulting in th preparation of an EIS. Nevertheless, if the threshold determination cannot be established, a Environmental Assessment (EA), initial study, or environmental checklist[5], must be initiated prior to th

[4] 'Categorical exclusion' is a term coined by the federal government whereas 'categorical exemption' i used in California and Washington.
[5]Initial study in California, environmental checklist in Washington. see Kreske, 1996, p.19.

EIS. The lead agency, a consultant, or the applicant can prepare the EA. If an analysis of the EA states that there would be no significant effects from the development actions, the lead agency will issue either a 'FONSI, a negative declaration (ND), or a determination of non-significance (DNS)[6]. This would be publicly reviewed and succeeded by the decision-making process. However, if the EA reveals significant effects, then a 'notice of intent (NOI), a notice of preparation (NOP) (in California), or a determination of significance and scoping notice (DS/SN) (in Washington)' will be issued, followed by the public scoping process. After publication, notification, consultation and incorporation of comments, an EIS draft can be prepared. Finally, the lead agency has to go through the decision-making process and issue a record of decision (ROD), a notice of determination (NOD) (in California), or a notice of action taken (NAT) so completing the EIA process. As with monitoring, there is no mandatory requirement in the US for action to be taken on this document.

In the Netherlands the EIA process is split into three categories. The first is the mandatory EIA requirement, the second is the potential EIA requirement needing thresholds and criteria for judgement whilst the third category is the exclusion of previous two categories requiring no EIA. A notice of intent is demanded for those projects with EIA requirements. The Commission for EIA draws up guideline recommendations, which are then issued by the competent authority. On completion of the EIS by the proponents, the competent authority first examines the report before the public review. Finally, the Commission for EIA will review the EIS whilst the competent authority make any decisions. In the Netherlands the monitoring and auditing process are a requirement.

In the UK Town and Country Planning Regulations (Assessment of Environment Effects in England and Wales, Environmental Assessment Regulations in Scotland) inextricably link the EIA system with the planning system. The screening process is similar to that in the Netherlands. The first category is Schedule 1 Project, which demands an EIA. The second category is Schedule 2 Project needing

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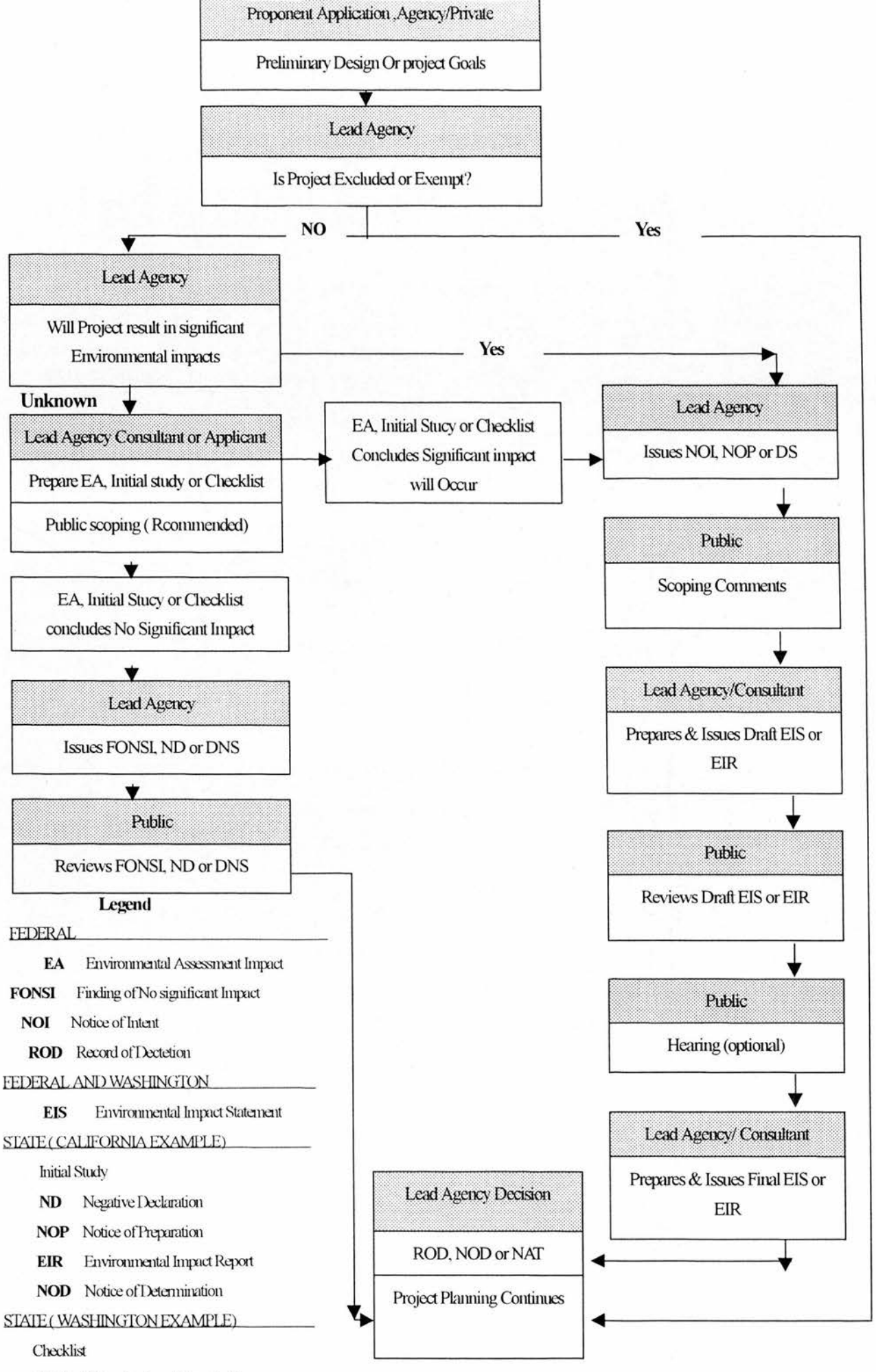
[6]Negative Declaration (Negdec or ND) in California, Determination of Non-Significance (NDS) in Washington State

thresholds and criteria to decide the EIA requirements and the third category again does not need an EIA. As there are no mandatory requirements for the scoping process in the British EIA system, the next stage is the preparation of an ES, which is revised through a public review procedure, as there is no Commission for EIA in the UK. Finally, the Local Planning Authority (LPA) evaluates all comments pertaining to the ES before making any decisions. Monitoring and auditing is not a requirement in the British EIA system.



Data source: Kreske : 1996, p.19.

Figure: 2-2 Overall environmental review process and participants

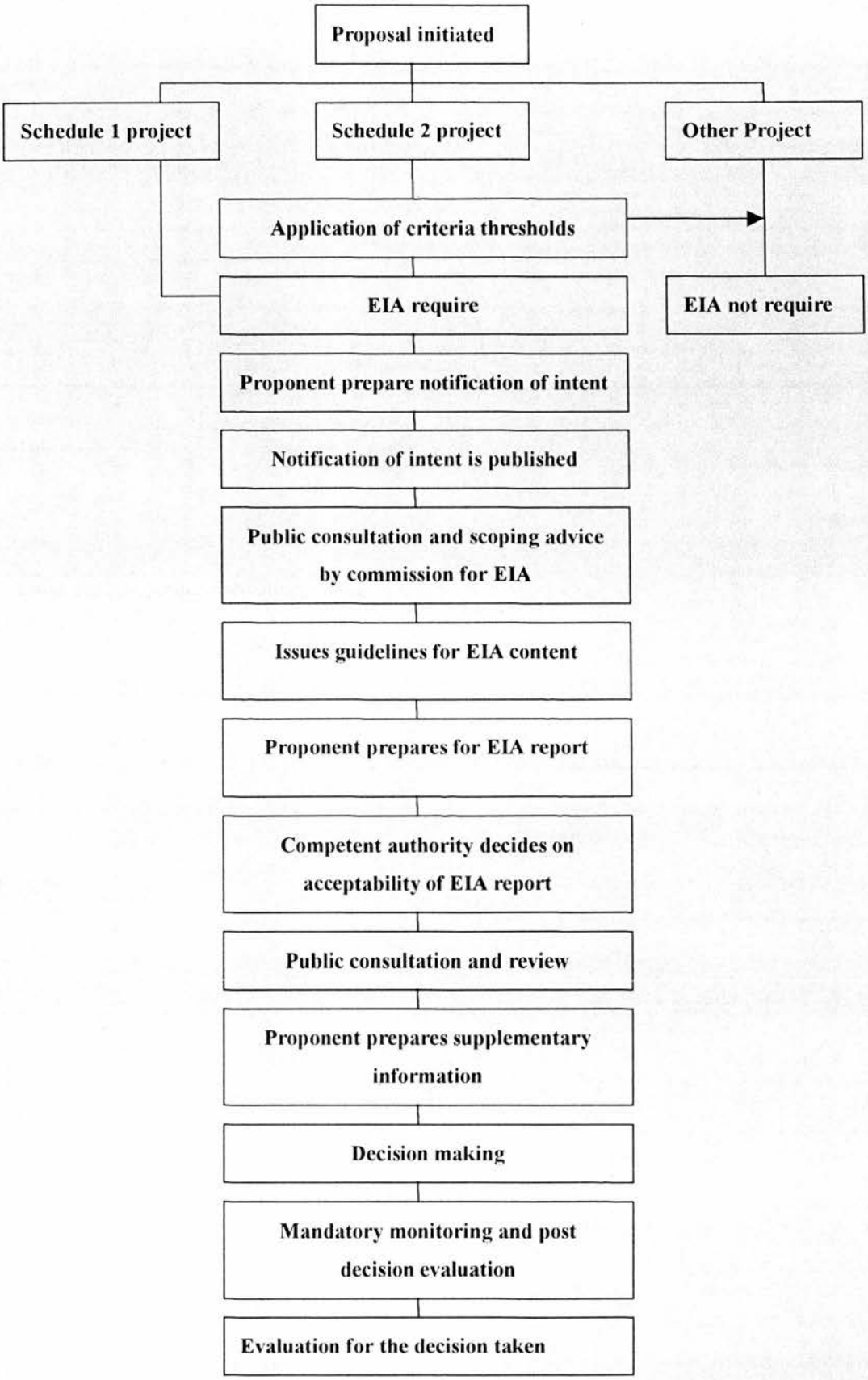
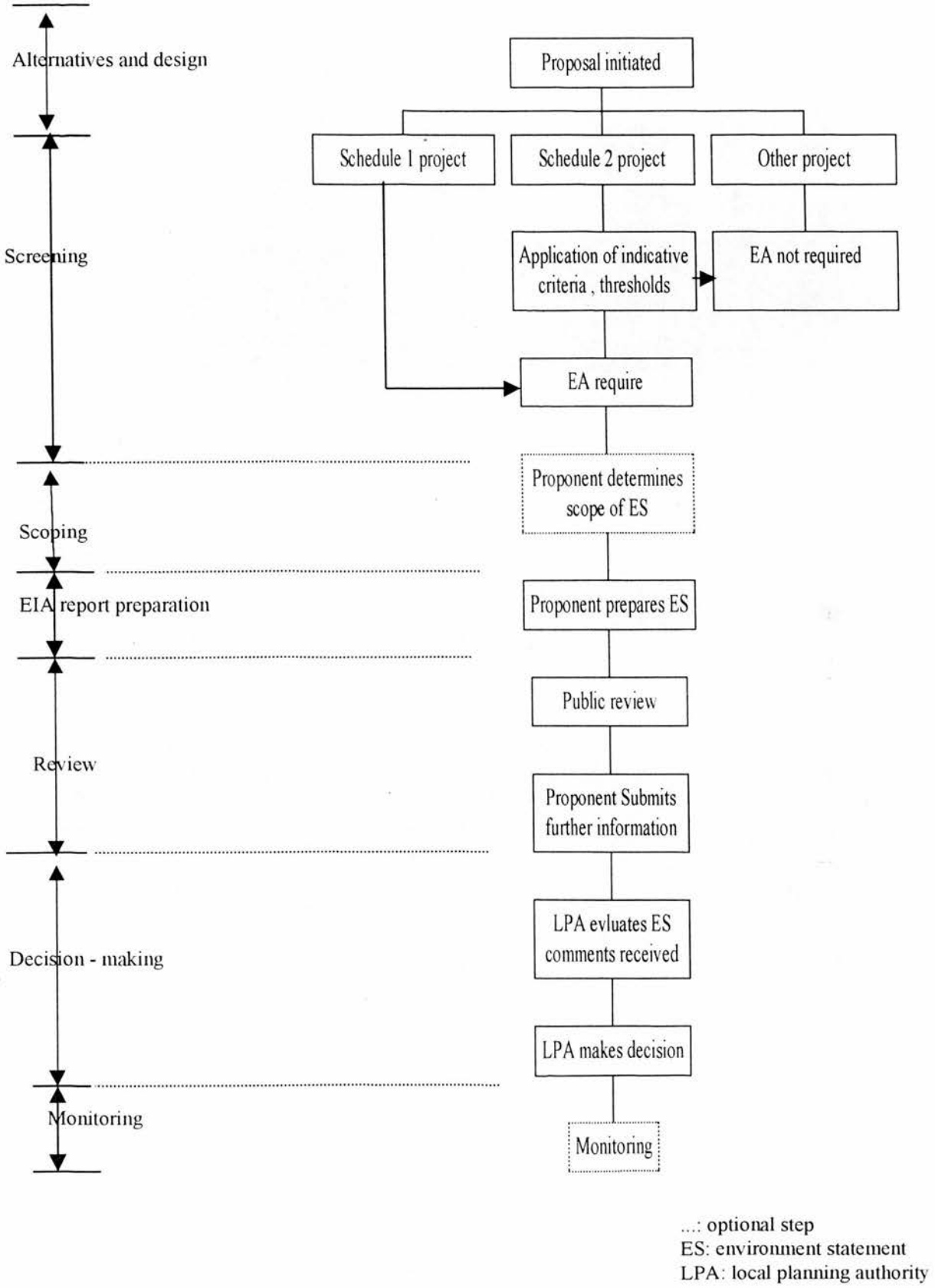


FIG. 2-3: Main steps in the Dutch SEA and EIA process



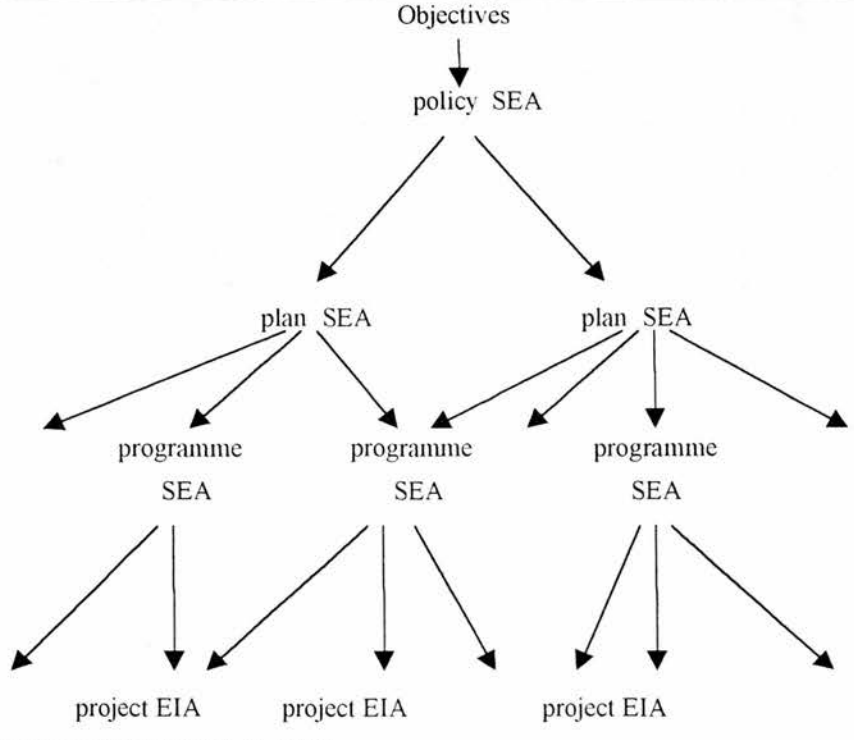
...: optional step
ES: environment statement
LPA: local planning authority

Data source: wood, 1995, p.50.

FIG. 2-4 : Main steps of the EIA process for UK planning decision

2.3.5 Strategic Environmental Assessment (SEA)

The Strategic Environmental Assessment (SEA) is a systematic and integrated assessment process aimed at environmental impacts caused by policy, plans and programmes (the 3Ps, Figure 2-5). It includes details from the assessment report, and any public policy brought about from the results of this report. A SEA is often called a 'second-generation EIA', as the first-generation EIA focuses on the EIA of a proposed project.



Data source: Glasson et al, 1994.

FIG. 2-5: Tiers of SEA and EIA

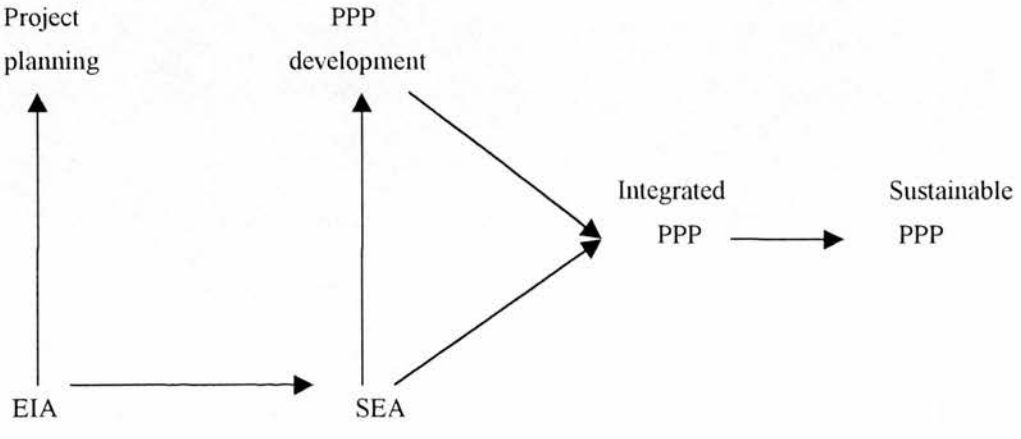
The first-generation EIA targets the environmental impacts of a project. However, there are som systematic shortcomings e.g. as cumulative impacts are not usually taken into consideration, alternative cannot be reasonably implemented. This is when the SEA system, the second-generation EIA, is usec The SEA has two divisions:

(a) earlier assessment: the function of the SEA system emphasises the need to make an EIA from th

3Ps as early as possible

(b) integrated assessment: the SEA system can improve the previous assessment method which only focused on individual development actions; the SEA stresses the overall, additive and cumulative impact assessment from a series of integrated effects.

The decision-making process from a SEA includes input from integral economic policies and development plans. Therefore, the government has to consider economic development together with the environmental impact and depletion of natural resources when instigating national development plans and resource management. The coverage of SEA targets is wider, the level is higher, and the timing of the decision-making is earlier. To best promote sustainable development in a country and for the environment and economy to work together, a SEA should be based on the contents and methods of an EIA and should combine all aspects of measures from the EIA (e.g. risk analysis, cost-benefit analysis) (Figure 2-6).



Source: Adopted from Partidario, 1992

FIG. 2-6: SEA: From Project EIA to More Environmental and Sustainable PPP Practices

A simple definition for a SEA is that it is the environmental assessment of a strategic action such as a policy, plan or programme (3Ps). SEA can be applied to three main types of action as stated by Therivel *et al* (1996):

- Sectorial 3Ps; related to specific sectors e.g. mineral extraction, energy, tourism
- Area-based or comprehensive 3Ps; cover all activities in a given area e.g. land-use or development plans
- Actions that do not give rise to projects, but nevertheless have a significant environment impact e.g. agricultural practices, new technologies, privatisation.

The purpose of the SEA is to improve the limitations currently encountered with an EIA, and to promote sustainable development. An EIA is essentially confined to direct impacts rather than cumulative, induced, synthetic and global impacts[7]. The SEA can incorporate environment and sustainable development into the aims of the 3Ps, and examine whether the impact and sustainability objectives of the 3Ps are consistent with the assessment process.

Figure 2-7 indicates that a SEA can assist in the integration of environmental concerns with the implementation of sustainable objectives. This more integrated system of planning enables environmental and sustainable criteria to be incorporated throughout the whole of the planning process e.g. in the location of a suitable site for development, or in the assessment of alternative 3Ps. A SEA framework allows the principle of sustainability to be carried forward from policy to individual projects (Therivel *et al.* 1996, p. 9). As the SEA identifies environmental and sustainable benchmarks, it can be determined whether the effects of the 3Ps are likely to be in accordance with sustainability objectives. Therefore, a SEA overcomes the limitations and shortcomings of the existing EIA system, allowing the implementation of sustainability.

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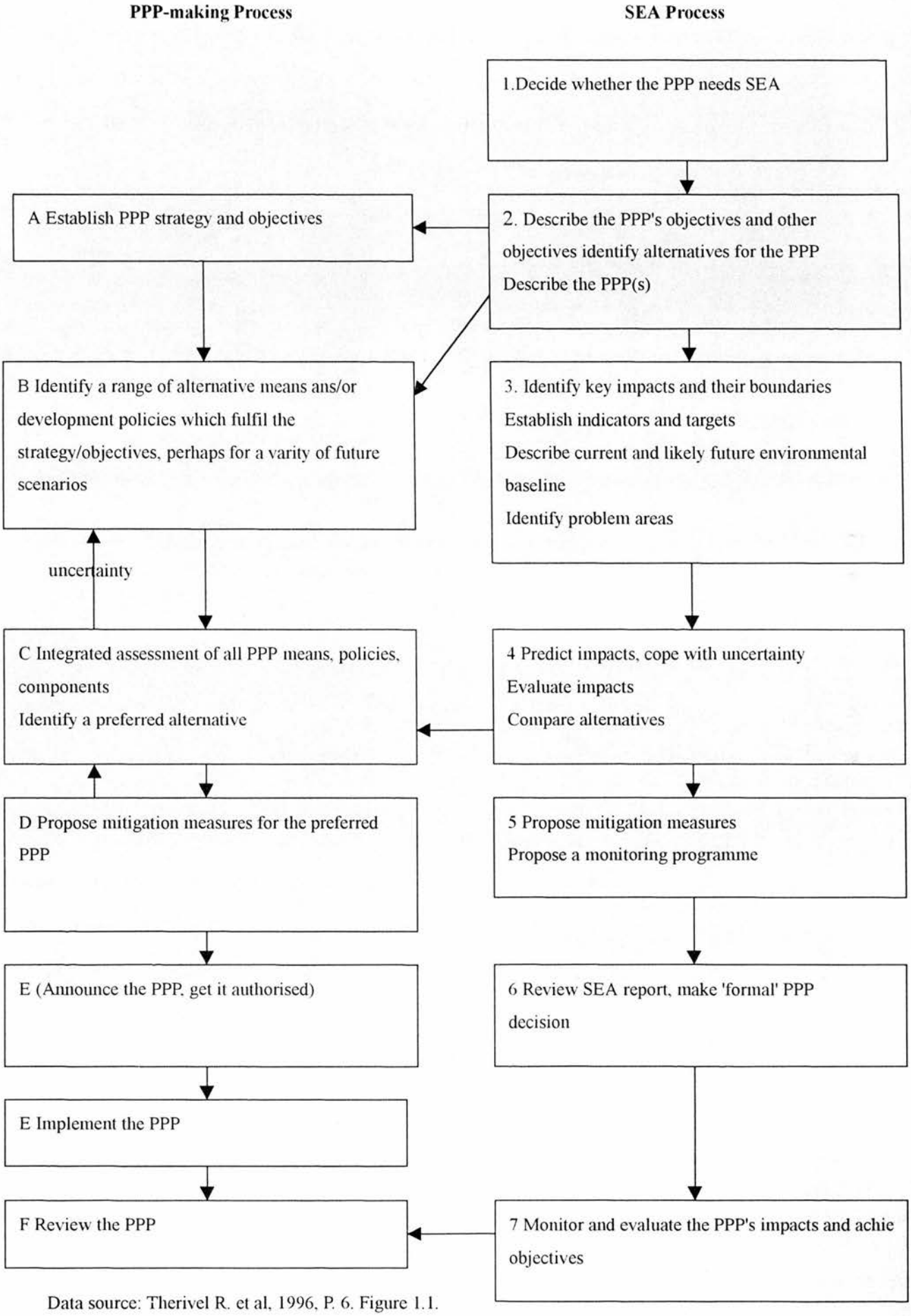
[7]Therivel *et al.*, 1996, p. 9



Data source: Therivel R. et al, 1996, P. 6. Figure 1.1.

FIG. 2-7: Stages in, and Links Between, PPP-making and SEA

2.4 LIFE CYCLE EIA

The purpose of conducting a Life-Cycle Assessment (LCA) is to provide thorough information on the interaction between human activities and the environment. This assessment not only throws light on the environmental impact of human activities but can also provide policy-makers with information on how to improve the situation.

2.4.1. The LCA Approach

2.4.1.1 The LCA Concept

LCA adopts a cradle-to-grave approach towards evaluating the environmental effects of products: all their life stages from raw material usage to final disposal are taken into account (Hortensius et al. 1997, p.29). The ISO-14000 series invokes the LCA methodology to evaluate relevant inputs, outputs and potential environmental impacts through the life-cycle of a product. The Society of Environmental Toxicology and Chemistry (SETAC) conceptualises LCA as a means of assessing environmental loading accompanied by human activities or production of products. Not only do we have to know the energy and raw material requirements for the whole production process and its release results, but we also need to assess the impact of energy consumed, raw materials and exhaust volumes and to consider methods to improve the status quo. The assessment process covers the stages of raw material acquisition manufacturing, transportation, operations, recycling and final disposal.

The Coca-Cola company was the first to use LCA to assess its drink containers (Vigon et al 1993, p.7). It used LCA to compare containers to find out which kind would generate the least exhaust and which use the least natural resources. By the end of the 70s' and throughout the 80s', it was becoming clear that the environmental information needed to conduct LCA research was extremely complicated, making it difficult to apply to the process of public policy-making. As the LCAs conducted by industrial organisations lacked credibility and the process was expensive and time-consuming, the LCA approach gradually lost favour.

However, as environmental protection management ideology gradually shifted from pollution minimisation using end-of-pipe control techniques towards a more preventive focus, LCA has begun to enjoy something of a revival. Both government policy-makers and individual entrepreneurs are beginning to use LCA as a tool to support environmental protection measures which become effective at the early stage of product design (Curran 1996, p.1.3). While manufacturers typically use it to improve specific production procedures at an early stage, governments tend to incorporate it into draft environmental protection policies. Table 2-8 outlines the main concepts of the LCA system.

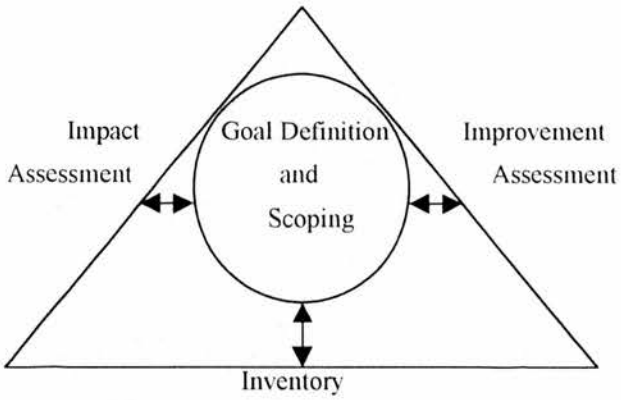
Table 2-8: The Main Concepts of the LCA System

- Life-cycle assessment is a tool to evaluate the environmental consequences of a product or activity holistically, across its entire life.
- There is a trend in many countries toward more environmentally-benign products and processes
- A complete life-cycle assessment consists of three complementary components: Inventory, Impact and Improvement Analyses
- Life-cycle inventories can be used both internally within an organisation and externally for applications requiring a higher standard of accountability
- Life-cycle inventory analysis can be used in process analysis, material selection, product evaluation, product comparison and policy-making.

Data Source: Vigon et al. 1994, p. 5

2.4.1.2 The LCA Model

The LCA, as a general term describing a cradle-to-grave assessment tool, has been applied extensively in Europe and the US. Resource and Environmental Profile Analysis (REPA) quantifies the resource use and environmental releases of products (i.e., it is a kind of LCA), while the "eco-balance" terminology commonly used in Europe is also a particular expression of the LCA concept. The Society of Environmental Toxicology and Chemistry (SETAC) offers further techniques which comply with the LCA concept, including **Inventory Analysis, Impact Assessment and Improvement Assessment** (Curran 1996, p.1.4), as Fig.2-8 indicates.



Data Source: SETAC 1993, Quoted in Curran, 1996, p.1.4

FIG. 2-8: The LCA Conceptual Model

Inventory Analysis quantifies the environmental data-based energy consumption required over the whole life-cycle of a product or an activity, including raw material requirements, air pollutant emissions, waterborne effluents, solid wastes etc. **Inventory analysis** starts with raw material acquisition and ends with the final stages of product consumption and disposal. The **impact assessment** technique applies quantitative and/or qualitative procedures to estimate the required resources and their environmental loading. As a result, this assessment exercise addresses impacts on ecology and human health consumption of resources, social welfare and others issues such as habit modification.

Improvement Assessment aims to analyse the opportunities for introducing energy savings and reducing material demands and environmental loading over the life-cycle of particular products or activities, using both qualitative and quantitative measures. For example, it informs decisions about manufacturing procedures, project designs, choices of material, consumption conditions, etc. **Scoping** (or Initiation) is regarded in Europe as the fourth element of LCA. As scoping is the first step of the LCA process, it has to be coupled with the system's goals, i.e., it must clearly define inclusive and exclusive items. As a result, scoping needs to reflect the extent and items of inventory data.

2.4.1.3 Life-cycle Environmental Impact Assessment

LCA provides a systematic structure for identifying, quantifying, interpreting and evaluating the environmental impacts of products or projects. It is also a diagnostic tool for re-examining existing products or services in order to improve manufacturing processes or materials or to introduce design innovations.

Though LCA is an excellent tool for environmental management, it has limitations. For instance, it cannot be used to guide the choice of building location; Environment Impact Assessment (EIA) is used instead to consider this kind of issue. However, as EIA is typically used to give policy-makers information on the predicted environmental impacts of development projects only during their construction and operational stages, the environmental impact of buildings over their entire life-cycle is not addressed by an EIA. For example, acquisition of materials, transportation and recycling/disposal are not evaluated. Therefore, to incorporate LCA ideas into an EIA, a Life-cycle Environmental Impact Assessment (LEIA) is needed.

A LEIA takes a vertical cradle-to-grave approach and its major targets are:

- to assess the environmental impacts of the retrieval and consumption of raw materials, including the exhaust pollutants and residuals of different life-cycle phases for products, processes or activities;
- to assess the ultimate disposal issues posed by products, processes or activities;
- to provide useful aggregated EIA information on products, processes and activities throughout the life-cycle; and
- to assess the relative environmental impact of alternative processes and design ideas, and to compare the impacts of differing products, processes and activities (Gilpin 1995, p.14).

As a LEIA is conducted at every stage of the life-cycle[8], environmental measures must be held constant across stages. These measures may include consideration of natural resources, raw materials, land use,

[8] LEIA can also be applied to a specific stage of the life-cycle.

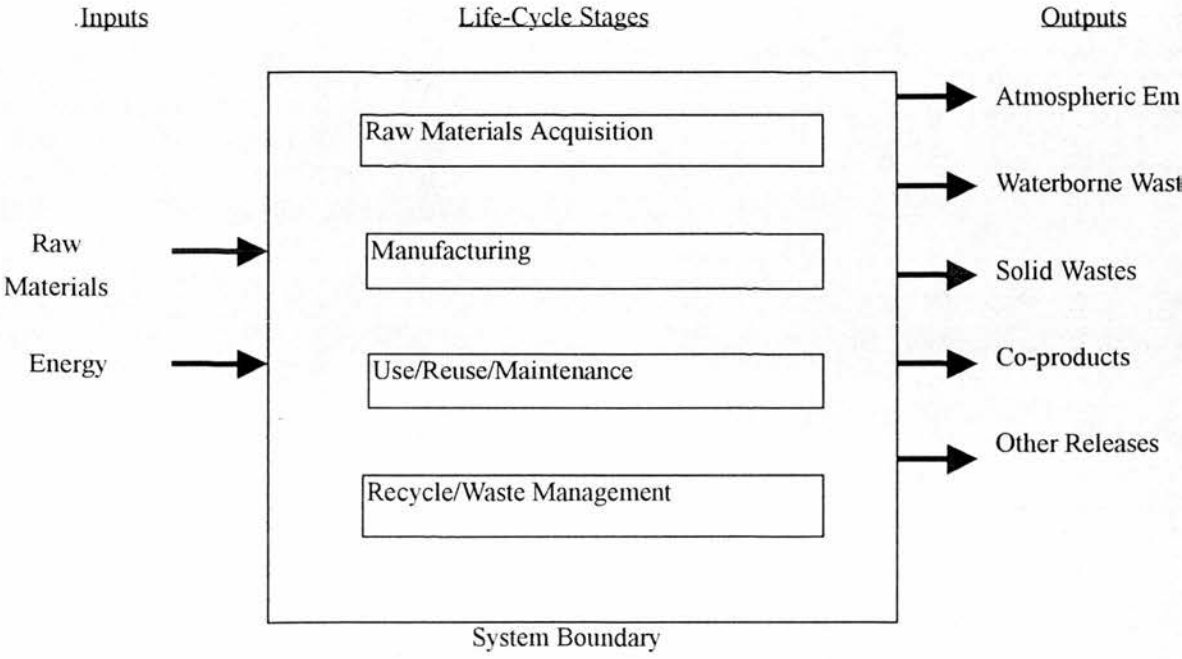
atmospheric pollutants, waterborne and soil pollutants, noise, economic implications, manufacturing processes related to energy consumption and public safety, waste disposal and recycling.

2.4.2 The LEIA Concept

As we have seen, the EIA system provides decision-makers with EIA reports which enable them to judg the likely consequences of development projects so that they can balance the demands of economi growth with their duty to protect the environment. However, as previously noted, the EIA system doe not provide environmental information which covers the project's entire life-cycle. Consequently, w need a LEIA system which unifies the LCA and EIA approaches.

2.4.2.1 Life-Cycle Stages

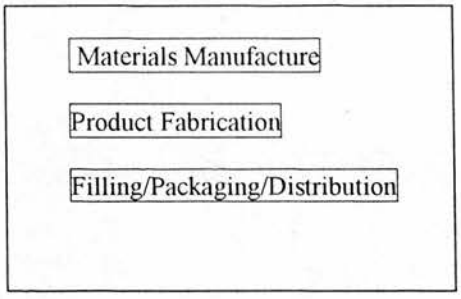
Generally speaking, the life-cycle of a product or activity can be divided into four stages: **raw materi acquisition, manufacturing, use/reuse/maintenance** and **recycling and waste management** (Vigo 1994, p.10). (See Fig. 2-9)



Data Source: Vigon, et al. 1994, p.19

FIG. 2-9: System Boundaries of Life-Cycle Stages (Manufacturing)

The **raw material acquisition** stage is the first phase of the life-cycle, e.g., felling trees, obtaining energy and petroleum, refining metals and transporting materials from the place of origin to the processing site. Generally speaking, the **manufacturing stage** involves three sub-stages - materials manufacture, product fabrication, and filling, packaging or distribution (see Fig. 2-10). Materials manufacture means transforming raw materials into products, and includes transportation from manufacturing sites to assembly sites. Product fabrication refers to the manipulation of processed materials into final products. The sub-stage of filling, packaging and distribution of products includes a consideration of the energy consumption and environmental impacts of transporting goods to consumers, e.g., via shops.



Data Source: Vigon et al. 1994 p.20

FIG. 2-10: Sub-Phases of the Manufacturing Stage

The **use, reuse and maintenance stage** refers to actual operations including their energy requirements and environmental impacts. Maintenance and later re-use are included so waste resulting from storage, maintenance and consumption also belong to this phase. The final **recycling/waste management stage** includes the waste generated and the energy required for ultimate disposal, e.g., demolition, landfill or incineration.

Generally speaking, the life-cycle of a product or activity includes these four stages though not all products can be neatly sub-divided in this way: some processes might cover two stages at the same time, and some products might not involve all four phases.

2.4.2.2 The Structure of LEIA

Within the EIA process, environmental impacts usually refer to outputs, i.e., the effect building projects have on their environment once they exist. However, the LEIA process assesses the environmental impacts of development activities in terms of inputs as well as outputs as Fig. 2-11 shows.

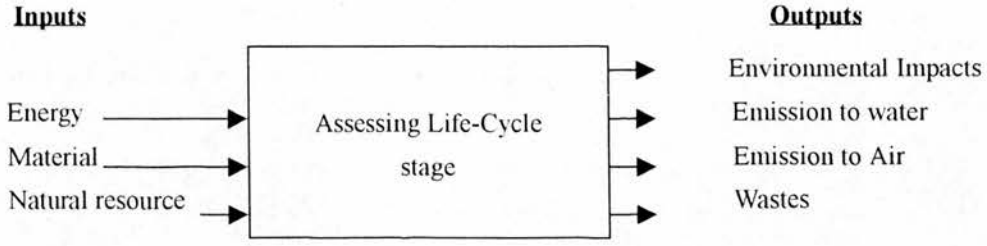


FIG. 2-11: The LEIA Concept

The first task in conducting a LEIA is to establish an **inventory**. This inventory lists the inputs and outputs of a development activity in detail rather than making a comparison between them. The LEIA system regards the best project choice as one which consumes the least energy and materials and produces the least pollutants. The environmental impacts of energy and materials consumed and pollutants emitted need to be estimated and the required materials and emissions over the whole life-cycle need to be converted into potential environmental effects. For example, to estimate the effect on climate change from CO_2 , N_2O, CFCs and CH_4 the **global warming potential (GDP)** should be applied. Similarly, the ozone layer depletion issue needs to take the **Ozone Depletion Potential (ODP)** as its basis as Table 2-9 shows.

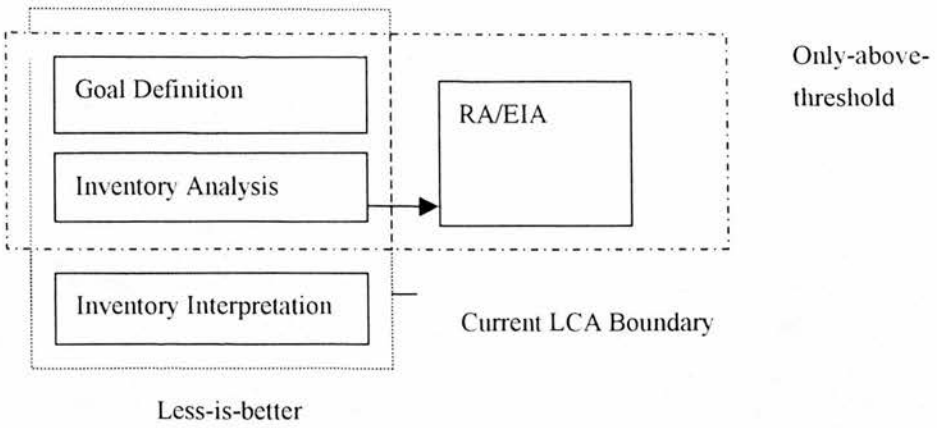
Table 2-9: Substances and their Impact on Various Environmental Themes

Environmental Themes	Measures of Effect	Substances
Climate Change	Global Warming Potential (GWP)	carbon dioxide (CO_2) chlorofluorocarbon(CFC_s) dinitrogen oxide (N_2o) methane (CH_4) hydrochlorofluorocarbon (HCFC)
Ozone layer depletion	Ozone Depletion Potential (ODP)	hydrochlorofluorocarbon (HCFC) Halon 1202 chlorofluorocarbon(CFC_s)
Photochemical oxidant formation	Photochemical Oxidant Creation	Acetylene, benzene, hydro-Carb (C_xH_y), methane (CH_4),

Environmental Themes	Measures of Effect	Substances
	Potential (POCP)	n-Hexane (C_6H_{14})
Acid Rain	Acidification Potential (AP)	Ammonia (NH_4^+), nitrogen oxide (NO_x), sulphur dioxide (SO_2)
Eutrophication	Nutrification Potential (NP)	Ammonia (NH_3), ammonium (NH_4^+), chemical oxygen demand (COD), nitrate (NO_3^-), nitrite (NO_2^-), nitrogen (N), phosphate (PO_4^{3-}), nitrogen oxide (NO_x)
Ecotoxicity, Aquatic	Ecotoxicity Aquatic (ECA)	Benzene cadmium (Cd), hydro-Carbons C_xH_y), lead (Pb), mercury (Hg), pyrene, tri- Chloromethane ($CHCl_3$), copper, Zinc
Ecotoxicity, Terrestrial	Ecotoxicity Terrestrial (ECT)	Cadmium (Cd), chlorobenzene, Lead (Pb), mercury (Hg), Copper, zinc
Human Toxicity	Human Toxicity (HT)	2-propanol,acrilonitri (CH_2 CHCN), ammonium (NH_4^+), benzene, cadmium, carbon dioxide (CO_2), chlorobenzene (Cr^{6+}), CFC_{12}, hydrogen sulfide (H_2S), lead (Pb), mercury (Hg), nitrate(NO_3^-), nitrite(NO_2^-) nitrogen oxide (NO_x), phosphate (PO_4^{3-}), pyrene, styrene, sulphur dioxide (SO_2), trichloromethane ($CHCl_3$), copper, tin, zinc
Abiotic Depletion	Abiotic Depletion Potential (ADP)	Cadimum (Cd), Lead (Pb), mercury (Hg), copper, tin, zinc
Energy Depletion	Energy Depletion Potential (EDP)	Crude oil, natural gas

The LCA process has four elements: scoping, inventory, impact assessment and improvement. The **inventory** is a list of all input and output items. The **impact assessment** (also known as **Inventory Interpretation**) analyses and interprets the environmental impacts of the various items in the inventory (Smet et al. 1996, p.16.5). However, this assessment does not aim to predict real environmental impacts. On the contrary, it provides a worst case scenario, termed the *less-is-better* approach.

To assess actual impacts over the life-cycle we need a LEIA. That said, even a LEIA does not concern itself with all likely environmental impacts, only those which seem most significant given the nature of the activity or the product. As a result, thresholds are used for screening for those items that are likely to impose significant impacts - the *only-above-threshold* approach. Fig. 2-12 shows the similarities and differences between the less-is-better and the only-above-threshold approaches.



Data Source: Smet et al. 1996, p.16.6

Note: "Less is better" provides a worst-case scenario. "Only above threshold" predicts actual impacts.

FIG. 2-12: Two Distinct Approaches to LCA.

Since LEIA is an environmental management method which integrates LCA and EIA systems, its structure combines the procedures of these two systems.

2.5 EIA AND SUSTAINABLE DEVELOPMENT

The Brundtland Report indicated that the EIA system was an important way to achieve sustainable development (WCED 1987, p. 222). Aspects of the EIA, such as public participation, mitigation measures, and impact assessment, are practical approaches in the aim to implement sustainable development ideology. As previously mentioned, the main aims in the sustainable development decision-making process are public participation, the pursuit of equality of intergeneration and infra generation, and the maintenance of the sustainable use of resources; very similar goals of the EIA system

2.5.1 Sustainable Development, and EIA Goals

The Brundtland Report not only regarded the EIA system as an important way of promoting sustainable development, but also indicated that the EIA system should be applied more extensively. Although th EIA system is popular in the application of major development projects, it is mainly applied at the level o

policies and programmes (especially major macro-economic finance and sectoral policies that induce significant impacts on the environment) (WCED 1987, p. 222). As well as determining direct and indirect environmental impacts, the EIA system can also alleviate and avoid negative environmental impacts through a choice of alternatives and the adoption of mitigation measures. In addition, the prediction and analysis of long-term impacts also provides opportunities to prevent environmental damage for future generations. As a result the EIA is considered to be a method for the promotion of sustainable development. The Rio Earth Summit in 1992 also emphasised this value of the EIA system for sustainable development. Twenty-seven principles for sustainable development were outlined in the Rio Declaration on Environment and Development. Principle 17 prescribed that the EIA system was the way to achieve the goals of sustainable development (Selman 1996, p. 152).

The value of the EIA system is its use as a decision-making tool and as a critical measurement for policymaking. The EIA system can make a clear and systematic analysis of environmental impacts determining a range of environmental impacts due to development activities enabling policymakers to come to a decision. The EIA provides an opportunity for the government to assess potential environmental, social, and economical impacts in the future.

Development actions that bypass the EIA system are, in effect, substituting the long-term well-being of the population for short-term economic profit. However, an aim of the EIA is to bring about long-term well-being, and to improve long-term living quality. Thus, development actions and the goals of sustainable development need not be contradictory.

Sustainable development, through the EIA, is an important opportunity to integrate environmental, social and economical aspects. A function of sustainable development is to seek long-term well-being and profit for the human race, and to avoid irreversible environmental devastation due to any shortsighted actions. The EIA stresses the use of preventative, systematic, integral, and multi-disciplinary measures to promote environmental protection and sustainable development. When considering long-term impacts,

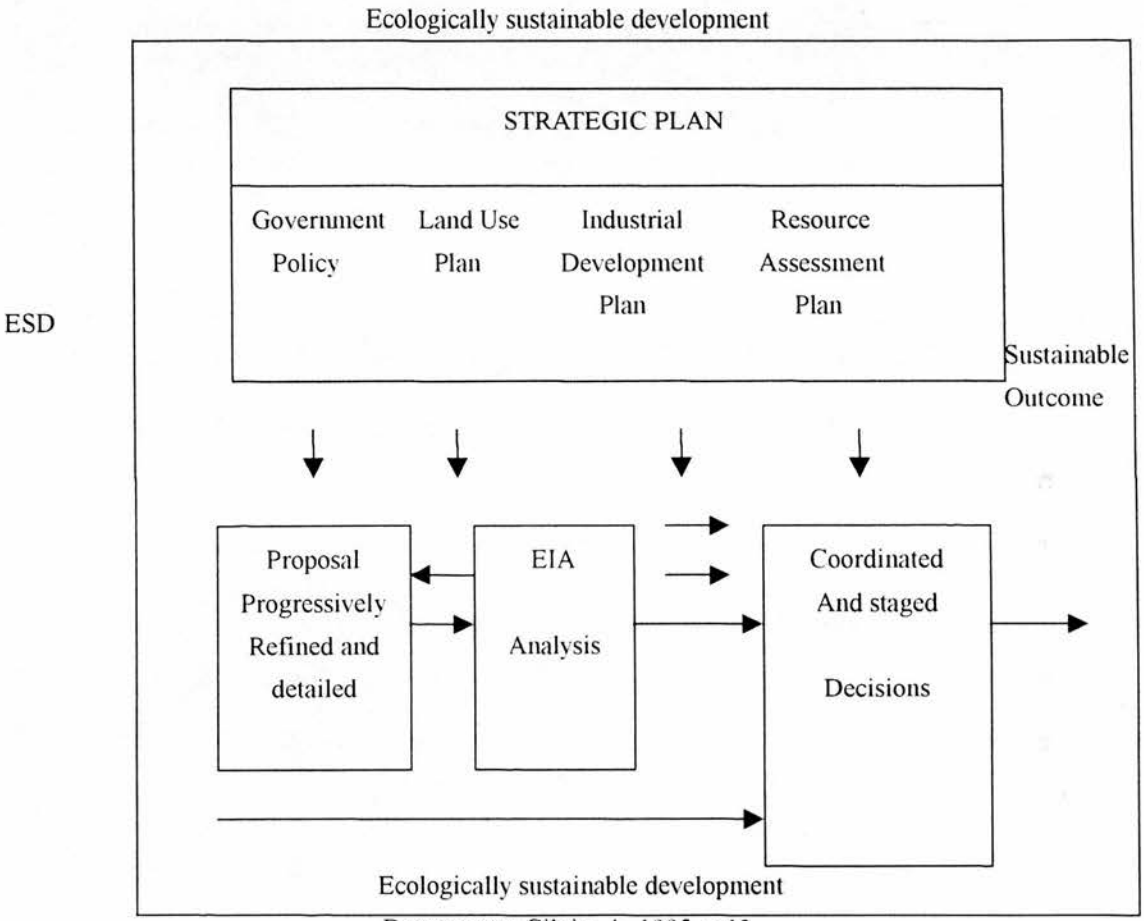
there are opportunities for the current generation to take part in decision-making with inter-generation gains. Figure 2-13 indicates the role of EIA in sustainable development.

The concept of sustainable development can be made operational in the form of 'carrying capacity '. Carrying capacity is a function of a series of variables such as region (watershed, city, world) and the type of resource (water, energy, a limiting resource to population growth). To achieve sustainability the carrying capacity should not be exceeded. Therefore, the current state of the resource and its uses must be monitored, predictions must be made concerning its future status, and the possible use of alternatives and mitigation measures must be made available if the carrying capacity is exceeded (Therivel *et al.* 1992, p. 124). This is the concept of EIA which requires information about potential environmental impacts of a proposed development project. Finally, additional monitoring and auditing is needed to ensure that EIA report is carried out correctly.

The SEA system is more widely adopted than the EIA system as it is felt to be more capable of promoting sustainable development. The methods of achieving sustainable development can be basically categorised as to whether they expand the existing EIA (incremental system) or if they 'trickle down' the objective of sustainable development[9]. The former expands 'green' policies to reach the goals o sustainable development whilst the latter takes sustainable development as the central goal for each programme, policy and plan in order to implement sustainable development directly. The incremental system extends the existing EIA system to the 3Ps in order to accomplish a greater degree o sustainability. Nevertheless, the trickle-down system first establishes the central goals of sustainabl development and then works towards them using EIA and SEA where the limitations of environmenta carrying capacity have to be evaluated for each project. The trickle-down SEA system could also be th primary method of achieving sustainable development (Glasson 1994, p. 311) by first establishing th goals for sustainable development, and then determining the carrying capacity of each paramete

[9]There are two kinds of relationships between SEA and sustainable development, 'incremental' and 'trickle-down' systems, see Glasson, *et al.*, 1994, p. 311.

Strategies for every plan, policy and programme should also be subject to an evaluation of the carrying capacity. Individual projects should then be evaluated for the carrying capacity before the implementation of the EIA. The aims of sustainable development can be achieved through the continued practice of the aforementioned procedures.



Data source: Gilpin, A. 1995, p.13

FIG. 2-13: Setting the Context for EIA

2.6 SUMMARY

The concept of the EIA system originated from America in 1969 with a view to providing a set of integral plans for reference, and balancing economic development and environmental protection requirements. As a result, the purpose of EIA is to predict and assess potential environmental impacts imposed by projects before decisions are made. Meanwhile, it can also prevent the environment from irretrievable destruction.. The EIA system changes the concept of pollution control from end-of-pipe to precaution. Thus, one country after another establishes and implements the EIA system.

As each nation differs in goals and backgrounds for implementing the EIA system, their approaches and procedures are different as well. For the features of the EIA system, they can be divided into three basic types, which are ex-ante survey of public hazards, simple procedure type and reasonable decision type. Basically, procedures mostly include consideration of alternatives, screening, scoping, preparation of the EIA report, public review, decision-making, and monitoring and auditing. Whereas, public participation is a vital procedure in the EIA system. Consequently, the sooner the EIA process carries out public participation, the better; besides, it should be performed throughout the EIA process. Furthermore, alternatives are also considered as an important spirit of the EIA system. And if consideration of alternatives can be practiced earlier, the more function of alternatives can be developed.

The early EIA process mainly focuses on biophysical environmental factor; however, the integral environmental management can't be achieved if only based on environmental factor. Thus, factors like social, economic, health, cultural heritage and material assets are incorporated into EIA items. Brundtland report in 1987 indicated that the concept of sustainable development should be presented for our common future and environmental protection ought to be combined with sustainable development. He also advocated in his report that application of EIA should be broadened to policies and programmes and quality of implementing EIA needed to be promoted. Thus, the applicable extent of EIA was extended from project level to 3Ps (policy, plan & programme), which is exactly the spirit of strategic environmental assessment (SEA). In addition, the goals of the EIA system changed from pollution

control and prevention of environmental destruction to pursuit of sustainable development. As a result, effects and issues during the EIA process were expanded from direct effects, secondary (indirect) effects, cumulative effects and large-scale effects to global effects, bio-diversity effects and sustainability considerations. Furthermore, from the aspect of post-decision, previous surveillance, effects monitoring and impact management were added with environmental management audit and process audit and evaluation in order to reinforce the effectiveness of the EIA system.

If the goal of the EIA system is to seek sustainable development, what is the target of sustainable development? The Department of Environment (DOE) in the UK considers targets to sustainable development should be like this: A healthy economy should be maintained to promote quality of life while at the same time protecting human health and the environment; non-renewable resource should be used optimally; renewable resource should be used sustainably; damage to the carrying capacity of the environment and the risk to human health and bio-diversity from the effects of economic activity should be minimized. Consequently, goals of the EIA system are to create a healthy economic environment, use natural resources in an effective and sustainable way and decrease damage to the carrying capacity of the environment as well as risk to human health and bio-diversity.

In this chapter, we started with emergence of environmental issues, deal with formation of the EIA system, prescribe improvement and promotion of the EIA system and then explain the relationship between the EIA system and sustainable development. Hopefully, a thorough understanding of the EIA system can be derived from this chapter. Under this context, we will attempt to establish the framework of evaluating the EIA system effectiveness in the next chapter.

CHAPTER THREE: THE EFFECTIVENESS OF THE EIA SYSTEM

3.1 INTRODUCTION

Chapter Two introduced the concept and main aims of the EIA. This Chapter sets out to discuss the effectiveness of such an EIA system. Although it is impossible to ascertain a single definition, to evaluate the effectiveness, and to analyse the quality of an EIA, there are a number of specific characteristics.

In this Chapter, effectiveness will be defined prior to a discussion of the potential influence of an EIA. Finally the evaluation framework of an EIA's effectiveness (including mechanism, criteria, and indicators) will be examined, with special emphasis on the Taiwanese EIA system.

3.2 THE CONCEPT OF EFFECTIVENESS

3.2.1 A Definition of Effectiveness of an EIA System

The EIA is implemented during the planning period, or certainly before the commencement of the project. The EIA investigates, estimates, and publicly states, the potential degree and scope of any environmental impacts caused by the development proposal. The assessment is based on scientific, objective, and comprehensive facts. Moreover, to assess the cost and impact of a development proposal, the environmental aspect is set as a priority to assist the decision-maker decide whether a particular project is worthwhile. The environmental aspect also applies weight among environmental quality, other social goals, and economic cost and benefit. Therefore, the EIA system changed the way the government set policies by ensuring the decision-maker considered the environmental value as well as analyses for technical feasibility, and costs and benefits.

The value of the EIA allows the decision-maker to make informed decisions. The effectiveness of the EIA is broadly defined, commonly discussed from the point of view of influencing the decision-maker.

Mostert (1995) stated that an effective EIA one that encourages better decisions to be made. Decision are termed 'better' when they meet two criteria: a) they are more in accordance with the concept o sustainable development than those made without an EIA; b) they are more 'acceptable' than decision made without an EIA. Mostert (1995) used three terms in his definition: decision, sustainable decision and acceptable decision[1]. 'Decision', in the sense, means a 'verdict' i.e. the decision of a developmen proposal that has an influence on the environment, including 'no-action'. Definitions for 'sustainabl development' have been dealt with previously, with the definition from the Brundtland report being th most renowned. According to the Brundtland report, sustainable development is 'a development whic meets the needs of the present without compromising the ability of future generations to meet their ow needs'. Aside from being sustainable, a decision has to be acceptable, at least to the groups directl influenced by it. The acceptability of a decision demands that a decision is made only after carefu preparation, and that the reason for the decision can be recognised by any affected groups. In essence, decision would not be carried forward if it resulted in a negative impact on all related groups.

The Council on Environmental Quality (CEQ) declared that the American EIA system could be viewe as effective. The CEQ stated that 'The [sic] act unquestionable has had a profound effect on attitud within the federal government, and its influence outside the federal government is almost as impressiv (CEQ, Quoted in Wood 1995, p. 71). In the US, the effectiveness of the administration of the EIA syste is reached through support both inside and outside the government. The EIA system has, therefore, als changed governmental policy-making procedures as well as the organisation of the government. A effective EIA system will influence the quality of policy-making. There is little doubt that a successfu EIA system depends on its executive procedure. Thus, the CEQ emphasises that a successful EIA shou include external reviewing procedures, public participation, and judicial review (CEQ, Quoted Woo 1995, p. 8). An effective EIA system should be integrated into the planning phase of a developme

[1]The EIA process aids decision-making. Many decisions are made by the developer eg. choice of location and concept. Some decisions may be made jointly by the developer, governments, and stockholders. Others will be made by the competent authority, termed the final decision. In this sectio decision refers to the final decision.

proposal, and its procedures should include screening, scoping, external review, and public participation.

Ortolano *et al.* (1993) emphasised that the effectiveness of EIA implementation is dependent on the existence, and degree, of various control mechanisms, including:

Procedural control: *centralised administrative unit promulgated EIA requirements*

Evaluative control: *centralised administration agency issues recommendations to decision-makers based upon an appraisal of performance with respect to EIA*

Judicial control: *court has power to exert formal authority, but not direct control over the project proponent in relation to EIA compliance*

Development aid agency control: *multilateral or bilateral lending institutions require that an EIA be conducted before a final decision to found a project*

Professional control: *project planners have professional standards and codes of ethical behaviour that include undertaking EIA for proposed projects*

Direct public and outside group control: *citizen's group and individuals or governmental agencies apply pressure to influence to EIA process.*

Ortolano *et al.* (1993) believed that two or more of these mechanisms generally operated simultaneously in the developing world (Ortolano 1993, Quoted in Tu 1994, p. 7).

The Canadian Environmental Assessment Research Council consider an EIA may be effective when the information generated in the EIA for decision-making processes is accurate, and when proposed mitigation and compensatory measures have achieved approval as management objectives (Wood 1995, p .9).

Nevertheless, EIA procedure is not an absolute factor in determining effectiveness, but is clearly of crucial importance. Hence, a good EIA system could be defined as: occurring during the planning phase of a development project using an appropriate method to assess environmental impact; providing the

decision-maker with appropriate and useful environmental information through the procedure of public review; combining environmental impact, economic development, technical, and other factors, the decision-maker can make appropriate judgements and a decision with regard to sustainable development, and follow through with monitoring on the implementation of the development proposal.

Thus the definition of good EIA system throughout this paper will include the following key concepts:

1. The EIA should be carried out during the planning period i.e. before the development proposal has reached the final decision stage, or before a detailed plan has been made. Therefore, EIA processes are instrumental in judging which alternative is acceptable.
2. The assessment of environmental impacts should be applied using appropriate methods. This concept also includes a preparation of a full statement of the environmental impact, helping the decision-maker and reviewer remain objective.
3. Open review i.e. the participation of various interest and related groups as reviewers. This ensure the statement of environmental impact has been carried out appropriately and comprehensively.
4. The decision-maker should make a decision to be more sustainable with respect to environmental impact, economic, and technical factors.
5. Finally, following-up and monitoring procedures are necessary to ensure the EIA report is carried ou The follow-up is usually carried out by the approval organisation of the development plan, whils monitoring involves other organisations, superior organisations, and judiciary.

Using the definition of a good EIA system, and the purpose of the EIA system, throughout thi dissertation the following definition of effectiveness of an EIA will be used.

Effectiveness occurs when the EIA can:

- improve the quality of a decision from an sustainability viewpoint,
- smooth consent procedures, and promote acceptable decision are taken, and
- raise environmental awareness.

- Conditions of approvals must be enforceable , and approval must be followed by monitoring and auditing of effects.
- The EIA process must be designed to facilitate efficient implementation.

Effectiveness ensures that adequate information from the EIA process is available to decision-makers, and that the final decision applies to the concept of sustainable development. An effective EIA can smooth out the planning consent procedure so improving the relationship between the developer, environmental NGOs, governments, and local communities. EIA should make the project more acceptable both to the courts and public, and speed up the decision-making process. In addition, the EIA is regarded as an educational tool that also looks forward to future aspects of the project (Marr 1997, p. 4). Through public participation, review and the consideration of environmental issues, the EIA should raise environmental awareness to the proponent, local communities, interest groups, the government, and decision-maker environmental awareness.

3.3 POTENTIAL FACTORS INFLUENCE EFFECTIVENESS OF THE EIA SYSTEM

3.3.1 Technical Factors

Application of environmental information

The most influential factor affecting the result of an EIA system is the collation of environmental information. The information is compiled as part of the EIA report, which is then applicable in the EIA system and includes screening, scoping, a review, evaluation, decision-making, and monitoring. According to Mostert (1995), environmental information has five influences on the effectiveness of an EIA result.

1. Environmental information can change the opinion of related groups toward the case of development, and any alternatives. Either wrong or incomprehensive information can misguide the opinion.
2. Environmental information can alter environmental management practices. Wrong and incomplete information will effect management policy.

3. Influence will occur on the internalisation of the environment among the competent authorities and initiators. The EIA system puts pressure on managing and development organisations to face understand, and care about the environmental issue. This could result in internal restructuring within the organisation, perhaps even forcing them to establish an environmental organisation.
4. The information will influence the understanding and the public position, whether pro- or anti development. When put to the vote, the bias of the EIA report can swing the result for or against a development project.
5. Finally, environmental information will affect the content of a development case. The direction o any alternatives such as improving present facilities or re-development will also be affected.

In short, comprehensive environmental information will potentially influence the effectiveness of an EIA system.

Method of assessing environmental impact

An appropriate or comprehensive assessment technique for environmental impact will potentiall influence the result of an EIA system. An assessment method must adopt one or more technique although the techniques can be modified in accordance with individual development proposals. Th appropriateness of an assessment method is usually verified by the professional reviewer, neverthele the opinion of the managing organisation and other groups may sometimes be included. However, th technique used could change according to changes in time and aims.

Common assessment methods include environmental appraisal, ecological impact assessment, habit evaluation, social impact assessment, eco-auditing, risk assessment, and assessing economic impac (Barrow 1997, p. 17):

environmental appraisal; so-called environmental assessment which is widely used for assessing th environmental impact of a development proposal, although sometimes it is used in desk-researc

exercises. **ecological impact assessment**; this takes the whole organism into account (not just humans) when assessing environmental impact. Recently it has been used in EIAs to describe and assess the ecological baseline. **habitat evaluation** is a method that assesses the suitability of an ecosystem for a species, or assesses the impact on the flora and fauna habitat caused by a development proposal.

Ecosystem approaches such as **ecosystem assessment**, **ecosystem analysis** and **ecosystem impact assessment** are used to evaluate environmental quality. Each technique systematically assesses the impacts as a result of interaction between a development proposal and the environment. This technique treats the ecosystem as a functional system where the organisms and their physical environment are assessed.

In the assessment of economic impact, the most commonly used method is **Cost-Benefit Analysis (CBA)**. This enables the decision-maker to choose the best alternative through the systematic analyses of all costs and benefits. CBA is mostly frequently used in the assessment of monetary items such as plans, programmes, polices and projects. A further technique to assess economic impact is **Cost-Effectiveness Analysis (CEA)**. CEA is used when choosing a cheaper development alternative. It is common for a project planner to use this technique to set physical targets, social indicators, health standards and environmental quality measures. The project planner then chooses the least-cost method in accordance with the appropriate setting. CEA is also used to determine improvement costs and the anticipated benefit of the environmental impact.

Agroecosystem assessment is a technique that attempts to quickly diagnose environmental impact using the concepts of ecosystem and socio-economy as parameters. It assesses impacts (even global) which might have an influence on the farming community; also world trade issues and global warming at the global scale. Agroecosystem assessment is often combined with land-use investigation. Since it takes the global factor as one of its consideration, it usually extends beyond the farming community to include the world trade issues and global warming.

In addition, **hazard and risk assessments** are also important methods in the EIA system, especially in countries with frequent natural disasters such as Taiwan, Japan, and California. **Hazard assessments** are often applied in the assessment of a development proposal in areas where the risks from disaster are high; the definition of disaster usually implies natural disaster, however hazard assessment can be applied to industrial and human activities. Hazard assessment verifies impacts that human activity could bring onto nature, the vulnerability of environment and wild animals. A similar technique, **risk assessment** assesses the combined negative impact of human activities and natural disaster. The risk assessment is a quantitative analysis, using methods of measurement, testing, mathematics, and statistics. The risk assessment can be used for screening a new development proposal, or for ensuring an activity is safe to the user and the environment. In the EIA screening procedure, risk assessment is used to estimate the effects of accidental disaster in e.g. the development of a chemical factory.

Recently other assessing techniques have gained in importance including **life cycle assessment,** and **monitoring and surveillance**. Life cycle assessment is often applied to assess the environmental impacts caused from the location of a factory or power plant. Life cycle assessment focuses on impacts occurring from raw material acquisition, construction, operation, recycling, and demolition. Taking the assessment of a power plant as an example, the life cycle assessment includes impacts accumulated after the closing down and reinstatement of the plant as well as during operation. **Monitoring** is a series of observations, measurements and estimations of a specific object. It can provide the EIA system, risk assessment, eco-auditing, etc., with the necessary information, quickly highlighting any problems or difficulties.

The **ultimate environmental threshold assessment** is applied to assess ecological limits. The environmental threshold is an upper limit beyond which any impact would be severe to the environment and possibly non-recoverable. The technique is often adopted in an EIA system to assess the limitation of cumulative impacts, as over-impacting would cause local catastrophes. **Aesthetic impact assessmen** applies to land capability, planning, and EIA. General speaking, aesthetic impact assessments focus on

the assessment of the visual impact incorporating factors such as psychology and the arts. **Eco-auditing** specifically assesses the practical impact of current activities, giving valuable information about the local and national environmental situation (Barrow 1997, p. 23-44).

To sum up, each method of assessment is specific to an appropriate field, at an appropriate time. An inappropriate technique could produce incorrect, incomplete and therefore misleading results. The assessment technique used is a further factor influencing the effectiveness of the EIA.

3.3.2 Uses of the EIA Process and Procedure

As well as the full preparation of environmental information and the appropriate use of assessment techniques, the EIA procedure will also have a potential influence on the effectiveness of the EIA system. There are two main factors in the EIA procedure that have a direct influence on the result of the EIA system: integrity and adequacy. Gilpin (1995, pp. 158-161), after researching the shortcomings of the EIA system, stated that the EIA procedure should include the following characteristics:

- better public participation and circulation of information
- reduction of poverty so that EIA can be given a higher priority
- a firm legislative formulation
- a clear schedule of what is to be subject to an EIA
- better data, planning and environmental management
- participant integrity
- adequate avenues of appeal if there is a problem.

Gilpin (1995) pointed out the importance of public participation and the different avenues of appeal i.e. high public participation can support and improve the effectiveness of the EIA system using different avenues of appeal. According to Gilpin (1995) the EIA system should include a system of appeal, similar to that used in the US judiciary.

Mostert (1995) noted that the EIA procedure has a number of direct influences on the decision-making process including the participation of interested groups from an early stage. The EIA provides an

opportunity for public and non-governmental organisations to participate, encouraging communication between the developer, competent authority, the review body, and other organisations. This ensures that any modifications to a development project will not be delayed, and costs will not be increased. A further influence is that an effective EIA procedure can balance various powers channelling them towards a more environmentally sound outcome. However, government organisations have the right to veto whilst NGOs have the right to appeal, which could to stop or defer the initiation of a development project. To prevent delays, the developer, and the planning and approval organisation must present a well-prepared EIS for public and NGO scrutiny. According to Mostert (1995), a good EIA procedure can provide the proponent, competent authority, general public, and environmental NGOs with communication opportunities to improve development plans and policy.

3.3.3 Culture of Decision-making

Decisions are made during the EIA procedure. Some are decided by the developer whilst others are made by the competent authority, decision-making organisations, or environmental NGOs and the public. Environmental information produced from the EIA process encompasses alternatives and mitigation measures etc. The development proposal can be approved or rejected by the competent authority depending on the weight the decision-maker gives the environmental factor relative to others.

As to policy-making, there are three factors directly affecting the effectiveness of the EIA system. The first is the influential power of environmental information in enforcing modifications to the proposal content. This could result in alternatives being proposed, or the original content of the proposal being amended. The second factor is the consideration given by the competent authority to the description of environmental impacts and the third factor is weight given to economic, technical, and political factors.

The nature of decision-making itself influences both the formation of the decision-making process and the effectiveness of the EIA system. Mostert (1995, p. 76), using political science terminology, split the policy-making model into democratic and undemocratic types. Furthermore, depending on the number

of decisions, the model can be split into monistic and pluralistic; the pluralistic can be further divided into consensus, adversarial, and lowly-structured decision-making.

The culture of decision-making potentially influences the effectiveness of the EIA system. For example, in an undemocratic culture as public participation is low and non-government environmental organisation is incomplete, resulting in difficulties in gathering much useful environmental information through screening and scoping procedures. Moreover, as the decision-making is controlled by just one decision-making centre the outcome may be biased, or may ignore some important factors.

Decision would be better if all influences were examined quantitatively. However, this would be impossible as many environmental impacts cannot be quantified e.g. aesthetics, site ecology, etc. Furthermore, different impacts cannot be treated using the same standard e.g. economic and ecological impacts. In other words, when making-decision, as well as determining whether a project should be approved, the pros and cons of various alternatives should also be considered. According to Wood (1995, p. 182) '*decision making is seldom straightforward and is dependent not only upon the merits of the proposal but on political circumstance. The environmental impact of the proposal will usually be only one of the factors to be considered by the decision-maker ... the making of any decision will involve a trade-off between factors in the information base i.e. between simplification and the complexity of reality, between the urgency of decision and the need for further information, between facts and values, between forecasts and evaluation, and between certainty and uncertainty*'.

Unfortunately, the decision-maker is often a publicly elected head of government without the time to thoroughly examine the results of the EIA system. The decision is, therefore, generally based on a summary from his advisors. Consequently, some countries have a committee or advisory agency to review the EIA and summarise relevant findings for the decision-maker. After the decision has been announced, if there is unsatisfactory public response, a judicial appeal can step in to force the decision-maker to reassess the outcome.

A further influential factor in decision-making is whether the environmental factor has been considered as the main criteria. This can highlight whether the EIA system is just another factor in the decision-making procedure, or if it has real influential power to guide the decision-making process.

3.3.4 The Characteristic of Participants

During the implementation of the EIA system, participants also affect effectiveness. This is especially so during the operational period of an EIA system as the attitude and background of participants are key factors. The participant is not solely limited to government organisations but to all participants in the EIA(see table 3-1). The first organisation to appear in the EIA system is the developer, which could be a public organisation or private company. Next in the EIA would be the consultant company or assessing team, the competent authority or lead agency, other administrative organisations, consulting staff or committee, the law court or appealing organisation, and the public (which includes the general public, environmental protective groups, and mass media). The following is a description of each organisation, their characteristics, and their influence according to the role they play in the EIA system.

Table 3-1 : Major participants in the EIA process

Process	Participant
Screening	Competent authority, developer
Scoping	Competent authority, environmental authority public, developer, expert committee
Analysing / predicting	Developer
Reporting	Developer
Review	Competent authority, environmental authority, public, expert committee
Design making	Competent authority
Follow up	
• Monitoring	Competent authority, environmental authority
• Managing	Competent authority, environmental authority
• Auditing / evaluating	Competent authority, environmental authority, developer

Note: based on the Dutch EIA system

Developer (or project applicant)

A developer is the applicant for a development proposal; proponent, investor, or initiator (Moster 1995, p. 27). If the project has to be approved by the government (e.g. a construction permit is needed for high

rise buildings) the developer is known as the project applicant[2]. When the developer is a private company, an application for funding, approval, or permit may be necessary. The developer might hire a consulting company to carry out the EIA and produce the report. The relationship between the developer and the consultant (or EIA assessing team) is, therefore, based on an enterprise and consignee association. However, the EIA should be independent and objective, it should not be directed or influenced by the enterprise as this will affect the effectiveness of the EIA.

Consultants (or EIS team)

Consultants, EIS team, or study team are those that conduct EIAs. The team could include planners, engineers, scientists, and sociologists depending on the characteristics of the development proposal, and the content of the assessment. For example, an assessment team for the building of a community centre in a mountainous region will be different to that for a residential building project in a city centre.

In some instances the consultant may be the same organisation as the developer i.e. the developer conducts the assessment. However, it is more usual for the developer to tender the EIA and report preparation to another organisation. The consultant is an executor of the EIA system whose responsibilities include preparing the environmental information, assessing the environmental impact of a development, and proposing alternatives. The professional and the objective attitude of the consultants are essential in an EIA system. In some countries private consultants are required to either be government registered or have a permit, whilst others require a member of the EIS team to hold a government issued technique license, as in Taiwan.

Competent authority

The competent authority, as well as being a public organisation, is also the final decision-maker for a development plan. In Japan and Germany, the competent authority is the main organisation in the implementation of the EIA system, whereas in Taiwan, Sweden and Canada the main organisation are

[2] The terms project proponent and project sponsor are synonymous see Kreske, 1996, p. 17

environmental protection agencies. When the competent authority is the main organisation, it plays a decisive role in the EIA procedure (scoping, public participation, screening) and is the final decision-maker.

The type and scale of the development proposal will determine whether the competent authority will be central or local government based. As the competent authority is a planning approval organisation and sometimes the main organiser of the EIA system, it has an all-important role in the EIA system. Moreover, as the EIA review will go to the competent authority for the final decision, the way in which the economic and technique factors are taken into consideration will influence the effectiveness of the EIA system.

Other related administrative organisations

Other related administrative organisations play a vital role in the EIA system. An environmental protection organisation for the immediate area likely to be affected by the development proposal provides opinions and comments after review of the EIA report.

Consultancies can be another related administrative organisation. While the EIA system initiates the assessment process, an EIA team should be in communication with related organisations when acquiring the necessary information e.g. data on environmental pollution monitoring from the relevan environmental organisation. Amongst related administrative organisations, the environmental protectio organisation is one of the most important. In some countries it is the main organiser in the EIA process. I has the right not to issue permits (e.g. for the disposal of wastewater) if environmental standards have been exceeded. In the US, it is a function of the EPA is to review and provide comment on the EIA system. When under review, the EIS draft is split into two types by the EPA: Environmental Impact of the Action, and Adequacy of the Draft Environmental Impact Statement (Kreske 1996, p. 29). The EPA also grades them to indicate a degree of acceptance (Table 3-2). There are four ratings for the environmenta-

impact of a development proposal: LO (Lack of Objection), EC (Environmental Concerns), EO (Environmental Objections), and EU (Environmentally Unsatisfactory). The adequacy of the draft EIS is further divided into three categories: 1 - Adequate, 2 - Insufficient Information, and 3 Inadequate.

Table 3-2 : EPA Ratings of Federal Actions and EISs

Environmental Impact of the Action
• LO (Lack of Objection); EPA has not identified environmental impacts requiring substantive changes to the proposal
• EC (Environmental Concern); EPA identified environmental impacts that should be avoided. EPA would like to work with the lead agency to reduce these impacts.
• EO (Environmental Objections); EPA identified significant environmental impacts that must be avoided. EPA intends to work with the lead agency to reduce these impacts.
• EU (Environmentally Unsatisfactory); EPA review identified adverse environmental impacts of sufficient magnitude that they are unsatisfactory from the standpoint of public health, welfare, or environmental quality. If these impacts are not corrected in the Final EIS, the proposal could be referred to CEQ.
Adequacy of the Draft Environmental Impact Statement
• Category 1 (Adequate); Draft EIS adequately sets forth impacts of alternatives. No further analysis is necessary.
• Category 2 (Insufficient Information); Draft EIS is insufficient to assess impacts that should be avoided, or new reasonable alternatives were identified that could reduce environmental impact and are within the spectrum of alternatives in the Draft EIS. The additional information or discussion should be included in the Final EIS.
• Category 3 (Inadequate); Draft EIS does not adequately assess significant environmental impacts, or new reasonable alternatives were identified that could reduce environmental impacts and that are outside the spectrum of alternatives in the Draft EIS. The Draft EIS should be revised and made available to the public as a supplemental Draft EIS. The EIS could be referred to CEQ.

Data resource: Kreske, 1996, p. 30

The advisory bodies

The advisory body provides information before the decision-making organisation makes a decision. As it is a consulting body, rather than a regulatory one, it has no power of veto or controlling rights. Its function is to provide a complete picture of the likely environmental impacts to the decision-maker. In practice it is impossible for the decision-maker to acquire the professional knowledge and to study the EIA report in full. Advisory bodies are, therefore, relied upon to provide a summary of such information. An advisory body needs to remain independent, free of bias, and not get involved in the decision-making process. Some EIA systems (e.g. Dutch EIA) have an expert committee (or panel) to review the EIA report.

The public

Public participation is an essential role in the procedure of the EIA system. The public role can be divided into the general public, environmental non-government organisations, academia, and mass media.

No matter how thorough the scoping and screening procedures are, public participation and opinion are vital, especially from ethnic minorities. Ways to enable public participation include seminars announcements, and public hearings. As in the development of the EIA system, the earlier the public is involved, the better the degree of effectiveness. In addition, the public and environmental groups can take on a safeguarding role i.e. when public response to a decision is negative, an appeal can be filed e.g. the public litigation system in the US (Tu 1994, p. 20).

Furthermore, the proceedings of the EIA system should be common knowledge as public opinion can defer progress of a development project whilst awaiting correction or amendment. Due to their professional knowledge, academic groups and university professors, often become the spokespeople for public opinion. Their position is, therefore, very important to the EIA system.

The court

Some countries provide the public the opportunity of litigation. The degree of public participation and their right to go to court is characteristic of the US EIA system, where cases are heard in court. The role of the public is to appeal against unacceptable points in the EIA statement, stating why it is felt to be inappropriate. The responsibility of evidence-finding belongs to those who need to prove the adequacy of the EIA statement (Jong 1990, p. 80). Normally, plaintiffs must exhaust applicable administrative remedies before seeking judicial review. Table 3-3 lists the number of NEPA cases for 1990 1991, and 1992. The most frequent defendant is the Department of Transport, and the most frequent plaintiffs are citizens and environmental groups. The most common complaint is that an agency should have prepared an EIS for an action followed by an inadequate EIS (Kreske 1996, p. 154).

In some countries the public appeal system influences the effectiveness of the EIA system as litigation obstructs and postpones the development progress. As a result, the developer will often modify the original plan, or choose a more sustainable alternative.

Table 3-3 : NEPA Litigation Survey (1990-1992)

Year	Cases filed	Number of Injunctions	Most Frequent Defendants	Most Frequent Plaintiffs	Most Common Complaint	Second most Common Complaint
1990	85	11	DOT COE EPA	Individuals citizen Environmental groups	No EIS	Inadequate EIS
1991	94	14	ARMY DOT DOI	Individuals citizen Environmental groups	No EIS	Inadequate EIS
1992	81	5	DOI DOT DOI	Individuals citizen groups Environmental groups	No EIS	Inadequate EIS

Notes: DOT, Department of Transport; COE, Corps of Engineers; DOI, Department of the Interior; EPA, Environmental Protection Agency.

Data source: Kreske 1996, p. 156

The legislative body

Policies need to be regulated by law. The EIA system is no exception as it needs the law to provide criteria for the participants to follow. The legislative body is, therefore, a further factor influencing the effectiveness of the EIA system.

The EIA system has a foundation law. Some countries, such as Taiwan, establish a separate EIA Act as a guideline, whilst others include the EIA provision into existing environmental laws. In the Netherlands, the EIA Act is a part of the Environmental Management Act. Whichever method is used, all legislation has to be reviewed and passed by the legislative body before being promulgated and put into force. The contents, procedures, main managing organisations, penalties etc., of the EIA system are all the products of the legislative system, and accountable to the legislative body.

The legislators, or members of parliament, are usually publicly elected. As their backgrounds are very varied, when reviewing the law their understanding and attitude towards the EIA system would affect the outcome of the environmental regulations. Local EIA regulations are reviewed and passed to the local legislative body. In effect, the legislative body has a direct effect on the design of the EIA system, which in turn affects the effectiveness of the system.

3.4 EVALUATION OF THE EFFECTIVENESS OF THE EIA SYSTEM

There has been extensive research into the evaluation of the effectiveness of the EIA system. Various aspects have studied; system design, system implementation, monitoring and auditing of environmental impact, and criticism of the quality of the EIA report. Some are discussed below.

3.4.1 Evaluating Effectiveness of the EIA System from the Quality of the EIA Report

The EIA report is a very important output from the EIA system. It not only provides environmental information but also presents the results of the EIA. The report is the communication medium of the EIA procedure. It is a guide and reference-point for the developer, the competent authority, the public, advisory bodies, and all the participants in understanding the environmental impact of a development project. The quality of the EIA report has a direct influence on the effectiveness of EIA system, enhancement of the quality of the report will improve the effectiveness. Most evaluating is carried out by the government, including the annual report and the report of criticism. These analyse the pros and cons of the EIA report from an adequacy and sufficiency perspective for the developer and consulting company.

After the US EIA system was in place for three years, a review was undertaken as to the effectiveness. In the review of past EISs, CEQ (1972) came across three main problems: problem of procedure, EIS content, and the role of the competent authority. This evaluative report resulted in the production of EIA Guidelines. Ray (1972) analysed and criticised 250 previous EISs, including any unclear investigations

insufficient alternatives, and the neglect of cumulative impacts of the project (Canter 1977, p. 11-15). The US General Accounting Office (GAO, 1972) reviewed seven EISs from Federal organisations[3], concluding that public participation was inadequate in the of EIA preparation process. The EIS quality and adequacy was also questioned and criticised. Problems included the inadequacies of the discussion of environmental impact in the EIA report and comment from the reviewing organisations, and insufficient consideration of alternatives and its environmental impact. Pearson (1973) criticised 50 EISs stressing that a number, aside from being untrue, were often written in quantitative rather than quality terms, and that alternatives were not clear enough.

The EIA team and committees also have a direct influence on the quality of an EIA report. In Taiwan there are 30 consulting companies that have prepared EIA reports. In 1997 these were examined and classified according to the quality of the report with respect to presentation and assessment of impacts. This classification allows the developer to choose a reputable consulting company. The result of the investigation indicated that only 13 of the 30 companies could adequately conduct an EIA report (EPA 1997d, p. 2).

In examining EIA report quality, it is hoped that once common shortcomings have been identified they can be improved so enhancing the effectiveness of the EIA system. Through an analysis of the cost of the EIA report, professional standards, consultation during EIA, and reviewing the EIA document. Buckley (1998) noted that to improve the effectiveness of the EIA system, the quality must improve. Four ways to improve the EIA report quality included: selection evaluation training and accreditation of consultants; mechanisms for effective public participation; mechanisms for effective review of EIA documents; and mechanisms for cumulative and strategic EIA. In improving the quality of the EIA report, the effectiveness of the EIA system will be enhanced (Buckley 1998, p. 41).

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[3]Federal organisations include Corps of Engineers, Forest Service, Soil Conservation Service, Housing and Urban Development Department, Reclamation Bureau, Federal Aviation Administration, and Federal Highway Administration (Canter 1977, pp. 12-14).

3.4.2. Assessing Effectiveness of the EIA from the EIA System

The use of the EIA system has a deep influence on its effectiveness. The design of EIA's process is at the centre of the EIA system.

Each section of the EIA system, including the investigation of environmental data, the assessment of environmental impact, screening processes, scoping processes, public participation, public review, the review by committee and advisory bodies, decision-making and the appeal system are closely linked. When a problem occurs at any part in this connection, the whole EIA system is influenced. Although the effectiveness of the EIA system is affected by the EIA procedure, there is no one set standard about what the most appropriate procedure is. However, through basic consensus, some researchers have proposed a series of criteria, measures and indicators to help evaluate the effectiveness of an EIA system. For example, Gibson (1993) has proposed eight interdependent principles for the analysis of the Canadian Federal EIA system. The key point is the procedure of an EIA system and how to go about ensuring the best option been adopted in the decision-making process. In addition, Wood (1995) has established 14 evaluation criteria to compare the effectiveness of EIA system between six countries[4]. Each criterion was further divided into many sub-criterion. The 14 criteria are legal basis, the coverage of the EIA, alternatives, screening of actions, scoping of impacts, the EIA report, public review, decision-making, monitoring of action impacts, mitigation measures, consultation and participation, EIA report preparation, costs and time, and the application of the SEA. Result from this research indicated that general shortcomings in the EIA system included weaknesses in coverage integrating the EIA into decision making, impact monitoring, public participation, system monitoring, and SEA (Wood 1995, p. 298).

Mostert (1995) also established nine indicators to assess the effectiveness of an EIA. These were procedural characteristics, quality of information, use of information, use of the procedure and process, anticipation, character of decision-making, specific decisions of sustainability and acceptance and finally, more general decisions and activities. These nine indicators can be grouped into three sections: the

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[4]California (US), New Zealand, UK, The Netherlands, Canada and Australia (Wood 1995, p. 12)

application and quality of environmental information, the procedure of operation, and the quality of decision-making. Mostert (1995) further divided each indicator into a sub-indicator. Taking procedural characteristic as an example, it has been divided into ten sub-indicators as follow[5]:

- *EIA early, at least before issue of permit or adoption of plan*
- *EIA process parallel with planning/permitting process; links between procedures*
- *Screening process*
- *Scoping process*
- *Monitoring*
- *Public review*
- *Requirement to motivate decisions*
- *Free access of information*
- *Possibilities for public participation and legal action*
- *Broad scope, including a requirement of develop alternatives*

To analyse the impact of the effectiveness of the EIA in the EIA committee, Mostert (1995) divided the EIA committee into four types: objectivity commission, utilisation commission, communication commission, and advocacy commission. The result of this research indicated that EIA committees can contribute significantly to the effectiveness of the EIA. This is achieved through improvement of the quality of implementation produced in the EIA by increasing the utilisation of information, by adding new process elements to the EIA, and by directly affecting decisions (Mostert 1995, p. 251).

Assessment from a systematic perspective focuses on procedure and decision-making along with assessment from the principle, standard, and indicator viewpoint.

[5]This research examined Dutch, Polish, and Hungarian EIA systems from an EIA commission contributing to the effectiveness of the EIA aspect (Mostert 1995, p. 54).

3.4.3 Assessing Effectiveness of the EIA System with Organisational Control Mechanisms

In the context of EIA implementation, organisational control mechanisms are the procedures and structures in, or between, organisations that ensure the development organisation, competent authorities, and the decision-maker consider all the factors of environmental impact.

Ortolano *et al* (1987) proposed six organisational control mechanisms: procedural control; evaluative control; judicial control; instrumental control; professional control; direct public and outside agency control. Tu (1994) conducted an evaluation of the effectiveness of Taiwan's and Thailand's systems using these six mechanisms. Results from this research indicated that evaluation control and direct public and outside agency control proved to be the most influential to the EIA effectiveness in Taiwan, whils evaluation, professional, and development aid agency control were more influential in Thailand (Tu 1994 pp. 297-298).

3.4.4 Assessing the Effectiveness of the EIA System from the Aspect of EIA Practice

This method assesses effectiveness by analysing the final outcome, following up the extent to which the EIA goal has been accomplished, and analysing the sustainability of the development.

Cole (1997) established environmental criteria based on how to evaluate the sustainability of a buildin after completion of the EIA procedure. Doxsey (1994) proposed seven categories in the Green Builde Programme (source, process, use, user factor, post-use, integration, and difficulty) to analyse the degre of sustainability based on residences in Austin, US. Each category has been further divided into sub categories, and performance (Cole 1997, p. 193). In addition, Building Research Establishment (BRE also proposed several sets of Environmental criteria for the evaluation of sustainability of variou buildings. Its evaluation criteria include global issues, local issues, and indoor issues. For new office there are ozone layer protection, environmental impact of energy use, indoor environment, resourc conservation, and site and transportation to criteria to evaluate (Prior 1993, p. 3).

Canter (1998) found 22 different kinds of commonly used techniques used to assess environmental impacts in the EIA system, and analysed them according to their evaluation methods and purposes. He grouped the techniques into seven categories: define issues (scoping), impact identification, describe effected environment, impact prediction, impact assessment, decision-making and results communication. From the EIA reports, Canter found that analogs, checklists, expert opinion, mass balance calculations and matrices are the most widely used methods.

The Dutch Commission for EIA (1998) conducted an international study into EIA practice. It analysed the status of EIA in 23 countries and two international organisations. The results of this study illustrated that most countries had between 11 and 99 EIA cases each year, the length of average an EIA report was between 51 and 99 pages, and the average cost of preparing an EIA report was between USD 25,000 and USD 50,000, around 0.1 percent to 1 percent of the total project cost. In addition Marr (1997) compared differences in EIA practice for a wastewater treatment plant between Germany and U.K. Both countries implemented an EIA in compliance with the formal requirement, the coverage of the associated ramifications of the project were limited, and EIA started too late and finished too early to influence the fundamental location and design of the project. It was concluded that neither EIA system met all objectives of an EIA.

3.4.5 Assessing EIA Effectiveness through Monitoring and Auditing

Monitoring and Auditing are used in the follow up to an EIA. They compare predicted with actual environmental impacts whilst establishing further environmental information, and improving prediction methods. Buckely (1991) described the post-EIA audit as a 'systematic comparison of predicted and actual impacts' (Barrow 1997, p. 120). Therefore, according to Barrow (1997, p. 121), impact assessment audits should consider four factors: a) effectiveness of the impact assessment in assessing impacts, b) how well it is used, c) whether it can be modified to adapt to unforeseen developments, and d) the relationship of the impact assessment to environmental management and planning.

On evaluation, Buckely (1991) found that the average accuracy of prediction in an Australian EIA was only 44% (± 5% standard error). The main failings were due to missed impacts, especially cumulative impacts, expert judgement (subjective and difficult to scrutinise), and unclear predictions (Barrow 1997, p. 123).

Wood (1995) considered the effectiveness of monitoring in the EIA system. He proposed a number of criteria that should be met in the auditing process. These included monitoring taking place earlier in the EIA, a monitoring plan to be stated in the EIA report, the plan to be ameliorated after monitoring, and a comparison of monitoring results with the EIA report predictions. These indicators are used in evaluating the results of monitoring, and also affect the effectiveness of the EIA system.

Shepherd (1998, p. 165) researched post-project impact assessment and monitoring (PPIAM). He observed that PPIAM is not widely carried out in the US because: a) environmental monitoring data are expensive and difficult to collect, b) monitoring can be time consuming, c) agencies lack guidance, d) agencies are under little legal pressure to conduct monitoring, e) agencies may fear self-incrimination through monitoring. Shepherd (1998) proposed four principles in the evaluation of the effectiveness of monitoring in the EIA system including a) Had the agency been clearly asked to carry out post-project monitoring? b) Were there incentives for carrying out monitoring? c) Had interest been expressed in the re-using and sharing of monitoring data and information? d) Had the scope and time of monitoring been extended? These principles propose both incentives and an extended timeframe for monitoring. To increase the effectiveness of the EIA system, the pre- to post-project stages should follow that of a life cycle process.

3.5 ESTABLISHING AN EFFECTIVENESS EVALUATION FRAMEWORK

3.5.1 Approach to EIA Effectiveness Review

In this thesis the effectiveness of the EIA system is defined as: "*Effectiveness EIA is EIA that can*

- *improve the quality of a decision from an sustainability viewpoint,*
- *smooth consent procedures, and promote acceptable decision are taken, and*
- *raise environmental awareness.*
- *Conditions of approvals must be enforceable , and approval must be followed by monitoring and auditing of effects.*
- *The EIA process must be designed to facilitate efficient implementation.*

However, it is difficult to precisely state the effectiveness an EIA system as it is not known whether sustainability of the project could have been achieved without the EIA process. It is also unclear to what extent the EIA smoothes the consent procedure, increases the acceptability of the decision, and raises the level of environmental awareness. Nevertheless, if the EIA process had been avoided, weakly sustainable and potential environmentally damaging decisions may be accepted. In this study several criteria will be established to help and evaluate to effectiveness of the EIA system. Two high-rise building involved in the EIA process will be chosen to review the level of sustainability.

Commonly used approaches to assess the effectiveness of an EIA are macro, micro and meso-scale reviews.

a. Macro or system-wide review: These are a synthetic or integrated evaluation approach during a specific period. For example, assesses the quality of the EIA report during a certain period when focusing on the evaluation of the EIA procedure.
b. Micro or process-specific review: These focus on a specific item, area or purpose for evaluating. For example, the following up of an EIA of a specific project such as a waste water treatment plant.
c. Meso-scale review: It is intermediary research between the other approaches; it is neither an integrated approach nor a case study. For example it focuses on the definition of scoping and a specific EIA procedure (Sadler 1998, p. 35).

In Taiwan, and using high-rising building as an example, the Meso-scale approaches should be adopted. Initially the development and implementation of the Taiwanese EIA system should be analysed. This should then be followed by case studies and analysis of the sustainability performance the high-rise building.

Recently the Taiwanese EIA system has reached a number of milestones: twenty years since the implementation of the first EIA; fifth anniversary since the promulgation of the EIA Act. The basis for a comprehensive evaluation approach of the effectiveness of the EIA is, therefore, available. A comprehensive approach can be built on a 'triangulation test' that interrelates policy, practice, and performance (Sadler 1998, p. 34). Policy specifies what is required, practice is what actually happens, and performance is concerned with the results (i.e. whether what happened corresponded to what was required). The framework for evaluation of policy-practice-performance (the 3Ps) can be undertaken three dimensionally including EIA process, EIA practice and post-project.

3.5.2 Evaluation Framework for the Effectiveness of EIA

This thesis inspects the application of the EIA system to high-rise buildings in Taiwan from a meso-scale perspective. The effectiveness of process and decision-making aspects of the EIA system will be evaluated first. The effectiveness of implementing the EIA system for high-rise buildings will then be assessed. Thus, the assessment approach in this chapter will be comprehensive.

The structure of a comprehensive approach to effectiveness is based on the interrelated 'triangulation test' of the 3Ps. Specifically, as policy is reflected through the establishment of the system, system design process, and decision-making processes of the EIA system need to be assessed. Assessment of the implementation process, decision-making mechanism, and monitoring and surveillance should be included for practice. As performance is determined by whether the outcome of implementation meet the objectives of the original EIA system, each case is individually assessed, with emphasis on sustainable development; post-project evaluation.

A. Dimension of Policy

The evaluation of the effectiveness of an EIA, from the policy perspective, refers to the EIA procedure i.e. can the EIA system design satisfy the original intention and purpose. The EIA procedure is crucial in determining effectiveness and is a necessary condition for the success of an EIA. Every EIA procedure operates within the boundaries of policy, politics, and legal and administrative circumstances. This aspect can be further divided (Figure 3-1) to include aspects of legal regulations, procedure, and decision-making.

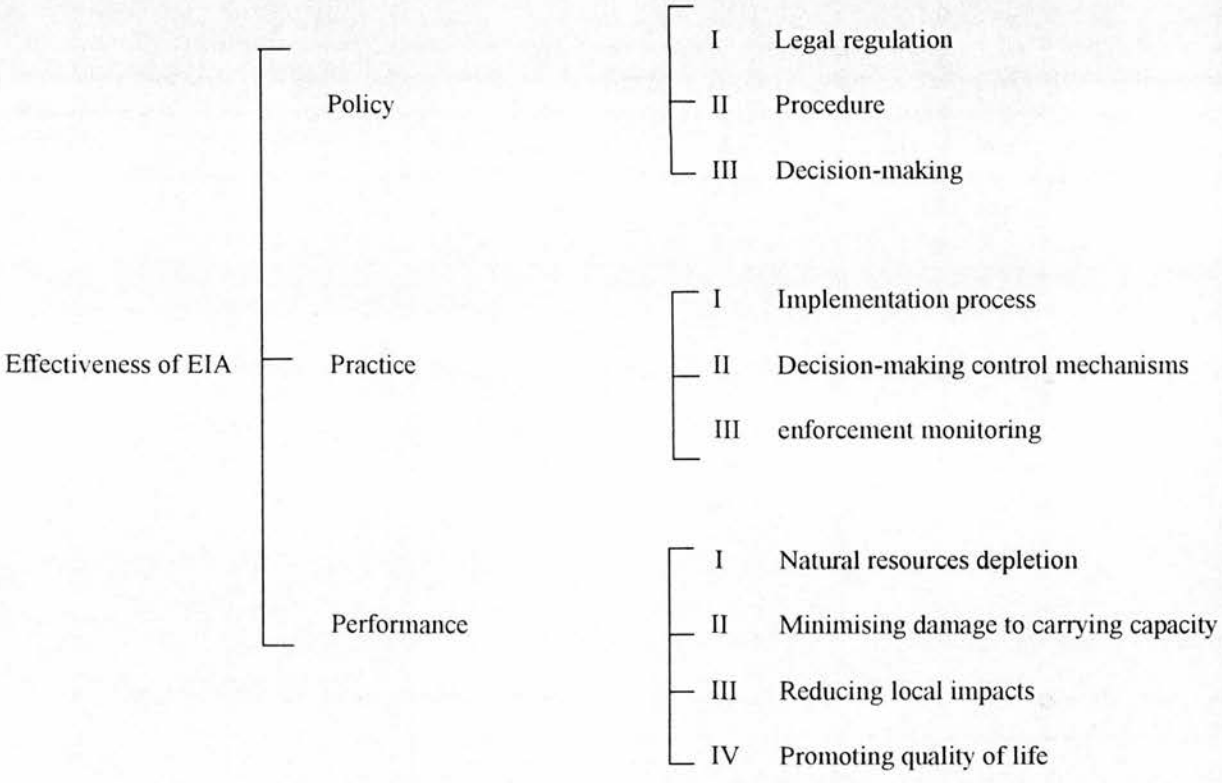

FIG. 3-1: Evaluation Framework for EAI Effectiveness

I. Legal aspect: This level focuses mainly on institution and organisation. In establishing criteria, it has been divided into four categories: legal basis, administrative organisational structure, application of the SEA system, and the preparation of the EIA report. Purposes of the evaluation include the legal basis of the EIA, the performance of each organisation, the adjustment in manpower, the application of the EIA system at the policy, plan and programme level, the content of the EIA report, and public participation. Vital to this legal aspect is the success and effectiveness of carrying out a policy as it influences the

following levels. It is, therefore, necessary to evaluate the result of an EIA system from a legal angle.

II. Procedural aspect: This focuses on evaluating the regulations for the EIA procedure. Procedure is used to determine whether to carry out an EIA. A reasonable procedure, clear regulations, and co-operation with other procedures are crucial in deciding whether a system will be successful or not. To create evaluation criteria, procedural aspect can be divided into four categories: screening, scoping, monitoring and auditing, and EIA review.

III. Decision-making aspect: One of the most important parts of EIA is the decision-making. Evaluation categories include alternatives and mitigation measures that assist with the decision-making and the process. Alternatives to the development project are listed. Mitigation measures are proposals that can reduce severe environmental impacts caused by the development proposal. These have a direct influence on the effectiveness of the EIA system.

B. Practice

Practice refers to the actual carrying out of the EIA. Assessment focuses on whether practice can meet the original system design, and whether implementation is complete or not. As this aspect is practical the assessment must be based on actual cases and should be conducted through the EIA process, the mode for decision-making, and the monitoring and surveillance for each individual case. Consequently, there has to be an evaluation of the implementation process, decision-making control mechanism, and enforcement monitoring and surveillance.

I. Implementation Process: The effective implementation of an EIA system requires a well run organisation with adequate labour resources to meet the original demands set out by the system design. External influences e.g. bureaucracy and culture, affect effectiveness.

Thus, aside from the evaluation of policy, the monitoring and surveillance of each case is critical when assessing the effectiveness of an EIA system. Time and cost are also important as delays and increased costs incurred when carrying out the EIA increased costs are criticised. Public participation is also an

important component in the design of the EIA system.

II. Decision-Making Control Mechanism: As the fundamental aim of the EIA system is to provide sufficient environmental information to policymakers, the role of the decision-making process is significant to the effectiveness of the whole EIA system. The assessment of the decision-making element of policy is primarily aimed at the design of the EIA system. Control mechanisms of the decision-making process of individual cases in the EIA process are analysed and the effectiveness of the EIA system is evaluated.

Policymakers are also influenced by procedural, judicial, and professional impacts, and NGOs etc. Specifically, the decision-making control mechanism in an effective EIA system is influenced by the organisational control mechanism[6]. Procedural control mechanism refers to the limitations and regulations set by legal procedures which have to be followed by policymakers.

Judicial control mechanism enforces procedural regulations allowing policymakers to make the most appropriate decision through judicial litigation. The general public can appeal to the competent authority to overrule or change decisions through the litigation system. Another important element in the EIA system is the process of public participation that encompasses the general public, NGOs and mass media.

Finally, professionals are vital to the decision-making process as they provide a professional opinion, and influence the policymakers into realising the importance of environmental impact when making decisions.

III. Enforcement monitoring: This is the monitoring and surveillance during and after completion of the development project. An aim of the EIA system is to prevent and mitigate bad impacts on the

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[6]According to research by Shih-Liang Tu, the structure control mechanism of an effective EIA system can be divided into procedural, evaluative, judicial, development aid agency, professional, and direct public and outside agency control (Tu 1994, pp. 15-24).

environment as a resulted of the project. Consequently, monitoring and surveillance directly influences the effectiveness of the EIA system. Many EIA procedures prior to development are written, therefore monitoring and surveillance during the construction, completion, and operation stages is the means to achieving the EIA aim.

Monitoring and surveillance is necessary for the implementation of mitigation measures. Monitoring and surveillance conclusions from the EIA review and environmental management project advocate needed modification or changes to future EIAs. The monitoring and surveillance plan, mitigation measures, the environmental management plan, and the implementation of conclusions from the review all rely on results and information from related agencies.

As this evaluation is through the assessment of individual cases, the original EIA design is involved. For example, legal regulations should force the proponent, competent authority, environmental protection agency, and related organisations to carry out their own roles, but also to co-operate when required. Fines should be introduced for failure to comply, which in itself may influence the effect of monitoring and surveillance during the practising stage. Therefore, an effective EIA system should control every stage of the project and improve the system through results and conclusions.

C. Performance

A goal of the EIA system is to achieve sustainable development. Therefore, every step in an EIA is a means to the prevention or alleviation of any detrimental environmental impacts. Thus, performance is the third area of evaluation when determining the effectiveness of the EIA system. This is established through the audit and analysis of projects to determine whether environmental protection can be accomplished after the completion of the EIA process.

The evaluation of performance can be divided into four aspects: optimal and sustainable use of natural resources; minimising damage to carrying capacity of the environment; prevention and mitigation of adverse impacts; promoting quality of life.

I. The optimal and sustainable use of natural resources: The first sustainability test for high-rise building is the optimal and sustainable use of natural resources. Sustainable development is the steady use of a natural resource without exhausting the supply and protecting biological diversity for future generations. Non-renewable resources should be used optimally, and renewable resources sustainably.

The sustainability performance of a high-rise building can be categorised into six elements. Each aspect of natural resource consumption is described as follows:

Energy depletion: This covers the use of non-renewable energy sources. To meet key sustainable development objectives, improved designs for high-rise buildings cutting the energy impact by reducing the depletion of non-renewable sources of fossil fuel and the use of renewable energy resource power must be encouraged. In 1995 in Taiwan, total energy consumption was 51 million tonnes of oil equivalent (MTOE) (MOE 1996, p. 28), which the majority (95%) of energy used is imported (EPA 1997a, p.576), equivalent to 33% of the total UK energy consumption[7], and equivalent to 92% of energy consumption per capita in the UK.

Water resource consumption: Freshwater is a renewable natural resource comprising rivers lakes, groundwater, and reservoirs. However, an increasing amount of financial and environmental costs from the development of new resources in Taiwan has put pressure on this resource. The demand for water has increased year by year. The reduction of water wastage a goal of sustainable building achievable through better design and installation of low-water-use equipment.

Abiotic resource depletion: This is the extraction of non-renewable products. Objectives are to reduce the use (but increase the efficiency of use) of the abiotic resource to minimise environmental damage from abiotic resource extraction. The majority (82.1%) of minerals used in Taiwan are imported (EPA 1997a, p. 281). A wide range of abiotic resources are used in building construction including aggregates

[7]Total consumption of energy in the UK is 150 MTOE (DOE 1996, p. 46).

for concrete, limestone for cement, clay shale and slate for bricks and tiles, and minerals for steel and aluminium doors. An aim is to minimise this use and wastage.

Use of recycled materials: A wide range of recycled materials can be used by the building industry to minimise the use of raw materials. The key sustainable development objective is to maximise the use of recycled material. The most commonly used recycled materials are from demolitions (e.g. bricks), are products containing over 10% waste, and by- product materials (e.g. waste and pulverised-fuel ash). Some demolition materials, or by-products, can be used as aggregate for lightweight walls.

Solid waste disposal: Solid waste is produced during the lifecycle of the building. The greatest volume is generated through construction and demolition. For example, 20 millions tonnes of solid waste resulted from the demolition of a building after the earthquake of 21 September 1999 in Taiwan. The key sustainable development objective for solid waste from the building sector is to minimise the amount of waste produced, and to make best use of the waste whilst minimising pollution.

Land use: A consequence of the spread of urban development is the loss of rural land and ecological disruption. Recently there have been increased concerns about travel demands and the negative impact this has on the environment (e.g. high levels of energy consumption) (Figure 3-3). The exponential increase in gasoline use as urban density falls, especially below 30 people per hectare (Roelofs 1996, p.89). A key sustainable development objective is to avoid further reducing the ecological value of a site through the re-development of urban land so reducing the pressure on the countryside. Re-development also helps maintain the vitality and viability of urban areas.

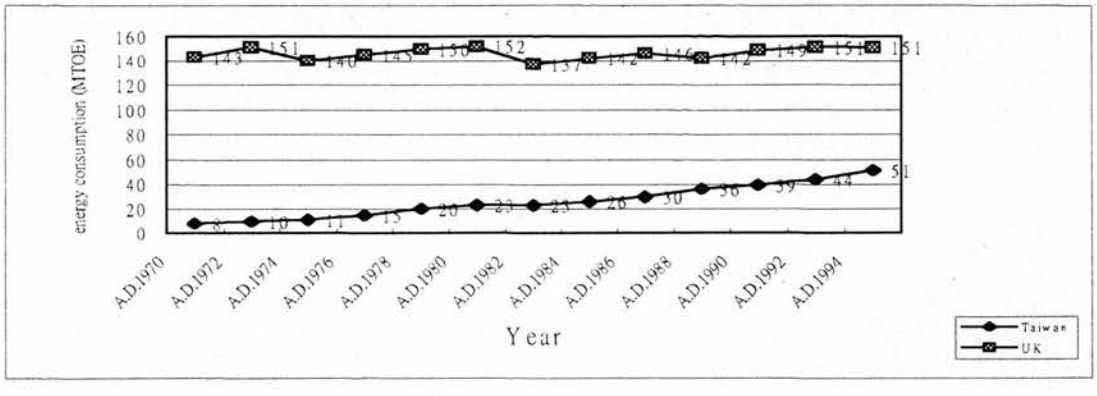
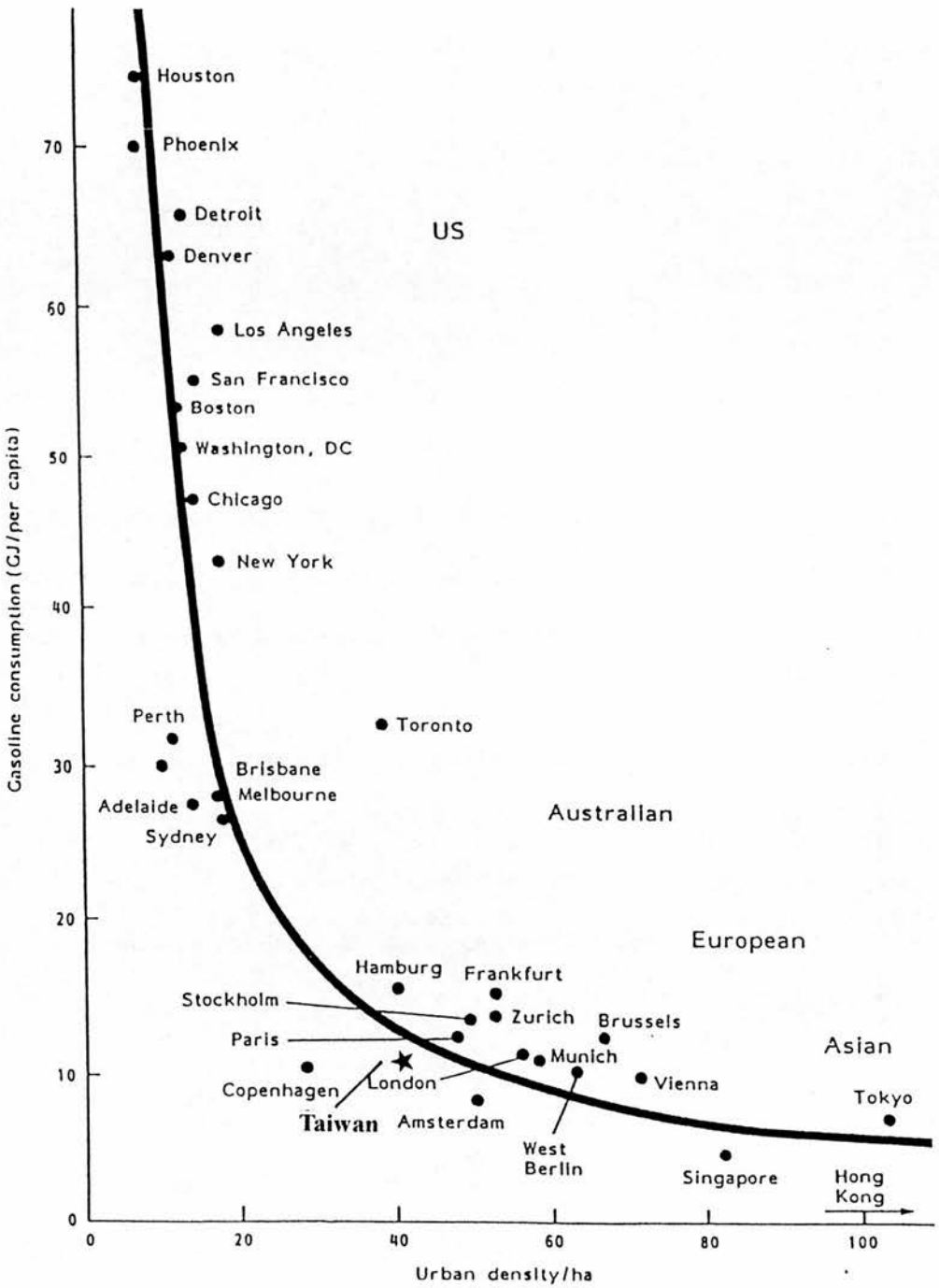


FIG. 3-2: Comparison of final energy consumption of Taiwan and UK



Note: gasoline consumption in Taiwan is based on energy consumption of 1995

Data source: Newman, Peter 1991, Quoted in Roelofs, Joan, 1997, p.89

FIG 3-3: Urban Density and gasoline consumption in 31 cities of the developed world

Table 3-4: Evaluative framework of natural resource depletion

Theme	Content	Effect Index	Unit
Energy consumption	Consumption of power, natural gas & fuel, etc.	Consumed energy amount of every floor area (m^2)	kcal
Water consumption	Consumption of water	Consumed water volume of every floor area (m^2)	m^3
Abiotic depletion	Consumption of Pb, Hg, Cd, copper, tin, zinc	Abiotic depletion potential (ADP)	kg
Use of recycled materials	Use of demolition materials product containing over 10% waste	Consumption amount	kg
Solid waste disposal	Produced volume of waste	Required area of landfill for every floor area	m^2/m^2
Land use	Use of land	Required land area for every floor area	m^2/m^2

II. Minimising damage to environmental carrying capacity: Minimising the damage to the carrying capacity of the environment is a second sustainability performance for of high-rise buildings. The evaluative framework is concerned with the negative impacts on the environment as a result of building practices. The provision and use of high-rise buildings has a great impact on the carrying capacity of the environment. These impacts are caused by the emissions of pollutants and a high-energy consumption. The aims of this framework is to ensure the development and use of a building is in harmony with the natural environment, and that the damage to the carrying capacity is minimised.

Environmental concerns are at a national and global level, and include climate change, acid rain, ozone layer depletion, photochemical oxidant formation, eutrophication, toxicity, atmospheric pollution, and waterborne pollution.

Climate change: An increasing amount of greenhouse gases in the earth's atmospheric leads to rising levels of absorption of radiation energy, and ultimately to an increase in temperature (Huppes *et al.* 1996, p. 17.32). The evaluation criteria are referred to as the global warming potential (GWP). CO_2, N_2O, CH_4, CFCs and HcFcs all contribute to global warming. The key sustainable development objective is to reduce the emissions of greenhouse gases.

Acid precipitation: Acid deposition will lead to a change in soil and water acidity which affects the flora

and fauna, damages buildings, and affects humans. The main acidifying pollutants are sulphur dioxide (SO_2) and nitrogen oxides (NOx). Evaluation criteria are referred to as the acidification potential (AP). Key sustainable development objectives are to reduce the emission of acidifying pollutants.

Table 3-5: Evaluative framework for carrying capacity

Theme	Content	Equivalency factor	Equivalency substance	Unit
Global warming	Emission of greenhouse gases	Global warming potential (GWP_{500})	CO_2	kg/kg
Acid rain	Emitted acidifying substances	Acidification potential (AP)	SO_2	kg/kg
Ozone layer depletion	Emission of ODS	Ozone depletion potential (ODP)	CFC_{11}	kg/kg
Photochemical oxidant formation	Emission of potential substances	Photochemical oxidant creation potential (POCP)	ethylene	kg/kg
Nutrification	Emission of nutrient	Nutrification potential (NP)	PO_4	kg/kg
Human toxicity	Emission of toxic substances	Human toxicity (HC)	human body	kg/kg
Atmospheric pollution	Emission of air pollutants	Critical dilution volume (air)	SOx	m^3
Waterborne pollution	Emission of waterborne pollutants	Critical dilution volume(water)	BOD	m^3
Ecotoxicity, aquatic	Ecology in the water, emission of toxic substance	Ecotoxicity aquatic (ECA)	water	m^3/kg
Ecotoxicity, terrestrial	Ecology on the land, emission of toxic substance	Ecotoxicity terrestrial (ECT)	soil	M^3/kg

Ozone layer depletion: Depletion of the ozone layer has lead to an increase in the amount of ultraviolet light reaching the earth's surface which has been linked to the increased risks of skin cancer, a reduced crop yield, and a detrimental influence on ecosystems. The ozone-depleting substances (ODS) are CFCs, HCFCs and halons. The evaluation criteria are the ozone depletion potential (ODP), and the key sustainable development objective is to reduce the atmospheric emissions of substances causing the stratospheric ozone depletion.

Photochemical oxidant formation: Reactions of NOx with volatile organic substances in ultraviolet light lead to the formation of photochemical oxidants. Photochemical oxidants are methane (CH_4) and hydrocarbons. The evaluation criteria are termed the photochemical oxidant creation potential (POCP), with the reduction of volatile organic substance emissions resulting in photochemical oxidant formation

as a key sustainable development objective.

Eutrophication: The addition of nutrients to the water and soil increases biomass production. This in turn results in a reduction in the oxygen concentration, which effects higher organisms like fish. This may lead to a shift in species diversity in an ecosystem being a threat to biodiversity. The compounds involved in eutrophication are nitrogen containing substances (e.g. ammonia), phosphates and organic material (Huppes *et al.* 1996, p. 17.32). The evaluation criteria are the nutrification potential (NP), and the key sustainable development objective is to reduce the effluence of substances which cause eutrophication.

Human toxicity: Exposure of humans to toxic substances results in health problems. Exposure can occur through the air, water, or soil, and especially via the food chain. Toxic substances produced from building development include cadmium (Cd), carbon dioxide (CO_2), CFC_{12}, lead (Pb), nitrogen oxide (NOx), and sulphur dioxides (SO_2). These evaluative criteria are referred to as human toxicity (HT). The sustainable development objective is to reduce the causes of human toxicity.

Aquatic and terrestrial ecotoxicity: The exposure of flora and fauna to toxic substances also results in health problems. Ecotoxicity occurs in the water (aquatic ecotoxicity) and the soil (terrestrial ecotoxicity). The main toxic substances generated from building are lead and mercury. These evaluative criteria are either ecotoxicity of aquatic (ECA) and ecotoxicity of terrestrial (ECT) ecosystems. The key development objective is to reduce the substances of ecotoxicity.

Atmospheric pollution: Air quality in Taiwan is classified as 'good', 'moderate', 'unhealthy', 'very unhealthy', or 'hazardous' according to the pollutant standard index (PSI). Although unhealthy, very healthy and hazardous levels occur less than 10% of the time, ground-level ozone concentrations are high in the summer due to the hot weather. The concept of critical dilution volume applies here (details in Chapter four). The key sustainable development objective is to reduce emissions of air pollutants.

Waterborne pollution: In Taiwan, about 30% of the rivers are classified as polluted due to discharges of municipal sewage and industrial wastewater. This also comes under the concept of critical dilution volume. The key sustainable development objective is to reduce the discharge of waterborne pollutants.

III. Reducing local impact on community environment

Development must respect environmental quality. All development processes must avoid actions that degrade the environment. Aims are, therefore, to prevent or reduce impacts that result in the degradation of the quality of the environment.

Criteria include noise nuisance, vibration, geology and soil, overshadowing of other buildings and land, local wind effects, and interference.

Noise nuisance: High-rise building, during the construction and operation phases, can cause substantial noise pollution affecting local residents. An increase of 3dB(A) is barely detectable by the human ear, but an increase of 10dB(A) is a doubling of the level of noise. An increase of more than 10dB(A) is classified as major adverse level impact, which should bring proposed mitigation measures in effect.

Vibration: Vibration is generated during construction. It causes appreciable shaking that is described in terms of peak particle movement (Carpenter 1994, p. 160). It is transmitted through (but dampened by) the ground. However, it can be magnified when passing through a flexibly framed building by as much as 65dB, which will influence the sleep of surrounding residents.

Geology and soil: Excavation work for high-rise building construction will cause various impacts from stockpiling, disposal of excess soil, settlement and subsidence, effects on the wildlife, stability of the earth work. Stockpiling requires space and can cause problems with dust and mud. Settlement after

excavation is very serious for surrounding (especially older) buildings. Normally, a number of independent detection devices are used to monitor any movement during building construction providing feedback to control this impact.

Table 3-6 Evaluative framework for local impact

Theme	Content	Effect index	Unit
Noise	Increased level of noise	Level of noise quality	dB(A)
Vibration	Generated level of vibration	Physical impact on human body	dB
Geology and soils	Settlement of ground	Sinking level of the houses near the site	Cm
Overshadowing	Overshadowing of other buildings and land	Effective insolation hours at the winter solstice	hr
Wind fields	Wind hazard from high-rise building	Environment with comfortable wind (<32km/hr) more than 80%	km/hr
Interference	Affected area of blocking electric wave	Interference extent of electric wave	km^2

Overshadowing of other buildings and land: High-rise buildings can cause substantial overshadowing of neighbouring buildings blocking both sunlight and light. The impact of overshadowing will depend on the use of the affected buildings e.g. homes, hospitals, schools, and workshops. The minimum for effective insolation required in Taiwan is more than one hour at the winter solstice.

Local wind effects: A high-rise building, being substantially taller than its surroundings, presents a large wind obstruction deflecting it both horizontally and vertically from its original course (Prior 1993, p. 18). This deflection can cause increased wind speeds near ground level in the area around the building. Consideration of this is a condition of the design. Wind nuisance depends on how frequently uncomfortable and dangerous wind levels are reached in pedestrian areas. In Taiwan, a high-rise building over 100 metres is required to conduct a wind tunnel test.

Interference: High-rise buildings will interfere with television and radio reception by blocking the path of transmitted signals, and can affect an area of several hectares. This impact has to be checked during the EIA process.

IV. Promoting quality of life

Promoting a good quality of life is an objective for sustainable development. Socio-economic impacts from high-rise buildings are a result of the interaction between the characteristics of the proposed project and host environment. An analyst must assemble baseline information for both these sets of characteristics.

A consideration of socio-economic impacts clarifies the type, duration, spatial extent, and distribution of impacts. Concerns regarding the quality of life consist of social, economic environment, public facility, traffic, community culture, and ecology and landscape impacts.

Social environment impacts: The result of changes in community population. The development of new settlements may have implications on the life style of a local community. The introduction of high-rise buildings, with a construction stage involving the employment of several hundred local people over a number of years, may be viewed as a serious threat to the quality of life.

Economic environment impact: High-rise buildings, during the construction and operation phases, will have direct economic impacts. Direct employment on a proposed project will generate expenditure on local services (e.g. for petrol, food, and drink). The ratio of local to non-local employees on a project is often a key determinant of many subsequent impacts. A project with a high proportion of immigrant labour will have greater implications for the demography of the locality. In addition to changes in local employment, major projects have a range of secondary or indirect impacts e.g. land-use change of neighbouring land, or fluctuations in land prices.

Public facility: A high-rise building project, during the construction and operation phases, with a high proportion of in-coming labour will result in a population increase. This will put an increased demand on local public facilities such as schools, parks, and general local infrastructure.

Traffic impact: It is implicit that success in planning many high-rise buildings will depend on their attention to the car user e.g. large department stores and restaurants. Impacts of traffic include driver delay, degraded conditions of the roads, parking impact, pedestrian delay, accident and safety of the locality, and air quality etc.

Community culture: A project with a high proportion of immigrant labour will have great implications on the local demography. There will be increase an in population affecting local services. A new high-rise building may involve a thousand people, which may alter the lifestyle of the community so affecting local culture.

Ecology and landscape: Landscape is inextricably linked to ecology and ecological quality. Ecology is a broad and complex discipline that aims to assess the conservation value of species and communities within the impact area of a development. It assesses the likely impacts of the development, and the mitigation measures that need to taken on to avoid or minimise these impacts.

Table 3-7: Evaluation criteria for socio-economic impact for the effectiveness of the EIA system

Index Group	Item	Content	Effect Index	Unit
Structure of community population	Total number of population	Distribution & immigration of population	Proportion of population	%
			Increasing rate of population	%
	Characteristics of population	Change of the structure of population	No. of household	People
			Age range	%
			Rate of nourishment	%
Economic change	Structure of industry	Distribution & structure of population in each industry	Population of industry	%
			Structure of industry	%
			Working population	%
	Land application	Change of land application & variation of land price	Compatibility of land application	+/-
			Variation of land price	%
	Economic change	Change of averaged income	Averaged income for each person	NT
			Averaged income for each family	NT
Public Service Facilities	Public facilities	Change of supply & demand for school facilities	Primary school	M^2/people
			High school	M^2/people
	Public equipment	Increased & decreased park areas	park	M^2/people
		Supply & demand of every public equipment, treatment of trash	Water, power, telecommunication	+/-
			Transporting of trash	+/-
			Treatment waste water	+/-
Traffic impact	Traffic transportation	Level of service (LOS)	LOS on the road	LOS
			LOS at the intersection	LOS
		safety	Rate of accident	Case/year
	Parking facilities	Supply & demand of parking space	Rate of supply & demand	%
	Community safety	Fire-fighting & health care facilities	Fire-fighting facilities	+/-
			No. of beds in the hospital every 10,000 people	Beds
			No. of doctors every 10,000 people	People
Community culture	Community culture	Change of life style	Life style	+/-
			Structure of community	+/-
	Cultural heritage		Historic architecture	+/-
			Ancient site	+/-
			Faith	+/-
Ecology and land scope	Ecolgy	Ecological impact		+/-
	landscape	Land impact		+/-

Note: +/- refers to positive (+) or negative (-), abundant (+) or insufficient (-).

Table 3-8 : The criteria of evaluation of effective EIA in policy dimension

I Aspect of legal regulation

a. legal basis

- EIA system is prescribed in the law
- EIA process is clearly prescribed in the law
- role of environmental agency is clearly prescribed in the law
- limitation of time in EIA process
- penalties are stated clearly in the law
- Guideline assists EIA practice

b. administrative organisation

- role of each authority is clearly prescribed in the law
- adjustment of man-power related authority
- EIA system is stability

c. application of SEA system

- application of SEA is prescribed in the law
- coverage of SEA contains PPPs with significant impact on the environment
- SEA process is clearly prescribed in the law
- Guideline for application of SEA procedure

d. EIA report

- content of EIA report is clearly prescribed in the law
- evaluation of EIA consultant
- preparation of untruth information will be penalised
- procedural review
- guideline for preparation of EIA report
- public participation during preparation of EIA report

I. Aspect of procedure

e. screening process

- coverage of EIA includes proposal of public and private sectors
- screening process is clearly prescribed in the law
- development project with significant impact should conduct EIA
- criteria or threshold for screening process
- appeal avenues

f. scoping process

- scoping process is clearly prescribed in the law
- scoping process need to consult with related authorities
- scoping process with public participation
- appeal avenues

- items of scoping are clearly prescribed
- guideline for scoping process
- all reasonable alternatives are required

g. EIA review

- review process is clearly prescribed
- review process with public participation
- independent advisory body conducts review process
- criteria for identifying adequacy of EIA report
- result of review will be published
- appeal avenue

h. monitoring and auditing process

- Monitoring and auditing are required in the law
- roles of related authorities are clearly prescribed
- findings of monitoring and auditing are open
- ameliorative proposal is required if monitoring indicates the need for it
- result of monitoring will be applied for prediction techniques
- monitoring process starts in early stage

III. Aspect of decision making

i. alternatives

- alternatives include no action, location design, goal alternatives
- assessment of alternatives in earlier stages
- alternative is required in the law
- guideline for consideration of alternative
- strength and shortcoming of all alternatives should be stated in the EIA report

j. mitigation measures

- mitigation measures is required in the law
- guideline for consideration of mitigation measure
- mitigation measure is required in each stage

k. assist in decision-making

- advisory body or committee help decision maker to review EIA report
- advisory body or committee is independence and neutrality
- role of advisory is clearly prescribed in the law
- advisory body with professional ability
- decision with reason will be published
- decision can not be taken prior to EIA report reviewed

Note: for part of criteria refer to Wood 1995

Table 3-9 : Evaluation criteria for effectiveness of EIA in practice dimension

I. Implementation process

l. procedure compliance

- effectiveness of screening procedure
- effectiveness of scoping procedure
- adequacy public participation
- effectiveness of EIA report review
- sufficient presentation of alternatives
- sufficient presentation of mitigation measures

m. Time and cost

- EIA implementation procedure meet for time requirement
- rationality of the integral time of EIA process
- rationality of EIA cost for each individual case
- rationality of environmental protection cost
- sufficient human resource of implementing EIA

II. Decision making control mechanism

n. decision making procedure

- policy makers take EIA review conclusions as an important reference to decision
- publication of decision and reasons of policymakers

o. decision making control mechanism

- public and outside group control mechanism
- judicial control mechanism
- professional control mechanism
- procedure control mechanism
- EIA process conducted at the early stage of the planning phase

III. Enforcement monitoring

p. implementation of mitigation measures

- mitigation measures conducted fully
- implementation of environment management programme
- surveillance performed by related authorities

q. implementation of EIA report review conclusions

- conclusion of EIA report review
- ameliorative was required if monitoring indicates the need for it
- results of project monitoring and surveillance have been applied to future

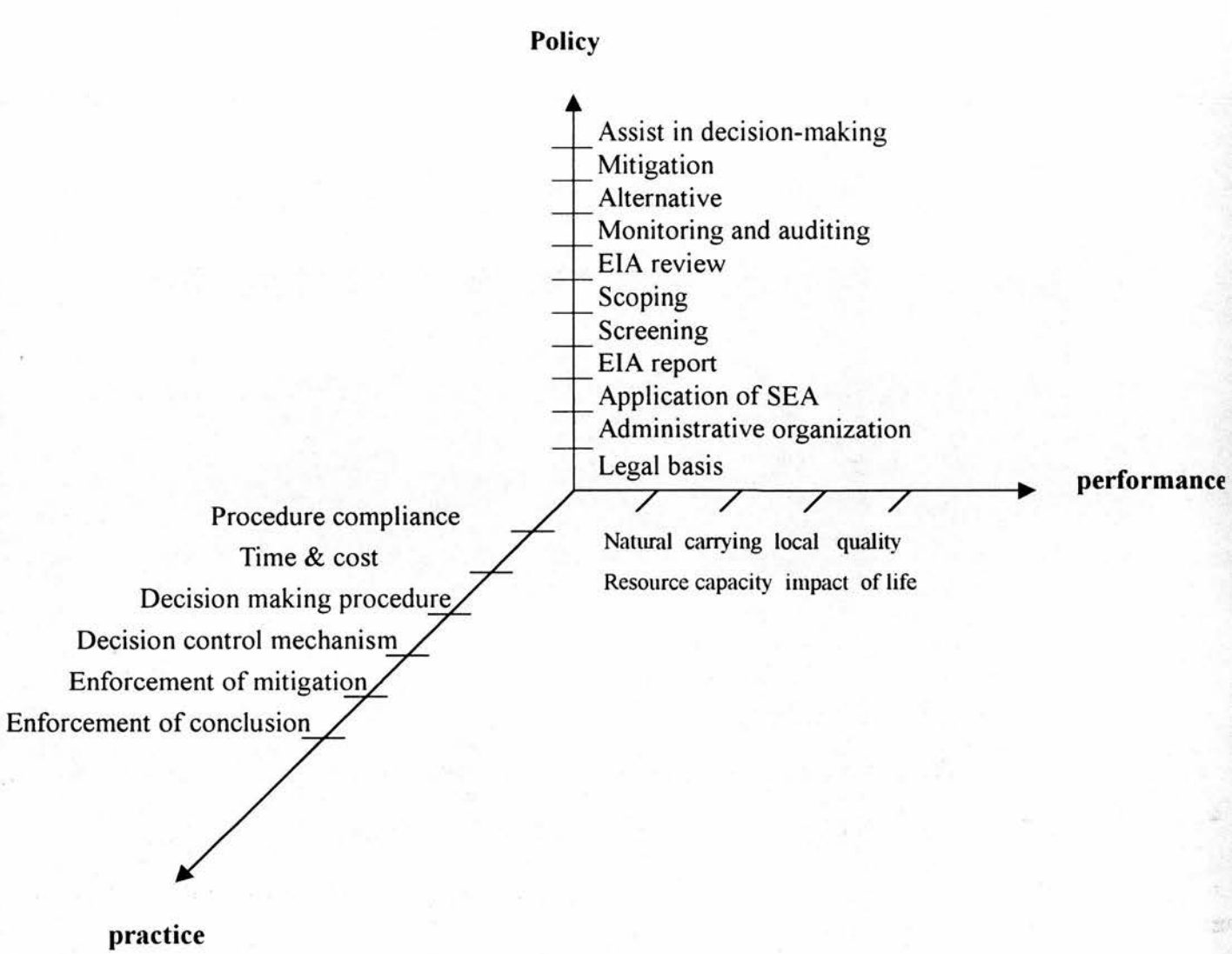


FIG. 3-4: The Dimension of Evaluative Framework

3.6 Summary

In this Chapter, the potential effects of the EIA have been examined. Five effectiveness review methods have been summarised. This enables a definition for the effectiveness of an EIA system to be provided. Finally, an evaluation framework can be developed allowing an analysis of the effectiveness of an EIA; this is the basis of this thesis.

Factors reducing the effectiveness of an EIA system include:

- technique types (environmental assessment approach, use of information, insufficient environmental data, inadequate assessment method)
- the EIA process and procedure (different EIA processes affect procedural design, which influences effectiveness e.g. timing of public participation and EIA review)
- the decision-making culture and circumstance (i.e. the relationship between decision-making characteristics and EIA effectiveness e.g. is the decision public and accountable? What elements affect decision-making?)
- and the organisational aspect (i.e. the participating body directly affects effectiveness).

Other factors include the initiator, consultants, competent and environmental authorities, advisory bodies, the public, courts and legislation.

There are five evaluative types used to determine the effectiveness of an EIA:

- evaluation of the EIA system - this examines the system itself as well as EIA procedures. The institutional framework and procedural characteristics (including EIA timing, the element of EIA process and procedure, possibilities for public participation and legal system) are evaluated.
- evaluation of the quality of an EIA report - this focuses on the adequacy and sufficiency of the report
- evaluation of decision-making control mechanisms - this analyses and determines influential factors

during the decision-making process e.g. procedural, evaluation, judicial, development aid agency, professional, direct public and outside group controls

- evaluation of EIA project performance - this evaluates the performance of an EIA using the post-project analysis approach, generally single-focus implementation and follow-up studies. Analysis of major development proposals occurs at various stages; during the EIA process, after approval, under construction, or upon completion and are occupied. The evaluation of the sustainability of an EIA case, or an evaluation of the "life-cycle" of a case are two examples.
- and the effects of monitoring and auditing - this examines prediction methods as well as determining the effectiveness of assessment techniques and suggesting methods of improvement.

These five evaluation approaches are interrelated as each type overlaps with another.

This research defines an effective EIA as one that can improve the quality of the decision-making from a sustainable development perspective, runs a smooth consent procedure, produces acceptable decisions, raises environmental awareness, conditions of approvals must be enforceable, and the EIA process must be designed to facilitate implementation. Based on this, an evaluation framework for the effectiveness of an EIA can be established using evaluation criteria from three dimensions: policy, practice and performance. The policy dimension evaluates the EIA system and procedure i.e. evaluates what is required. This includes legal regulation, procedural, and decision-making aspects. The practice dimension indicates what actually happened i.e. evaluates the implementation of the EIA case. This covers the implementation process, decision-making control mechanisms and monitoring enforcement. The performance dimension examines results and outputs i.e. evaluates high-rise building performance according to the EIA. The evaluation framework is in compliance with high-rise building performance, including the use of natural resources, damage to carrying capacity local impact, and socio-economic environmental impact. The use of natural resources includes energy consumption, abiotic resource depletion, and the use of recycled materials, solid waste disposal, and land use. Physical environmental

impacts deal with global issues, such as global warming, ozone layer depletion, and acid rain. Each criterion is inextricably linked with sustainable development goals. An ideal model of sustainable impact assessment (SIA) will be constructed in next chapter.

CHAPTER FOUR: ESTABLISHING IDEAL MODEL OF SUSTAINABLE IMPACT ASSESSMENT

4.1 IDEAL MODEL OF SUSTAINABLE IMPACT ASSESSMENT

4.1.1 A Sustainability-Led Approach to EIA

Sustainability can be assessed using the carrying capacity model. The carrying capacity concept has long been applied by ecologists and in wildlife management. Initially it aided discussion on the natural environment and the numbers of animal populations sustained and supported by an ecological system. Through advancements in the field of ecology, it now applies to the operation and management of the relationship between species and their habitat.

After modification, the carrying capacity concept enables the interactive relations between humans and their environment to be measured indicating the sustainability of a region. The idea of carrying capacity has also been adopted by land planners and is used to explore the supply-demand relationship between the population, resources and public facilities in a particular region (Cheng 1996, p.2). Mayhew (1997, p.408) regarded the carrying capacity as being the maximum potential number of inhabitants that could be supported in a given area. The sustainability of carrying capacity refers to the bearable extent of population growth or substantial development, provided no significant damage occurs to the environmental system.

Carrying capacity is not a static quality. It changes with additional (external) pressures on environmental resources, with variations in life styles, scientific technology, and substantive facilities. In general, the carrying capacity will be affected by the following factors:

- the region e.g. a watershed

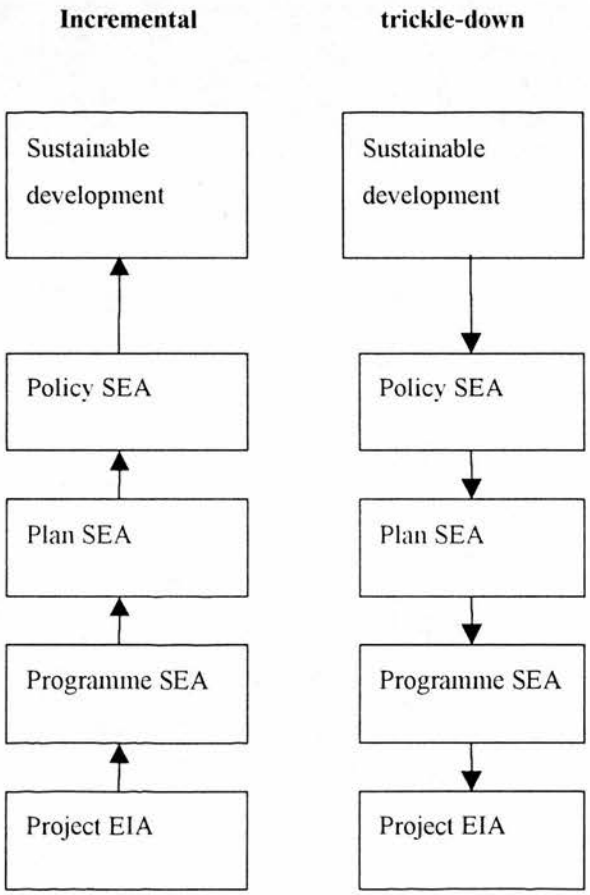
- type of resource e.g. water, energy, the resource limiting population growth
- what is being 'carried' e.g. human population, noxious gas emission
- whether the resource is assumed to be constant or is changing over time, and if it is renewable or not
- whether what is being 'carried' is assumed to be constant or not
- value judgements e.g. ideal/optimum capacity versus maximum/minimum capacity (Therivel, *et al.* 1992, p. 125)

Therefore, in the approach to sustainability development actions should not exceed the carrying capacity. To ensure this, the use of resources and the environmental status quo must be thoroughly analysed. When development projects exceed the maximum limitation of the carrying capacity, alternatives and mitigation measures have to be proposed and their environmental impacts analysed. These procedures are an intrinsic part of the EIA system. Therefore, a sustainability-led EIA system should further expand to the 3Ps in order to move towards sustainable development.

The trickle-down system, as previously indicated in Figure 4-1, is a smoother path to sustainability. Key features are:

- commitment to the objective of sustainability
- determination of the parameters within which sustainability is to be achieved (e.g. area, resource, use, time, and expected 'level' of sustainability
- determination of carrying capacity based on above (e.g. CO_2 emissions)
- SEA of all the 3Ps affecting the environment, and alternative development scenarios which do not exceed the carrying capacity
- EIA of individual projects within the constraints set by SEA
- monitoring programmes to provide feedback allowing any or all of the above to be adjusted (Therivel et al. 1992,pp.125-126).

To conclude, the sustainability-led EIA system assesses environmental impacts as well as the depletion of resources. It assesses and analyses alternatives and mitigation measures once the maximum limitation of the carrying capacity is reached so the main targets for sustainable development can be achieved and maintained.



Data Source : Glasson, et al., 1994, p.312, Figure 13.5

FIG. 4-1: Incremental vs. trickle-down SEA systems

4.1.2 Concept of Sustainable Impact Assessment (SIA)

Concept of sustainable impact assessment (SIA) is to evaluate impact concerning on sustainable development resulted from a certain development action. Consequently, assessment targets should

include proposals of policy, plan, program and project, etc. Fig. 4-2 indicates that concept of SIA combines approaches of SEA, EIA and LEIA and applies to urban development. Environmental impact assessment is conducted from the structure plan on the top and the city development policy is aimed, based on the idea of sustainable development. Then, a local plan is drawn up in compliance with the idea of sustainable development. On the other hand, various plans (such as land use plan, traffic plan, zoning plan and public facilities plan, etc.) are subject to the structure plan, which is served as the highest guideline. As a result, all plans derived from the local plan cannot exceed the carrying capacity determined by the structure plan and the principle of SEA should be based on it, too. EIA of development investment programs of each individual sector, such as construction program of public facilities and traffic improvement program, etc. is to be conducted next. The guiding principle of SEA at this level should comply with those constraints set by the local plan. Next stage is the development projects of each site, whose EIA adopts the LEIA system, i.e. from-cradle-to-grave approach, as Fig. 4-3 shows.

FIG. 4-2: Chronological sequence of actions of urban development

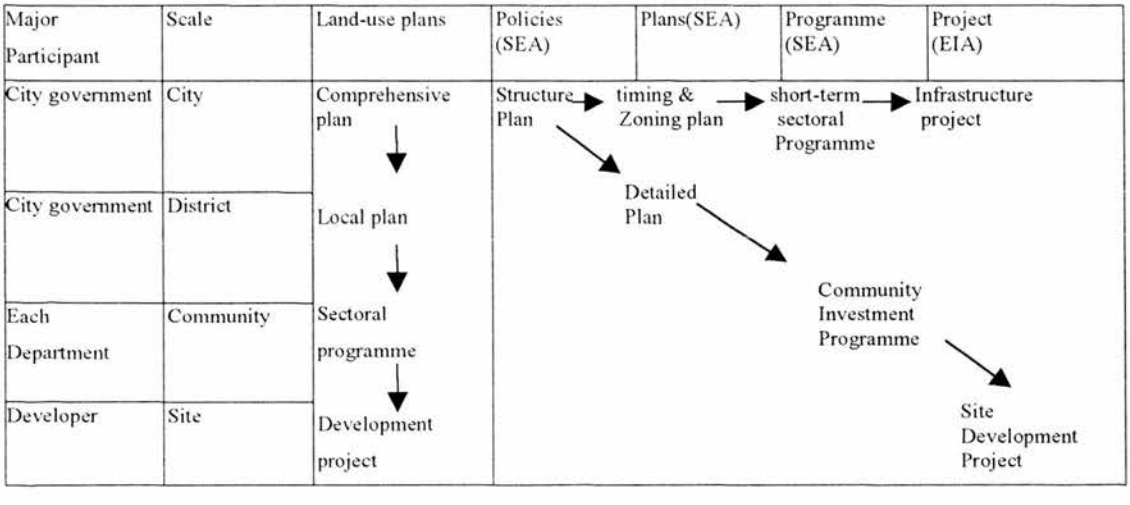


FIG. 4-3: the Concept of SIA for urban development action

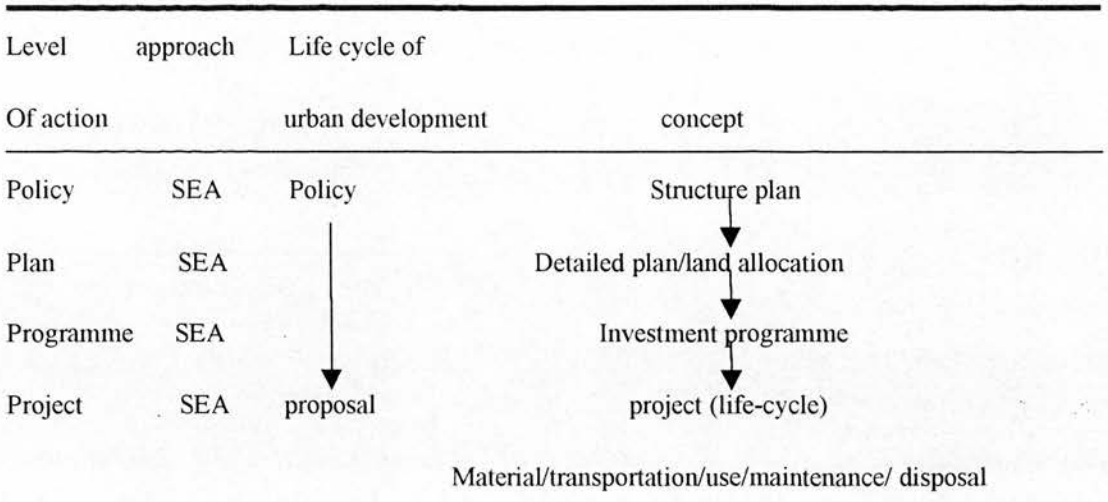


Fig. 4-4 reveals the overall flow of SIA. During the SEA process of the structure plan, urban policies should be reviewed with sustainability criteria first in order to inspect if urban policies follow the principle of sustainable development. Then, suitability of each planned district in details can be reviewed through urban carrying capacity for the primary analysis of characteristics and potentiality of development for each district. At last, the EIA process of 3 Ps is to be conducted. We can realize from Table 4-1 that environmental issues to be assessed at each level of EIA are not the same. For SEA of the structure plan, assessed goals are emphasized on the impact upon the international environment treaty, depletion of resources and socio-economic environmental impact items. However SEA of the detailed plan stresses assessment of urban carrying capacity in addition to resource depletion and socio-economic impact. As for SEA of the investment program in the community, EIA items for each site development project consist of resource depletion, carrying capacity, local environment and socio-economic environmental issues, etc.

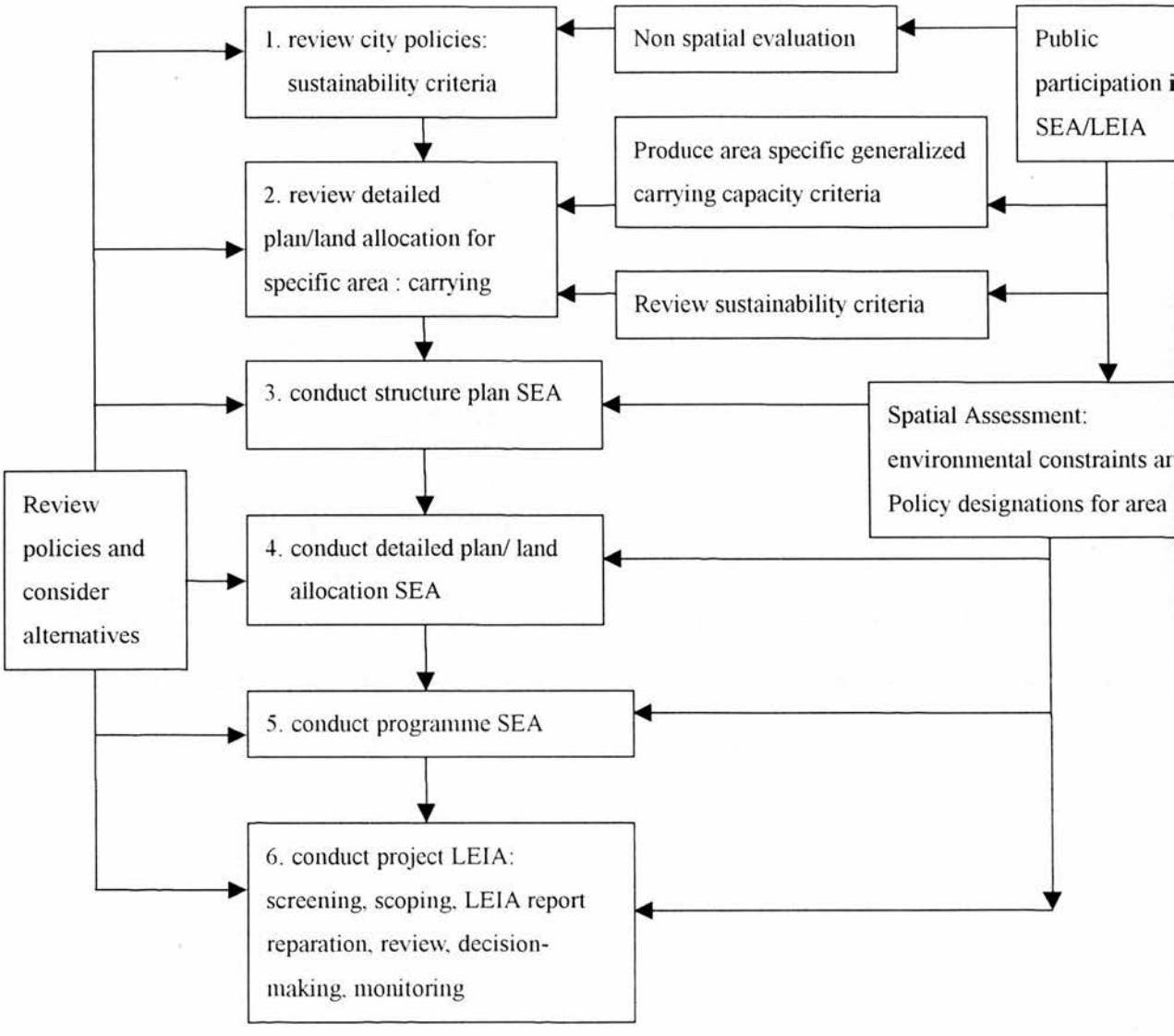


FIG. 4-4: Overall Procedure of SIA

Table 4-1: Environmental Impact Matrix of SIA

	Environmental theme	Structure plan	Detailed plan	Investment programme	Development project
Resource depletion	Energy depletion	×	×	×	×
	Water resource consumption	×	×	×	×
	Abiotic resource depletion		×	×	×
	Use of recycle material			×	×
	Solid waste disposal		×	×	×
	Land use	×	×	×	×
Carrying capacity	Global warming	×	×	×	×
	Acid rain potential	×	×	×	×
	Ozone depletion			×	×
	Photochemical oxidant formation				×
	Nutrification potential				×
	Human toxicity				×
	Atmospheric pollution		×	×	×
	Waterborne pollution		×	×	×
	Ecotoxicity of aquatic				×
	Ecotoxicity of terrestrial				×
Local environmental	Noise nuisance			×	×
	Vibration			×	×
	Geology and soil		×	×	×
	Overshadowing				×
	Local wind effects				×
	Interfere wave				×
Quality of life	Community population	×	×	×	×
	Economy	×	×	×	×
	Public facility	×	×	×	×
	Traffic impact	×	×	×	×
	Community culture	×	×	×	×
	Ecology and landscape	×	×	×	×

4.2 PROCEDURAL FRAMEWORK FOR SIA

Procedures of SIA include SEA process of the urban plan and LEIA process of the development project. SEA process consists of definition of objectives, scoping, consideration of alternatives, impact assessment, recommendation, review, decision and monitoring. Whereas, LEIA process of the development project includes seven items, which are screening, scoping, LEIA report preparation, improvement, review, decision-making and monitoring. SEA process will be fully explained and described in the next section and LEIA are going to be discussed in the following four sections(see Fig 4-6). The procedures and contents of screening, LEIA report preparation, review, decision-making

and monitoring are identical to those in the EIA system. So, this chapter will only describe scoping, LEIA report preparation and improvement. LEIA report preparation will mainly focus on inventory analysis and the assessment of life-cycle environmental impacts.

4.2.1 Methodologies for SEA

As methodologies for SEA are not well developed and a common knowledge has not been reached as well, for procedural and methodological sake, some people consider EIA process can be applied; whereas, other people think another set of different procedures and methods should be set up since SEA for policy, plan and program is different from that of EIA concerning features, time and contents (Therivel et al. 1992, P. 143). The development type of land use will be utilized as the basis of drawing up methodologies in this section. Consequently, process and methodologies mentioned in this section are targeted for land use development application only.

Figure 4-5 indicates SEA process for the structure plan, detailed plan and investment program, which consists of the following steps.

- define objectives / identify the constraints
- define the scope of the SEA: establish boundaries, analysis units, physical limits, carrying capacity
- consideration of alternatives: set up an environmental database, alternative
- analyze environmental impacts / possible mitigation measures: impacts evaluation and synthesis
- recommendation: propose recommendations, prepare an SEA report
- review
- decision / announcement: weights up the cost and benefits
- implementation and monitoring / feedback
- evaluation the plan / program

As the system of the city planning includes three levels of plans and programs and contents of plans of each level differ from one another, focused points during SEA process vary as well. SEA for the structure plan includes land use, traffic plan, public security, natural resources, public facilities and socio-economic impacts, etc. Nevertheless, SEA for detailed plans and land allocation is concerned with land use, development intensity of the project, public facilities, environmental quality, traffic plan, reserved and open space, community characteristics, economy and financial situation etc. Besides, SEA for investment program covers depletion of resources, public facilities, development project, noise & air quality, cultural resource and landscape project, etc.

As for the environmental themes to be assessed during SEA process, evaluation items include depletion of natural resources, carrying capacity, local environmental impact and social-economic environmental impacts, etc.

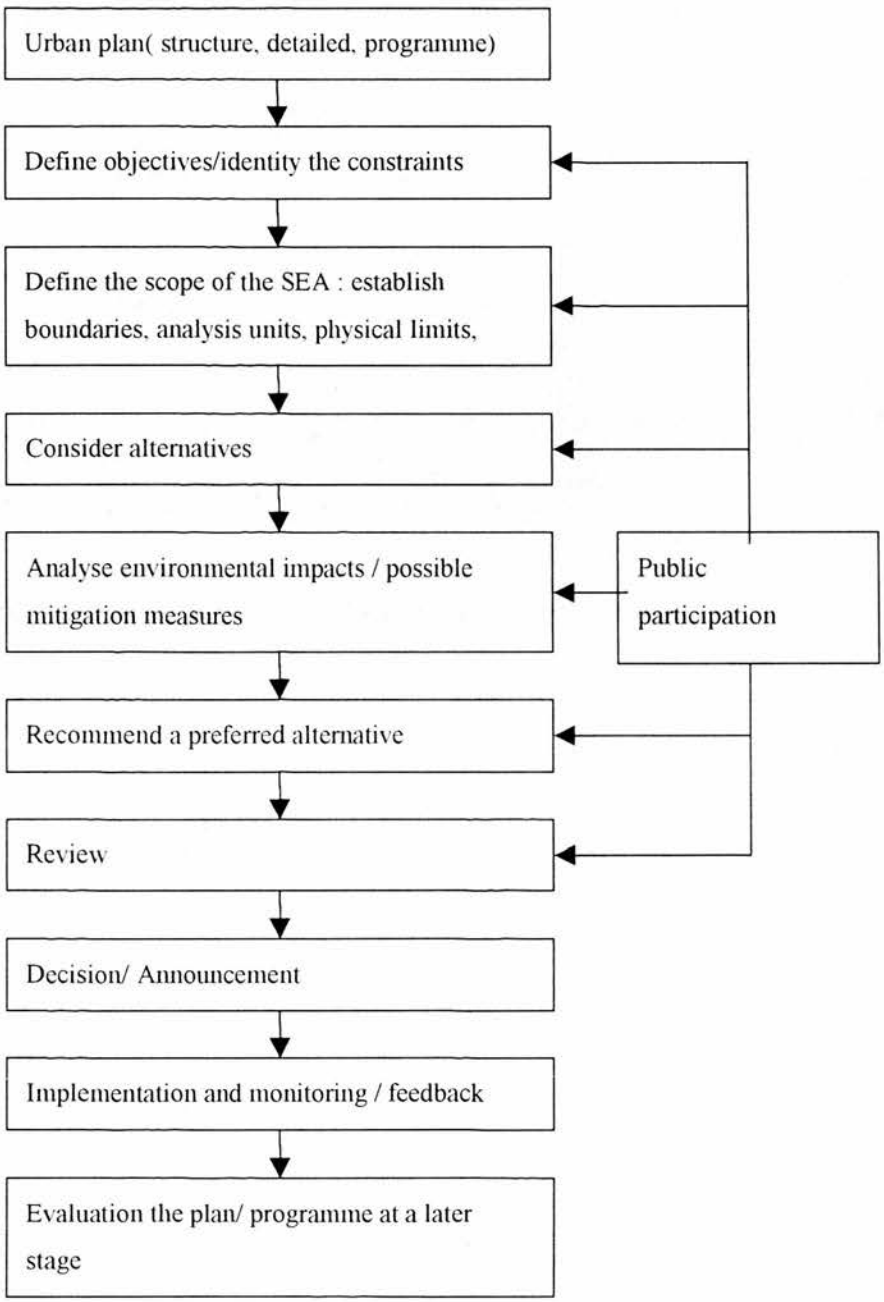


FIG. 4-5: process of SEA within SIA

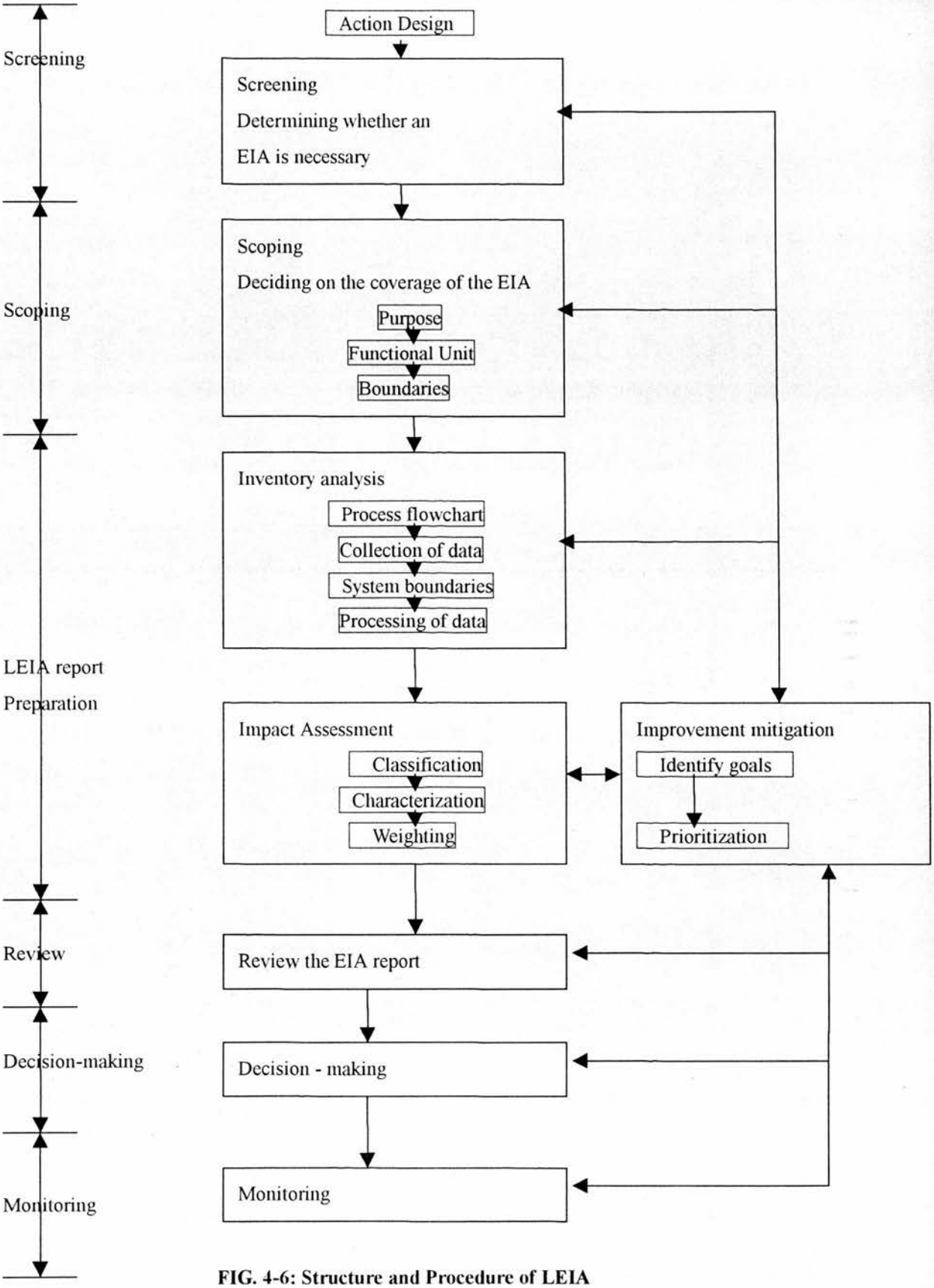


FIG. 4-6: Structure and Procedure of LEIA

4.2.2 Scoping

The purpose of scoping in the LEIA system is to determine the significant issues relating to a proposed action and its alternatives and to provide channels of communication and coordination for environmental protection groups, individuals and relevant organisations in order to promote the quality and credibility of assessment reports. As a result, its major goals are to identify the coverage of issues to be addressed in the LEIA report; to decide on which investigative, predictive, analytic and assessment methods to be adopted; and to ascertain which alternatives require further assessment.

According to ISO 14040, the first phase of LCA is goal and scope definition. Consequently, the following issues need to be identified during this stage:

- The purpose of conducting a LEIA of the development activity;
- The identities of the initiator, the target group, affected groups and residents;
- Confirmation of the subject of the study (i.e., its assessment items and functional unit); and
- Confirmation of the scope of the study (i.e., its assessment issues, surveys and analytic approaches) (Huppes et al. 1996, p.17.5).

Scoping is extremely important; it defines the range and area of research, the purpose of conducting a LEIA, the assessment subjects and the research scope, all of which identify the target to which the LEIA is being applied. Meanwhile, the type of information required, and at what level of detail, can be clearly evaluated too. As a result, scoping can establish the range and categories of the assessment system, which is extremely important in conducting a LEIA.

In addition to determining the purpose of the LEIA, the scoping process identifies the study's **functional unit**. This technique of simplifying complicated calculation is required when the choice of production strategy must be selected from several alternatives, as it can show the differences

between them. A functional unit is a directly-given standard parameter, which serves as the basis for comparing equivalent products. It acts as the final output unit of the system as well. For example, to compare different kinds of paint, the functional unit may be defined as $1m^2$ of painted surface over 20 years. Or again, when comparing commercial buildings with different types of structure, the functional unit can be defined as $1m^2$ of gross floor area (GFA). When comparing different products, the functional unit serves as the standard for comparison so, prior to conducting a LEIA, the functional unit must first be made explicit. After specifying the functional unit to be used, various environmental burdens and impacts of pollutant emissions from the product or development activity can then form the basis of calculation and accumulation.

After fixing the goal of the study and its functional unit, the **boundaries** of the research need to be defined. A complete boundary of the life-cycle inventory must include resources, energy depletion and environmental releases over the whole life-cycle of a product or development activity, as we saw in Fig. 2-9. The definition of the boundary is mainly shaped by the goal definition, the process flow chart and the data collected.

There are three steps to defining the boundary. First, the boundary between the assessed project and the environment must be defined. This means considering the materials and energy acquired from the environment as well as the emissions exhausted into the environment, as suggested by the input/output schema of Fig. 2-9. Next, the boundary between the system under study and other interrelated systems must be defined. Some product processes generate other products, by-products, functions in co-products, recycled products or waste treatment, and the boundaries amongst these need to be defined. Finally, the boundary between relevant and irrelevant processes needs to be fixed. This means defining the depth and width of the assessment and defining which impact factors are deemed to be significant and so require assessment (Huppes et al 1996, pp.17.17-8).

4.2.3 Inventory Analysis

There are two important tasks at the report preparation stage - the **inventory analysis** and the **impact assessment**. In this section, we will focus on the former. The data information used in the inventory analysis has to be capable of establishing the various forms and grades of energy and raw material in the industrial system as well as the results of emission into the environment, as Fig. 2-9 indicated. The inventory analysis should aim at the research system and collect relevant quantitative or qualitative information. The collecting procedures vary depending on the scoping of the research assessment, the procedures of the operating unit and the expected applications. Meanwhile, documentation of the reporting process should be undertaken.

Huppes and Dutilh (1996, pp.17.8-25) split the inventory analysis into four parts - the **process flow chart**, **data collection, the system boundaries** and **data processing**. These four parts affect each other. The process flow chart is a series of procedures linked by material flows. The flow chart provides an overview of the procedures relating to environmental interventions. According to Huppes and Dutilh (1996), the process flow chart stage can itself be divided into four parts. To begin, the manufacturing process of the main product is placed at the centre of the flow chart to establish the relevant procedures, steps and main material flow. As the flow chart needs to include the whole life-cycle of the product or development activity, the next step is to extend it to include the previous and succeeding stages of the manufacturing process, e.g. previous stages may include the acquisition and handling of materials and succeeding stages product consumption, recycling and disposal of waste. Next, combine or sub-divide those processes as appropriate. Finally flag up unfamiliar processes or points in the process where information is missing. In sum, the life-cycle process flow chart should include material acquisition, transportation, manufacturing, consumption and post-consumption waste management.

The second part of the inventory analysis is data collection. In order to collect information systematically, a checklist or worksheet is usually devised. A checklist often consists of eight decision areas, including the purpose of the inventory; system boundaries; geographic scope; type of data used; data collection and synthesis procedures; data quality measures; a computational model construction; and presentation of the results (Vigon 1993, pp.25-8). Data collection is a time-consuming task which is divided into input (economic) and output (environmental) flows, as Fig. 4-7 shows. After obtaining the data, it should be checked for completeness and for consistency with other information sources.

	Inflow	**Outflow**
Economic	Raw materials (e.g. steel), services (e.g. transport) energy input (e.g. electricity)	(Semi)final products, by-products and waste
Environmental	Mined or grown raw materials (e.g. energy carriers, plant materials, water)	Emissions to air & water (e.g. CO_2 or BOD) and solid waste dumped

Data Source: Huppes et al. 1996, p.17.12

FIG. 4-7: Schematic Representation of Economic and Environmental Inflows and Outflows

The third step in the inventory analysis is to mark system boundaries. The boundary (or amended boundary) is defined according to the data collected, the results of the flow process of the precious stage, etc. The final stage of data processing can be divided into two steps. First, the output of each operating unit has to be set up so that all comply with the quantitative functional unit previously established, and the output results of each operating unit quantified using the mass balance method. The second step is to accumulate and calculate the standardised data obtained from each system. Meanwhile, the distribution and energy calculations must be attended to as well.

4.2.4 Assessing the Life-cycle Environmental Impact

The task at this stage is transform the outcomes of the inventory analysis into their environmental effects (grouped by theme) so that they are scientifically comprehensible and can be used to describe the importance of the activity's effect on a wider environmental theme. Thus, the assessment task is to systematise and simplify the data amassed in the inventory of environmental issues or impact categories and then transform those impact categories into quantitative indices. Note, however, that there are some impact categories that cannot be quantified, e.g., landscape or aesthetics.

This stage consists of mounting a three-phase LCA conceptual model including **classification, characterisation** and **weighting. Classification** is the process of assigning and aggregating results from the inventory into relatively homogeneous impact categories. These categories are chosen to represent specific issues of interest. SETAC lists four general impact categories: the quality of the environment or ecosystem; the quality of human life (including health); the utilisation of natural resources; and social welfare (Boguski et al. 1996, p.2.28). When classifying, two complications need to be noted. First, that every effect on an environmental theme is usually caused by several different stressors or substances and, second, that a single stressor or substance can affect several different kinds of environmental theme.

The second step of the impact assessment is **characterisation**, i.e.the magnitude of potential impacts on the chosen major categories for each of the subcategories evaluated (Boguski et al.4 1996, p.2.30). Five approaches can be adopted during this stage. First, based on the results of the inventory analysis, the **loading assessment** lists various pollution loadings so that the relative levels of their environmental impact and consumption of resources can be compared. The assumption of this approach is that less quality produces less potential impacts. Second, the **impact equivalency assessment** adopts an impact equivalency factor which is used as the basis for summing up

environmental impacts, aiding the task of comparing items on the inventory list. Third, the **toxicity, persistence and bio-accumulation assessment** identifies specific chemical characteristics and uses them to generate ecological information about individual pollution sources. Fourth, the **generic exposure and effect assessment** simulates the potential impact of each emitted substance based on general health information. Finally, the **site-specific exposure and effect assessment** uses information provided by specified sites to establish the impacts related to those sites (Chang 1998, pp.16-7).

The second and fifth of these approaches (i.e., impact equivalency, and site-specific exposure and effect) are the assessment methods usually adopted for LEIA. The latter is suitable for assessing choice of site, while the former can meet the need to quantify environmental impacts.

The model of **Critical Dilution Volume (CDV)** and the **Dutch system model** are typically used for an environmental impact assessment[1]. The former represents an impact equivalency assessment since it models the dilution of each factor (i.e. pollutant) in the inventory list to meet the legal limitations on each. This method accumulates the CDV of each emitted substance and presents the results of their assessed impact. The CDV can be acquired by dividing the emission volume of pollutant (g) with the standard of quality (g/vol.).

$$\text{Critical Dilution Volume (CDV)} = \frac{\text{emission of pollutant (g)}}{\text{Legal requirements on quality (g/Vol.)}}$$

The advantage of this model is that it shows the results of the EIA amongst different media (e.g.,

[1] The CDV model was developed by the Swiss Federal Ministry for the Environment and the Dutch System was developed by the Center for Environmental Science (CML) in Holland. See Chang, 1998, p.18

water, air, soil). Table 4-2 presents an example of the calculation of the CDV.

Table 4-2: A Calculation of the CDV of Water Pollutants

Stressor	Amount of effluent (g)	Legal water quality (mg/l)	CDV of water (l)
BOD	1	1	1000
COD	1	2	500
SS	1	25	40
Total			1540

The second model - developed by the Centre for Environmental Science (SML) in Leiden University, Holland - is an **effect-oriented assessment model** which uses environmental indices as equivalency factors to measure potential impacts. Environmental impact items include global warming, ozone depletion, photochemical oxidant formation, acid rain, eutrophication, aquatic eco-toxicity, terrestrial eco-toxicity, human toxicity, etc. Table 4-3 lists common substances and their impact on various environmental themes, while Table 4-4 shows the properties of CFC_s, $HCFC_s$, HFC_s and halons.

Table 4-3: Common Substances and their Impact on Various Environmental Themes

Score: Units: Substance:	ADP (-/kg)	EDP (MJ/kg) (MJ/m^3)	GWP (kg/kg)	POCP (kg/kg)	AP (kg/kg)	HT (kg/kg)	ECA (m^3/kg)	ECT (kg/kg)	NP (kg/kg)
Benzene				0.189		3.9	2.9E +04		
Carbon dioxide (CO_2)			1.0						
Carbon monoxide (CO)						0.012			
Chemical oxygen demand (COD)									0.022
Dinitrogen oxide (N_2O)			270						
Hydrocarbons (C_xH_y)				0.377					
Lead (Pb)	1.3E -11					160	2.0E +06	4.3E +05	
Methane (CH_4)			11	0.007					
Nitrogen (kjeldahl nitrogen or N)									0.42
Nitrogen oxide (NO_2)					0.7	0.78			0.13
Phosphate (PO_4^{3-})						4.8E -04			1.0
Sulphur dioxide (SO_2; SO_x)					1.0	1.2			
Copper (kg)	2.9E -12					0.24	2.0E +06	7.7E +05	
Tin (kg)	2.3E -10					0.017			
Zinc (kg)	6.8E -12					0.033	3.8E +05	2.6E +06	
Crude oil (kg)		42.3							
Natural gas m^3)		35.7							

Abbreviations:

ADP Abiotic depletion potential, relative to the worldwide stores

EDP Energy depletion potential, equals energy content

GWP Global warming potential, relative to 1 kg CO_2

POCP Photochemical oxidant creation potential, relative to 1 kg ethylene

AP Acidification potential, relative to 1 kg SO_2

HT Human toxicity, relative to 1 kg human body

ECA Ecotoxicity aquatic, relative to 1 m^3 polluted water

ECT Ecotoxicity, terrestrial, relative to 1 m^3 polluted soil

NP Nutrification potential, relative to 1 kg PO_4

ODP Ozone depletion potential, relative to 1 kg CFC-11

Data Source: Huppes et al. 1996, pp. 17.15-17.16

Table 4-4: Properties of CFC_s, $HCFC_s$ and Halons in relation to ODP and GWP

Substance	Formula	Montreal Protocol	Ozone Depletion Potential (CFC11=1)	Global Warming Potential (CO_2=1)	Atmospheric Lifetime (years)	Flammability	Toxicity Testing complete
CFC11	CCl_3F	Y	1.000	1500	60	No	Y
CFC12	CCl_2F_2	Y	1.000	4500	120	No	Y
HCFC22	$ChClF_2$	(N)	0.050	510	15	No	Y
CFC114	$CClF_2CCLF_2$	Y	1.000	5500	200	No	Y
CFC115	$CClF_2CF_3$	Y	0.600	7400	400	No	Y
HCFC123	$CHCl_2CF_3$	(N)	0.014	29	2	No	1992/3
HCFC124	$CHClFCF_3$	(N)	0.017	150	7	No	1994/5
CFC500	CFC12/ HFC152a	Y	0.740	3333	?	No	Y
CFC502	HCFC22/ CFC115	Y	0.330	4038	?	No	Y
Ammonia	NH_3	N	0.000	0	<1	Yes	Y
Halon 1211	CF_2ClBr	Y	3.000	Not yet Measured	25	No	Y
Halon 1301	CF_3Br	Y	10.000	5800	110	No	Y
Halon 2402	$C_2F_4Br_2$	Y	6.000	Not yet measured	28	No	Y

Notes:

a. CFC500 and CFC502 are implicitly included in the Montreal Protocol because they contain the restricted refrigerants CFC12 and CFC115.

b. Global and ozone depletion potentials are per unit mass, and values are current best estimates which may be subject to revision. Global warming potentials relate to the long-term (500-year) warming potential.

c. (N) means that the substance is an HCFC and is expected to be phased out between 2020 and 2040 or earlier as alternatives are developed.

d. Abbreviations:

CFC: chlorofluorocarbon

HFC: hydrofluorocarbon (contains no chlorine so has zero ozone depletion potential)

HCFC: hydrochlorofluorocarbon or hydrogenated CFC (has a low ozone depletion potential)

HFA: hydrofluoroalkane (wider chemical group for HFCs and HCFCs)

Halon: halogenated hydrocarbon fire-fighting agent (all contain bromine so have high ozone depletion potential).

Data Source: prior, 1993, p. 11

Policy-makers lacking a professional background can easily understand impact items and their levels if the substances causing the impacts are categorised and accumulated quantitatively, and these two models contribute a great deal to the application of LEIA. However, items such as aesthetics, traffic,

and socio-economic effects cannot be dealt with by these models; they require alternative assessment techniques.

The last step of the impact assessment is **weighting**, i.e., assigning relative values or weights to different impacts. This final step allows integration across all impact categories. Once weighting is done, decision-makers can then directly compare the overall potential impact of each alternative. However, the task of weighting is inherently subjective for allocating particular weights to particular potential impacts is necessarily a value-laden judgment. For this reason, it is recommended that assigned weights be compared with those developed in other research exercises using questionnaires devised by fellow experts (e.g., the Delphi technique). Generally speaking, global, irreversible and persistent impacts are regarded more seriously than local, reversible and temporary impacts and carry a higher weighting on that account.

4.2.5 Improvement Assessment

The improvement stage of LEIA integrates the inventory analysis and impact assessment outcomes. It also feeds back the LEIA results to the previous stage, suggesting mitigation measures or refinements which could improve the environmental consequences, and thus aid developers or policy-makers.

The improvement stage of a LEIA is also the point in the process where the LEIA is written up in a report which documents the whole process for peer or public review. Charts and tables should be used as much as possible to relay accurately the LEIA assessment results and to maximise the reviewers' understanding of the process. An improvement assessment can help a company plan or develop its product(s), and can serve as a reference point for government when it is formulating environmental management policies or executing control over developments.

4.3 THE APPLICATION OF LEIA TO HIGH-RISE BUILDINGS

4.3.1 LEIA and the life-cycle of high-rise building management

The approval procedures of a high-rise building can be divided into four stages (described in 8.3.2): the planning review, the design review, the construction review and the occupancy review. Fig. 4-8 shows the concept of integrating LEIA into the planning review stage.

In Fig. 4-8, LEIA method is integrated into the planning review phase during the life cycle of high-rise building management, which includes screening process, scoping process prediction and assessment of LEIA, LEIA review, urban review and open space review. That is to say that prediction and assessment is not only confined to construction and occupancy stages, but expands the assessment extent from cradle to grave, i.e. production stage of construction materials, transportation stage of construction materials, constructing stage, occupancy stage and demolition stage.

Major assessment items during the production stage of construction materials refer to the process from acquisition of materials to production phase of construction materials, which include acquisition of raw materials, energy consumption, water resource consumption, abiotic resource consumption, emission of pollutants, environmental effects (such as global warming, ozone layer depletion, etc.) and socio-economic environmental impact, etc. The transportation stage of construction materials refers to the process of transporting construction materials from the production plant to the construction site. For general LCA, the transportation stage is always incorporated into the manufacturing stage. However, as high-rise buildings have a tremendous demand for materials, delivering of construction materials has to be assessed individually. The main assessment items during

the transportation stage of construction materials consist of energy consumption, pollutants emission, environmental effect and socio-economic environmental impacts, etc.

The construction stage refers to the process of constructing buildings. Since it always takes more than 2 years to construct high-rise buildings, environmental impact during each construction phase is different. For example, major environmental impacts during the excavation stage are pollution emitted from trucks delivering waste soils and floating dust during construction operation. Another instance is the primary impact of volatile organic compounds (HC pollution) during the phase of architectural coating and painting process. As a whole, major assessment items during the constructing stage include energy consumption, water resource consumption, pollution emission, environmental effects and socio-economic environmental impacts, etc.

The occupancy stage refers to daily use and maintenance of the buildings. As a great deal of uncertainties are involved in maintenance and repair, a detailed and maintenance assessment is hard to conduct during the planning stage. Therefore, the main assessment items during this stage consist of energy consumption, water resource consumption, emission of pollutants, environmental effects, biological and recreational impacts, culture impact and socio-economic environmental impacts, etc. The demolition stage of high-rise buildings refers to recycling of wastes and final disposal, etc. As the occupancy span of buildings is usually beyond 50 years, the assessment of the demolition stage is full of uncertainties. For simplification, its assessed items only include energy consumption of construction machinery, pollution emission during demolition and transportation stages, potential recycling of demolished materials (steel bars as the primary) and disposal of wastes (such as disposal cost, required land for landfill) etc.

From Fig. 4-8, we can see that review for the planning phase of high-rise building occupies a greater

proportion than the approval flow chart of the general buildings. Meanwhile, its review timing shows up in the earlier stage, which transfers the review focus of high-rise buildings from the traditional design phase to the planning phase.

Environmental themes of high-rise buildings contain resource depletion, physical environment (carrying capacity and local impacts) and socio-economic environment (as Fig. 4-9 shows). Resource depletion is comprised of energy depletion, water resource depletion, abiotic resource depletion and use of recycled materials, solid wast disposal and land use.

Energy depletion includes fossil fuel, crude oil, natural gas, electricity, which all belong to non-renewable resources and should be used optimally. Water resource consumption mainly refers to manufacturing and occupancy stages. Abiotic resource depletion means consumption of steel and non-ferrous metal materials such as Cadmium (Cd), Lead (Pb), Mercury (Hg), Copper, Tin and Zinc. Copper, Lead and aluminum products are mostly applied for high-rise buildings. As for use of recycled materials, reinforced steel bars use blast-furnaced slag or waste steel materials; cement applies by-products, such as pulverised fuel ash; plastic steel doors and windows used recycled plastic materials; demolition materials include crushed concrete aggregate and lightweight blocks (containing waste materials) and re-use of bricks or stones, etc. There are five categories for assessment: (a) Steel bars usually use more than 10% of blast-furnaced slag or waste iron materials. (Waste steels below 50% are required to be limited to meet the demand of ductility.) (b) Plastic steeled doors and windows usually use more than 50% of waste materials. (c) Re-used bricks or stones. (d) Demolition materials apply such as crushed concrete aggregate. (e) Lightweight blocks or lightweight walls (such as plywood, fiber board, lath board) usually contain 50% of waste materials.

There are sixteen themes to analyze the physical environmental impact, including local issues,

national issues and global issues, etc. Items consist of climate change, acid rain, ozone layer depletion, photochemical oxidant formation, eutrophication, human toxicity, atmospheric pollution, waterborne pollution, noise nuisance, vibration effects, geology and soils, overshadowing of other buildings and lands, local wind effects, interfere wave, aquatic ecotoxicity, terrestrial ecotoxicity, etc (see 4.3.2). Socio-economic environmental impact items include community population, economic environment, public service facilities, traffic impact, community culture, ecology and landscape, etc. (as Fig. 4-9).

For application of LEIA to high-rise buildings, the impact of every environmental theme during each phase of the whole life cycle of buildings should be accumulated for a full understanding. The next section will discuss environmental issues applicable to life cycle stage of high-rise building.

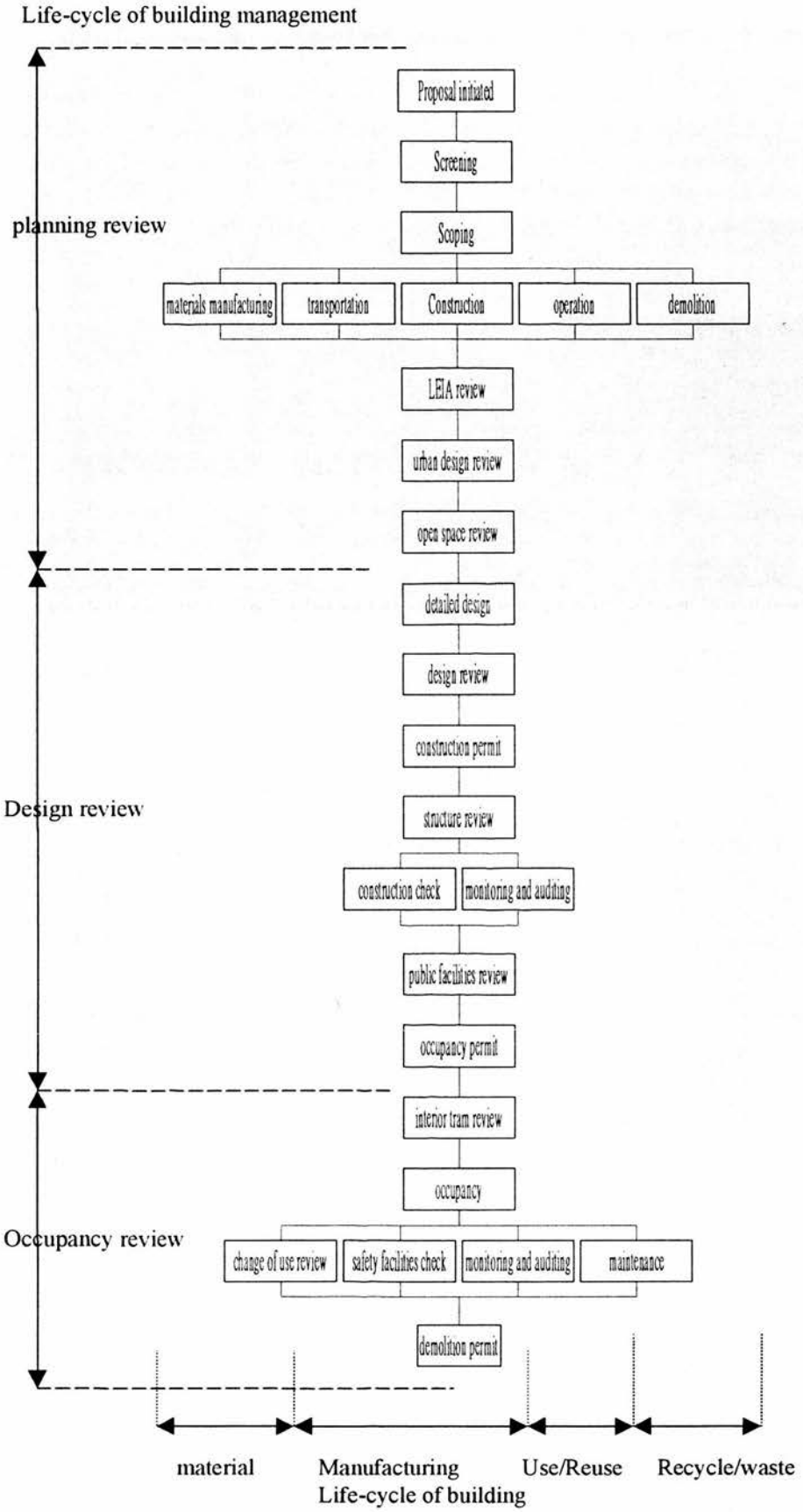


FIG. 4-8 Integration of LCA and EIA in the high-rise building management decision-making process

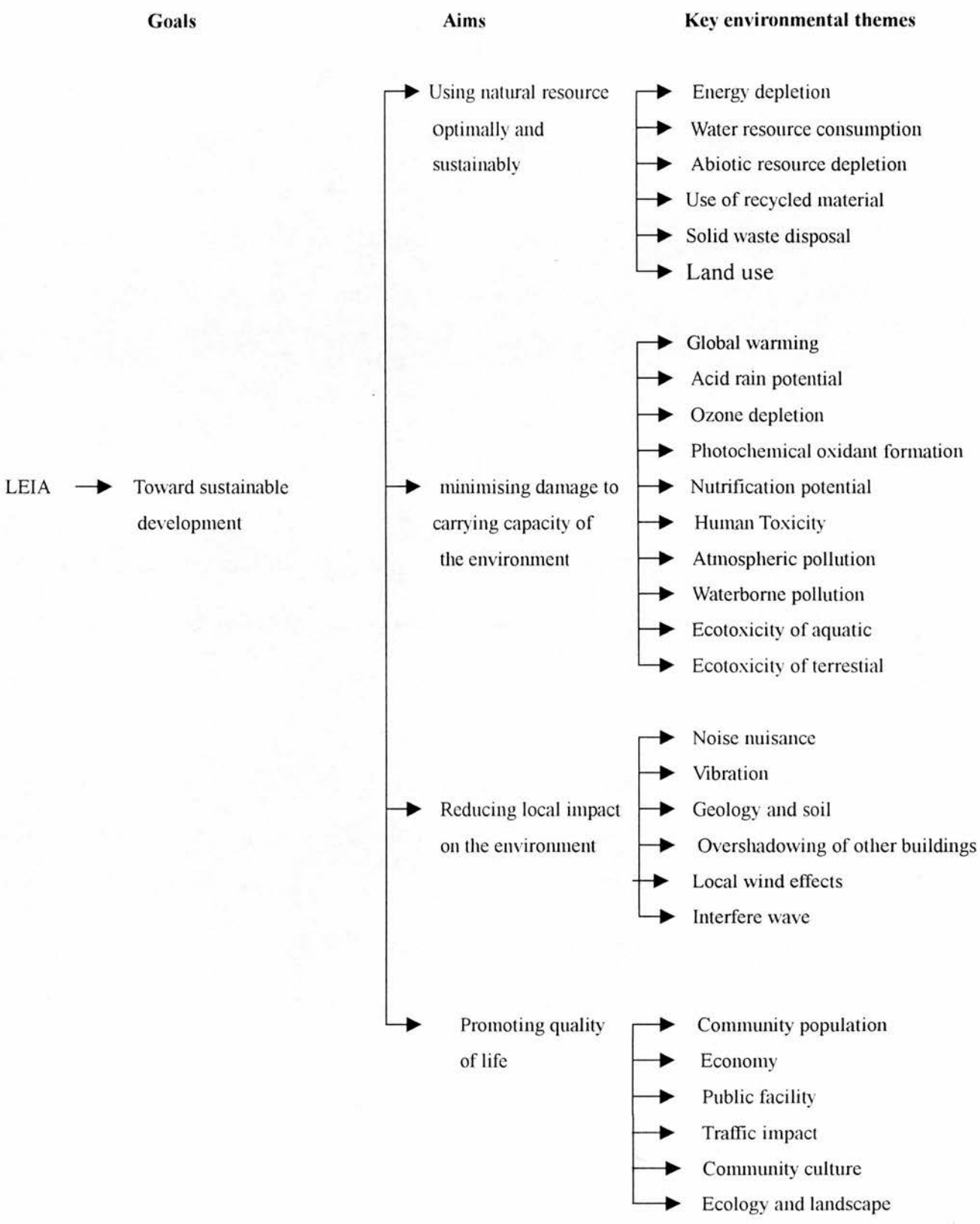


FIG. 4-9: Issues applicable to specific life-cycle stages of high-rise building

4.3.2 Environmental issues and the life-cycle stages of high-rise buildings

The concept of sustainable development is very complex because there are so many interconnections between the environment and human activities. To systematically consider the sustainability themes raised by the life-cycle of a high-rise, it would be helpful if we could first mount a conceptual framework which would ensure that none are overlooked. Unfortunately, as there is no accepted framework within which we might develop sustainability measures, this section adopts a broad-brush approach to the key themes which need to be addressed to improve the sustainability of high-rise buildings.

The environmental themes raised by high-rise development over the buildings' life-cycle include the **depletion of natural resources, the damage done to the environment's carrying capacity, the impact of the buildings on their local environment**, and their **effect on the quality of life.** The first theme (**natural resource depletion**) raises issues such as energy depletion, water resource consumption, abiotic resource depletion, use made of recycled materials, solid waste disposal and land use. The second (**damage to carrying capacity**) includes a consideration of global warming, acid precipitation, ozone layer depletion, photochemical oxidant formation, eutrophication, human toxicity, atmospheric pollution, waterborne pollution, and aquatic or terrestrial ecotoxicity. The third theme (**effects on the local environment**) encompasses noise, vibration, effects on geology and soil, overshadowing of other buildings or land, local wind effects and wave interference. The final theme (**quality of life**) spans issues about the social environment, the economic environment, public facilities, community culture and ecology and landscape.

The key sustainable development objectives for the natural resource depletion issue are that non-renewable resources should be used optimally, and that renewable resources should be used sustainably (DOE 1994, p.9). Issues which need to be tackled to meet these objectives concern fossil

fuel depletion, consumption of water resources, abiotic resource depletion, the use made of recycled materials, and landfill and land use requirements.

Primary energy consumption has increased significantly in Taiwan since 1975; total energy consumed has increased from 15.9 million kl (in 1975) to 70.11 million kl currently. Most improvement has been seen in the manufacturing sector where final energy consumption is now 51.3%. However, energy consumption in the building sector (domestic and commercial) has risen by ninefold since 1970, making it the sector with the fastest growth in energy demand(MOE 1994, p.97). Final energy consumption by the domestic and commercial building sector has risen from 9.14% in 1990 to 15.18% in 1995 (MOE 1994, p.127).

Taiwan has a plentiful supply of freshwater, but its seasonal distribution does not match demand. Our water consumption stands at 17.1 billion m^3, 33.1% from rivers, 25.2% from reservoirs, and 41.7% from underground, making water an increasingly scare resource with an associated increase in the financial and environmental costs of ensuring an adequate supply. The continuous growth of the aggregate industry is provoking increasing public concern about the impact of raw materials extraction from quarries and sand and gravel pits. There is an equal concern with the disposal of large quantities of building demolition waste. Significant quantities of demolition materials can be used or recycled for new building, e.g., pulverised fuel ash, timber, plastic waste bricks and waste metal. The large-scale recycling of waste needs to be encouraged to increase the utility of both renewable and non-renewable resources.

Rapid urban development in Taiwan has led to a consequent loss of hillside and rural land. In 1986, land in urban use accounted for just 11.8% of Taiwan's land area. By 1996, this figure had risen to 12.2%. Thus, there is a mounting need to reconcile the land requirements for housing and for urban

commercial development with the loss of countryside. In addition, the vitality of town centres must be preserved, with people living close to where they work.

As to the second theme (damage to the environment's carrying capacity) global greenhouse gas concentrations have increased over the last 200 years and the balance of evidence now suggests this has led to discernible global climate change (DOE 1996,p.16). The emission of greenhouse gases (the most important being CO_2, CH_4 and N_2O) and of CFCs is largely a consequence of the burning of fossil fuels. While the world has seen an annual increase of 1.8% between 1971 and 1993, Taiwan's national rate is rising by 7.2% annually so it is extremely challenging to reduce greenhouse gas emissions here (MOE 1994, p.2).

CFCs, which are also powerful greenhouse gases with typically long atmospheric life-spans, have a GWP of 4500 (CFC_{12}) (Prior 1993, p.11). CFCs are being phased out under the Montreal Protocol because of their significant contribution to the depletion of the ozone layer. The photochemical breakdown of Ozone Depleting Substances (ODS) like CFCs, HCFCs and halon in the upper atmosphere releases chlorine and/or bromine which catalyse to destroy ozone (DOE 1996, p.83). Although the import and production of CFCs has been prohibited in Taiwan, by 1998 189 tonnes of CFC_{11} and 467 tonnes of CFC_{12} still remained in stock for future use (EPA 1998, p.5.3). HCFCs have similar properties to CFCs but cause significantly less damage to the ozone layer. As CFCs and HCFCs are commonly used in buildings as components of air conditioners, the ozone layer depletion theme is a vital issue for the building sector.

According to an EPA survey conducted in Taiwan, the annual average pH value of rain in northern

Taiwan is below 5.0, especially in Taipei and Taoyuan where the value is about 4.5[2]. Estimates of the likelihood of acid rainfall suggest that the Taipei and Taoyuan region has an 80% possibility, and Kaohsiung 74%, as Table 4-5 and Fig. 4-10 show.

Table 4-5: Acid Rain in Taiwan (1990-1995)

Place	PH Value	Occurrence Rate of Acid Rain (pH<5)	(SO_4^{2-}) (ueq/1)	(NO_2) (ueq/1)	Sulphuric Acid Deposition	Nitric Acid Deposition
Taipei	4.43	86%	111.7	44.8	117.4	49.6
Kuei Shan	4.52	83%	116.8	51.0	108.4	57.5
Chung Li	4.59	80%	138.2	39.7	122.4	53.1
Hsiao Kang	4.79	74%	104.9	24.9	79.0	35.5
Kenting	5.99	11%	35.4	8.6	29.0	15.9
Tai Ma Li	5.18	44%	57.2	25.7	60.4	31.7
Lo Tung	5.36	44%	95.5	29.3	123.2	32.5
Taichung Port	5.07	48%	168.8	47.4	70.8	45.1
Chyai	6.39	23%	104.8	37.5	49.2	43.8
Penghu	6.03	13%	89.9	31.9	21.4	58.5
Tainan	5.23	43%	106.8	34.1	46.3	36.3
A-li Mountain	5.32	35%	38.8	14.1	34.3	19.4

Data Source: EPA, 1997a, p. 760

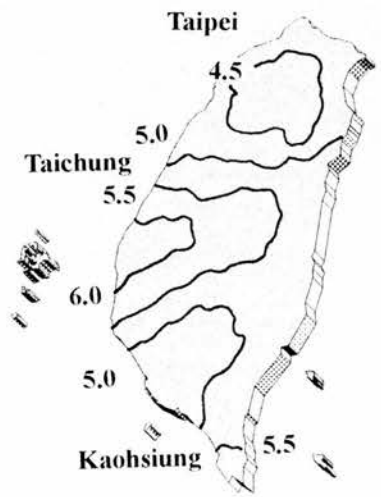


FIG. 4-10: Average PH value of rain in Taiwan

Data Source: EPA, 1997a, p.761

[2] Generally, acid rain means that the pH value of the rain is below 5.0. See EPA, 1997a, p. 758

The presence of various nutrients in excessive quantities in water, combined with particular weather conditions, can lead to eutrophication and excessive algal growth. By depleting oxygen, this can cause long-term ecosystem disruption especially to fish. While eutrophication levels in reservoirs have decreased significantly, 30% of reservoir water still displays a high eutrophication level as Table 4-6 shows.

Table 4-6: Eutrophication in Reservoirs in Taiwan

Year	Poor Eutrophication		Medium Eutrophication		High Eutrophication	
	Number of Reservoir	%	Number of Reservoir	%	Number of Reservoirs	%
1993	1	5.6	4	22.2	13	72.2
1994	1	4.8	8	38.1	12	57.1
1995	2	10.0	14	70.0	4	20.0
1996	2	10.0	12	60.0	6	30.0

Data Source: EPA, 1996b, pp. 152-3

Within the third theme (local environmental impacts) the specific hazard of high-rises' wind effects looms large for the public. A high-rise building which is substantially taller than its surroundings deflects the wind both horizontally and vertically from its original course, increasing wind speeds at the building's ground level where it affects pedestrians. The nuisance it causes for pedestrians depends on how often the wind is felt as being merely uncomfortable ranging upward in intensity to being actually dangerous. To gauge this, wind tunnel tests are mandatory for buildings over 100m.

Other hazards which can be categorised within this third environmental theme include the noise pollution high-rises engender for local residents and their over-shadowing of sunlight on neighbouring properties and land. The re-use of existing sites can help to slow down or halt another local hazard, i.e., the destruction of natural habitats and the wildlife they support. However, there is always the risk that however environmentally friendly the high-rise itself may be, it may threaten the local ecology or landscape. The ecological value of individual building sites needs to be assessed in the

project's planning stage so as to minimise this kind of damage.

4.3.3 A Methodology to Assess Environmental Effects

The Critical Dilution Volume (CDV) model, developed by the Swiss Federal Ministry for the Environment, can be used to assess the environmental impact of atmospheric pollution. The CDV of pollutants from a development project can be obtained by diluting each stressor of atmospheric pollution to meet regulatory requirements and then accumulating the critical volume of the same medium. The CDV is defined by dividing the emission volume of the pollutant (g) with the quality standard value (g/vol.). The CDV is then (g) over (g/vol.). The transformed coefficient (i.e. dilution volume equivalency) of each gas can be obtained by referring to the local quality standard along with this definition, as Tables 4-7 and 4-8 show. The formula for the equivalent SO_2 (atmospheric pollutant) critical dilution volume [CDVA (E)] is as follows:

$$CDVA(E)=1xSO_2+0.61xNO_2+36.5xCO+1.55xD_3+365xPb+1.4xTSP(\text{or } 2.43 \times PM_{10})$$

The CDV of 1kg of SO_2 emission is 2,739,726m^3 of air according to Taiwanese air quality standards. Stressors mentioned above are based on pollutants which are covered by air quality standards and do not include pollutants which are not listed with air quality indices (e.g., CO_2, HC, CH_4, etc.). A similar method is used to develop the CDV of waterborne pollutants (see Table 4-8). The formula for the equivalent BOD critical dilution volume [CDVW(E)] is as following:

$$CDVW(E) = 1* BOD + 0.04 * SS + 0.5 * COD + 10 * N + 100 * Cd + 10 *Pb + 20 * Cr +$$

$$20 * As + 500 * Hg + 20 * Se + 33 * Cu + 2* Zn + 20 * Mn + 20 *Ag+1 * Fat$$

Table 4-7: Equivalent CDV of Atmospheric Pollutants

Stressor	SO_2 Critical Volume Equivalency
sulphur oxides (SO_2, SO_x)	1.00
nitrogen oxides (NO_2, NO_x)	0.61
carbon monoxides (CO)	36.50
Ozone (O_3)	1.55
Lead (Pb)	365.00
total suspended particulates (TSP)	1.40
suspended particulates (PM_{10})	2.43

Notes:

a. The legal standard of this gas is in compliance with the Pollutant Standard Index level (PSI) and belongs to the moderate range (PSI=100)

b. Regulated standard of Lead (Pb) is based on R.O.C. Air Quality Standards

c. Critical Dilution Equivalency means the dilution volume (NM^3) relative to SO_2 CDV

d. The CDV of 1 kg of SO_2 emission is 2,739,726m^3, which is 365 ug/m^3 of the air quality standard for SO_2

Table 4-8: The CDV Equivalency of Waterborne Pollutants

Stressor	BOD Critical Dilution Volume Equivalency
BOD	1.00
Suspended Solids	0.04
COD	0.50
NH_3-N	10.00
Cadmium	100.00
Lead	10.00
Chromium	20.00
Arsenic	20.00
Mercury	500.00
Selenium	20.00
Copper	33.00
Zinc	2.00
Manganese	20.00
Silver	20.00
Fat/Grease	1.00

Notes:

a. Legal standards are in compliance with the water quality standard for the waterborne group on the ground

b. Stressors are chosen in compliance with those inspected to check the water quality in waste water treatment facilities, restaurants, hotels and recreational resorts according to the standards required of effluent water in Taiwan

c. The CDV refers to the CDV(l) relative to the BOD CDV

d. The CDV of 1 kg BOD is 1,000m^3, which means the water quality of the BOD standard is 1mg/l

The themes of global warming, photochemical oxidant formation, eutrophication and toxicity are dealt

with by estimating the emission volumes of these driving substances and quantifying them in compliance with each equivalency factor (see Table 4-9).

Table 4-9: Methodology for Assessing Various Environmental Themes

Environmental themes	Index of effect	Substance	Assessment	Note
Global warming	Global warming Potential (GWP)	CH_4, N_2O, $HcFc_{123}$	GWP(E)=1 * CO_2 +9 * CH_4 + 190 * N_2O + 29 * $HcFc_{123}$+ 1500*CFC_{11} +4500 * CFC_{12}	Relative to 1 kg CO_2
Acid rain	Acidification potential (AP)	SOx, Nox	AP(E) = 1* SOx + 0.7 * Nox	Relative to 1kg SO_2
Ozone layer depletion	Ozone depletion potential (ODP)	CFC_{11}, $HcFc_{123}$	ODP(E) = 1* CFC_{11}+0.014 * $HcFc_{123}$	Relative to 1kg CFC_{11}
Photochemical oxidant formation	Photochemical oxidant creation potential (POCP)	HC, CH_4	POCP(E) =0.377*HC+0.007 * CH_4	Relative to 1kg ethylene
Nutrification	Nutrification potential	N,No_x, PO_4, COD	NP(E)=0.42 *N + 0.13 *No_x +PO_4,+ 0.022 *COD	Relative to 1kg PO_4
Human toxicity	Human toxicity	No_x, SO_x, CO, Pb	HT(E)= 0.78 *No_x+ 1.2 * SO_x + 0.012 *CO +160 * Pb	Relative to 1kg human body
Atmospheric pollution	Critical dilution volume of air (CDVA)	SO_x, No_x, CO, Pb, TSP	CDVA(E) = (1*SO_x +0.61* No_x+ 36.5 * CO+ 365*Pb +1.4 * TSP) * 2739726	CDV of air pollution
Waterborne pollution	Critical dilution volume of water	BOD, SS, COD, N, PO_4, fat	CDVW(E) = (1*BOD+0.04 * SS +0.5 * COD +10* N +50* PO_4+10* grease)*1000	CDV of water pollution
Solid waste	Solid waste disposal	Waste	SWD = weight of waste / 0.217 * 0.06	Area of landfill
Noise nuisance	Noise level	Noise dB(A)	Leq of receiver	Control standard of second zone
Vibration	Vibration level	dB	Lv of neighbour	
Geology and soil	Settlement	cm	Settlement of other land	
Overshadowing of other building and land	Effective insolation	Hour	Isolation of other building and land	Minimum of isolation over 1 hr
Local Wind effect	Comfortable for human activity	Level	Sitting, standing, walking: comfortable, uncomfortable, dangerous	Probability of uncomfortable more than 20 %
Interfere wave	Blocking area	Area	Blocking area	
Ecotoxicity aquatic	Ecotoxicity, aquatic (ECA)	Pb	ECA(E) =2*10^6*Pb	Relative to $1m^3$ polluted waste
Ecotoxicity, terrestrial	Ecotoxicity, terrestrial (ECT)	Pb	ECT(E)=4.3 * 10^5 * Pb	Relative to $1m^3$ polluted soil

Note: Global warming potentials relatives to the long-term (500-year) warming potential

As discussed earlier, LEIA uses the concept of impact equivalency assessment which makes it possible to construct a system that allows for intercomparison. The equivalency factors can be

obtained from several assessment modes based, for example, on chemical potentials, environmental or ecotoxicity data values, hydrogen-ion or acid equivalents, quantitative risk assessments, acute toxicity values, carbon equivalents, oxygen equivalents, halogen-ion equivalents, cancer potency indices, molecular weight, etc. (Boguski et al. 1996, p.2.32). However, a set of dimensionless equivalency impact factors are frequently derived when inventory data are multiplied or summed or when some combination of mathematical operations is applied. The problem is that there is no single method for doing this which is widely endorsed by the scientific community. However, one subset of equivalency models has met with some success, i.e., the impact potential of a global warming set of chemicals (Boguski et al. 1996, p.2.32). Hence, this study will adopt the equivalency factors set out by the Dutch System (SML) and BRE (see Table 4-3 and 4-4 above).

To estimate likely CO_2 results, we multiply the energy requirement with the carbon emission coefficient giving us a preliminary carbon emission volume. As for incomplete burning, we multiply the preliminary volume of carbon emission with the fraction of oxidised carbon, giving us the amount of carbon emission. To estimate emissions of CO_2, we multiply this carbon emission figure with the transformed coefficient (44/12).

As fossil fuel is required during specific life-cycle stages of the building and incomplete burning of fossil fuel results in CH_4, we can see that the higher the burning efficiency, the less CH_4 is generated. To estimate CH_4 emissions we first present the energy consumption of various fuels in terms of a thermal value unit (Kcal), and then multiply the consumption figures of each kind of energy (thermal value unit) with their CH_4 emission potential.

N_2O mainly comes from the burning of fossil fuel. To estimate the level of N_2O emissions we first calculate the NO_x emission, which can be obtained by multiplying the energy consumption of each activity or vehicle kilometre traveled (VKT) with the NO_x emission factor. The N_2O emission volume can then be calculated by multiplying the NO_x emissions of each type of energy with the

transformation rate. Figures for other pollutants such as SOx, CO, Pb, TSP, etc. can be estimated using a similar method; their emission volumes can be gauged by calculating their energy consumption or by quantifying the intensity of the activity and its resulting emission factor as Table 4-10 shows.

Table 4-10: Method for Estimating Pollutants throughout the Building's Life-Cycle

Activity items	Substances	Estimation methods	Unit
Water resource consumption	Water	Consumption = unit water Consumption * activity intensity	M^3
Energy consumption	Electricity, natural gas, fossil fuels	Consumption = unit Consumption * activity intensity * heat value	Kcal
Abiotic depletion	Lead copper zinc	Consumption = Σconsumption * unit	Kg
Air pollutant emissions from building materials production	CO_2, CH_4, N_2O, NO_x, TSP, SO_x, CO	Unit emission volume = unit building material consumption of energy * emission factor	Kg or Tonnes
Water pollutant emissions from building materials production	COD, BOD, SS	emission volume = unit waste water emission volume * amount of building material used * effluent concentration	Kg
Air pollutant emissions from building materials transportation	CO_2, CH_4, N_2O, NO_x, TSP, SO_x, CO	Unit emission volume = unit building material consumption of energy in transportation * emission factor	Tonnes
Vol. of air pollutant emissions from construction machinery	CO, HC, NO_x, TSP, SO_x,	Emission volume= unit emission volume * activity intensity* working days	Tonnes
Volatile organic emissions from painting the building	HC	Emission volume = emission factor * activity intensity	Tonnes
Diffused particle pollutants from construction work	TSP	Emission volume = emission factor * construction area * construction period	Tonnes
Floating dust from driving vehicles	TSP	Emission volume = emission factor * vehicle kilometre traveled	Tonnes
waste water during construction	COD , BOD, SS, Fat, P,N	Emission volume = unit emission volume * activity intensity * effluent concentration	Kg
Air pollutant emissions from energy burning	CO,HC, NO_x, SO_x	Emission volume = emission factor * energy consumption volume	Tonnes
Living activity associated waste water	COD , BOD, SS, Fat, P,N	Emission volume = Unit * emission factor * activity intensity * effluent concentration	Kg
The refrigerant agent of air conditioning	$HcFc_s$, CFC_s	Emission volume = emission factor * consumption volume	Kg
Pollutant emissions from traffic the building attracts	CO, HC, CH_4,P_b, Nox, SOx, TSP, CO_2	Emission volume = emission factor * vehicle kilometre traveled	Tonnes
Building demolition	CO, HC, Nox, SOx, TSP, CO_2, CH_4	Emission volume = unit area emission factor(EF) * Total floor area (TFL) *	Tonnes
CO_2 fixation from green design (photosynthesis)	CO_2	Fixation Volume = NO_1 * fixation Facttor XL_2 + NO_1 * fixation * L_4 + NO_1 * fixation factor * L_6	Kg

The environmental impact of traffic noise varies according to location. Regulations against noise pollution are more strict in the vicinity of hospitals and schools, for example, while other locales such as business districts permit a greater volume of noise. As shown in Table 4-10 above, a figure for the emission of atmospheric pollutants and waterborne pollutants can be obtained by multiplying the intensity of the activity with the emission factor.

4.4 SUMMARY

An ideal model for the environmental impact assessment (EIA) system is established in this chapter, which is termed as sustainable impact assessment (SIA). Each methodology and procedural framework are set up in compliance with the categories of urban development for high-rise buildings. Therefore, methodologically speaking, comprehensive land use planning system and the management system for high-rise buildings should be combined for an integral analysis and establishment. In addition, development of high-rise buildings has to start with zoning for the urban plan. Consequently, SIA phases can be divided into the structure plan phase, the detailed plan phase, the investment program phase and the development project phase. As for evaluation methodologies, concepts of SEA, EIA and LEIA are exercised from the superior plan to the development project in order to assess environmental impacts imposed by plans and actions at each level and to reach the goal of sustainable development.

The structure plan is the most superior plan in the comprehensive land use planning system. Consequently, concept of SEA is adopted for environmental impact assessment. As this is an outlined essential plan, evaluation contents are emphasized on land use plan, traffic plan and resource constraints. Environmental themes to be assessed mainly focus on natural resource depletion and socio-economic environmental impacts. The assessment approach applies carrying capacity and

concept of sustainability criteria. Within the constrains set by the structure plan, SEA is drawn up for environmental impact assessment. Furthermore, as the detailed plan / land allocation plan belongs to the specific land use plan, evaluation contents of SEA include zoning plan, traffic plan, land use intensity plan, community plan and open space plan. In addition, as the plan at this level is a detailed zoning plan, environmental themes for assessment are more extensive as well, including natural resource depletion, carrying capacity, socio-economic environment and impacts specified by the international treaty (such as global warming).

Under the level of the detailed plan, every sectoral investment program comes into existence, including public facilities and physical construction programs. Thus, the assessed targets consist of sectoral plans and medium-term & short-term improvement projects, etc. For environmental themes for assessment, natural resource depletion, damage of carrying capacity, local environment impact and impact upon the quality of life are covered.

Based on the level of an urban development project, this chapter deals with high-rise buildings. Procedural and methodological speaking, high-rise buildings are aimed. Environmental impact assessment under such project level adopts LEIA approach and environmental impact imposed by certain development action is assessed at each phase during its life-cycle.

Major procedures of LEIA include screening process, scoping process, preparation of LEIA report, LEIA review, decision-making and monitoring and surveillance, etc. The screening process refers to a set of procedures to decide if LEIA process is required for a specific development project. Threshold and criteria are usually utilized for screening means. The scoping process means to determine the coverage of LEIA, including analysis of the purpose of the study, decision of the functional unit and confirmation of boundaries. There are three steps for the process of preparing LEIA report, which are

inventory analysis, impact assessment and improvement assessment. For the process of inventory analysis, confirmation of the process flow chart is the first step, then collection of data and analysis of the system boundaries are the next procedure. The final step is processing of data. After the inventory analysis is conducted, the impact assessment can be proceeded next.

The first step is classification in impact assessment process, which means to classify results of the inventory analysis to environmental themes. Whereas, environmental themes should take local, regional, national and global issues into consideration. Generally speaking, themes include natural resource depletion, energy depletion, abiotic resource depletion, climate change, photochemical oxidant formation, acidification, human toxicity, acquatic ecotoxicity, terrestrial ecotoxicity, eutrophication, ozone layer depletion, atmospheric pollution, and waterborne pollution, etc. Upon completion of the classification process, characterization and weighting tasks are conducted next so as to integrate different environmental themes. After finishing inventory analysis and impact assessment, improvement assessment should be implemented. Improvements acquired during this phase should be fed back to each phase previously. Processes of LEIA review, decision-making and monitoring, etc. are identical with those of EIA.

CHAPTER FIVE : ISSUES RELATING TO THE LIFE-CYCLE OF BUILDINGS

Assessing the environmental impact of a high-rise means more than merely examining its effects when occupied. Throughout the various stages of its life-cycle it consumes energy and resources and generates emissions. Its consumption refers to more than its immediate gas and electricity requirements; every item that goes into its construction (including bricks and steel) consumes natural resources and the task of building it and disposing of it consumes energy as well. As a result, a comprehensive assessment of its environmental impact must evaluate its entire life-cycle which we can divide into six stages: the production of building materials, the transportation of materials, the construction phase, the occupancy phase, maintenance and repair, and demolition. The environmental impacts of each stage are listed in Table 5- 1.

Table 5- 1: Major Environmental Impacts at Specific Life-Cycle Stages of High-Rise Buildings

Life-Cycle	Assessed Item	Environmental Issues	Impact Item
Manufacture of Materials	Pollution, resource	Natural resources depletion Emission of pollution	GWP, HT, AP ADP, EDP
Transportation of materials	Pollution, traffic, energy	Emission of pollution; Traffic impact	GWP, EDP, POCP, AP, HT
Construction	Ecology, landscape, Social & economic, Cultural, energy, traffic	Terrain, emission of pollution, noises, wastes, landscape, traffic impact, cultural impact, consumption of energy, vibration	EDP, GWP, POCP, AP, HT, ECA, ECT, NP, ODP
Occupancy	Ecology, landscape, Social & economic, Cultural, traffic, energy	Emission of pollution, noises, micro-climate, interfere waves, ecology, landscape, recreation, energy, land use, social environment, culture, traffic, vibration, wastes disposal.	EDP, GWP, POCP, AP, HT ECA, ECT, NP, ODP
Maintenance	Material, energy, pollution	Wastes, emission of pollution, application of natural resources	EDP, GWP, ADP, POCP, AP, HT
Demolition	Energy, traffic, wastes	Consumption of energy, traffic impact, emission of pollution, disposal, traffic, application of energy, wastes	ADP, EDP, GWP, POCP, AP, HT, NP

Figure 5-1 identifies the building's inputs and outputs over its life-cycle. Input items include raw materials, energy, natural resources, land etc. and output items include pollutants and waste, and its effects on the local micro-climate, landscape, traffic, etc.

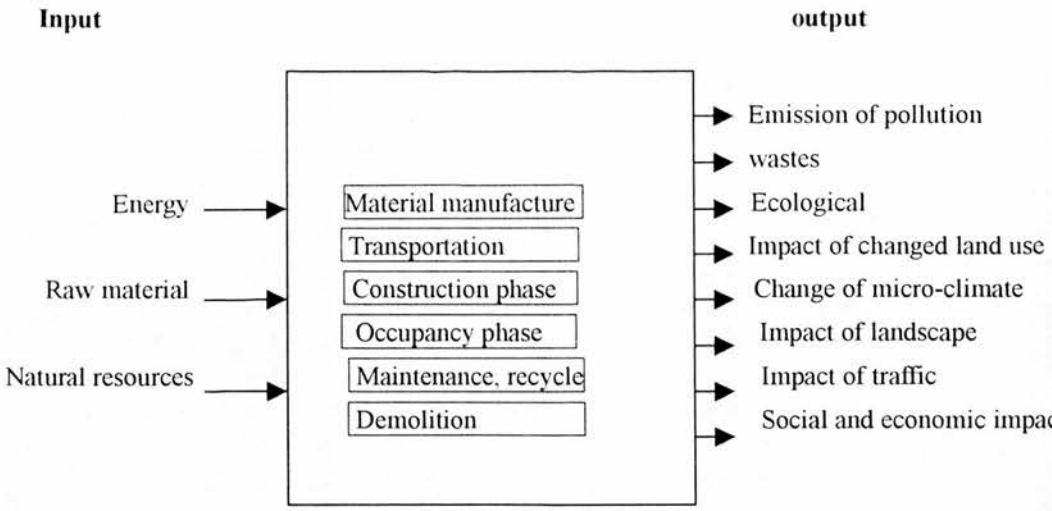


FIG. 5-1: The System Boundary of the Life-Cycle of High-Rise Buildings

As a building usually remains in use for decades or longer, its energy and resources requirements during the maintenance and repair stage are less than those found in other stages, so we will focus in this chapter on the five remaining phases.

5.1 ENVIRONMENTAL ISSUES RELATING TO THE PRODUCTION OF BUILDING MATERIALS

The salient environmental issues which feature at this first stage of the life-cycle include energy consumption, raw materials acquisition, pollutants (e.g., CO, CO_2, N_2O, NO_X, TSP and SO_2) and waste water. First-stage environmental effects may contribute to global warming, atmospheric pollution, acid rain, photochemical oxidant formation and eutrophication, human toxicity and waterborne pollution since the various building materials used during the manufacturing process each generate their own waste water and exhausts. For example, factories engaged in paper-making, plastics, brick manufacture, glass and the plating of building materials will each emit their own particular mix of heavy metals, waste water and HT pollutants. This section will deal mainly with estimates of the volume and impact of the various pollutants which result from first-stage energy consumption.

5.1.1 Energy Consumption at the Manufacturing Stage

A building consumes a great deal of fossil fuel and energy during the process of its production, e.g., coal, petrol, natural gas and electricity. Over half of Taiwan's power is generated from thermo-electric power stations which take fossil fuels as their energy source. A high-rise building, in particular, requires a large amount of material so its consumption of cement, aggregate, reinforcing steel bars, tiles, plate glass, plywood etc. is especially great. As building materials are so various - ranging from the largest steel frames to the smallest screws - only main ones will consider.

As the energy to manufacture building materials mainly comes from fossil fuels and electric power, the total energy consumption of each kind of building material can be obtained if by adding together the electric and thermal energy it consumes.

The total energy consumption of building materials manufacture is 10,521 thousand kilolitres oil equivalent, or 15.95% of Taiwan's annual energy consumption.[1]. Of the various kinds of building material, the energy consumed by the steel frame production industry was the highest (27% of the total) while cement production came a close second (26.2%)of the total energy consumption of this stage. The industries producing aluminium doors and windows, glass and tiles are also high energy consumers because of the extreme processing that goes into the manufacture of these items[2].

5.1.2 Raw Material Consumption at the Manufacturing Stage

In addition to using a great deal of energy, the building materials industries also consume a tremendous amount of raw materials, e.g., gravel, timber, aluminium, steel, iron, non-metal materials, etc. They annually consume 7.6 million m^3 of gravel, 10 million m^3 of stone, 12 million tonnes of steel and 41,430 tonnes of aluminium. As a large building requires a great deal of materials, this particular

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[1] In 1994, gross national energy consumption was 65,956.2 thousand kilolitres oil equivalent. See Yang, 1996, p. 6.

[2] Ibid., pp. 6-7.

project requirement needs to be evaluated prior to conducting the assessment of impacts during the manufacturing stage.

5.1.3 Effects on Global Warming at the Manufacturing Stage

The global warming effect mainly results from the exhaust of greenhouse gases from the burning of fossil fuel. Greenhouse gases primarily refer to carbon dioxide (CO_2), methane (CH_4) and dinitrogen oxide (N2O). This section will estimate emission volumes from these three gases and will quantify them in terms of their global warming potential (GWP) as we saw in Table 4-3 of Chapter Four. GWP is relative to 1kg CO_2.

If we multiply the unit emission level of each kind of building material with national output capacity , we discover that total CO_2 emissions during the manufacture of building materials is 27,950 tonnes or 16.4% of Taiwan's annual CO_2 emissions.[3].

To estimate CH_4 emissions, we first present the energy consumption of various fuels in terms of a thermal value unit (Kcal) and then multiply the Kcal of each type of energy with its CH_4 emission potential. annual CH_4 emissions from the manufacture of building materials come to 109 tonnes or 0.52% of Taiwan's total (see Table 5-2). Among building materials, cement products generate the most emissions (47 tonnes or 44.66% of the total emissions from building materials manufacture). The manufacture of steel products (including bars, frames and plates) generates 27 tonnes (25.64%). Figure 5-2 shows that although cement and steel product manufacture account for the largest proportion of CH_4 emissions in this industrial sector, paper-making and artificial fibre manufacture are also significant (accounting for 7.1% each).

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[3] See Yang, 1996, pp. 8-12

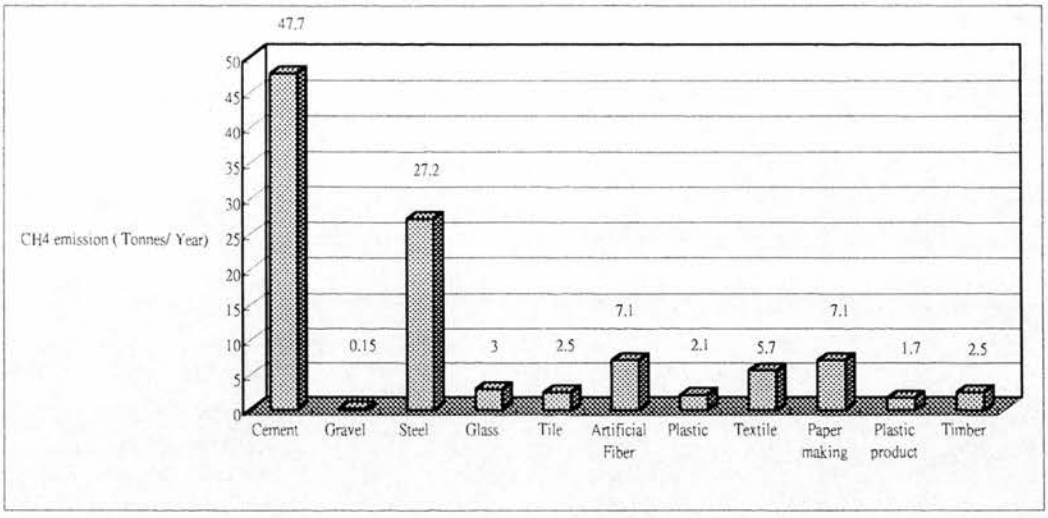

FIG. 5-2: CH_4 Emissions from the Manufacture of Main Building Materials

Table 5-2: CH_4 Emissions at the Manufacturing Stage

Building Material	CH_4 Emission (tonne/year)	building Material	CH_4 Emission (tonne/year)	Building Material	CH_4 Emission (tonne/year)	Building Material	CH_4 Emission (tonne/year)
Gravel	0.0589	Timber	0.0148	Paper for Publishing	3.2636	Poly-ammonium	1.6679
Excavated Stone	0.0921	Plywood	0.0716	Paper for Household	0.5187	Knitting Textile	1.8127
Steel Bar	18.8879	Paper Board	2.4563	Paper for Packaging	0.2052	Paint	0.0012
Frame Steel	2.8225	Pre-mixed Concrete	0.1820	Synthetic Resin	0.7935	Linear Light Tube	0.0485
Steel Plate	5.5723	Brick	2.654	Polyvinyl Chloride	1.1248	Wires & Cables	0.1316
Cement	47.7154	PVC Tube	0.2358	Synthetic Rubber	0.2341	Wires	0.3787
Aluminium Door & Window	0.1715	Plastic Bag	0.4087	Poly-cotton	2.4402	Window-style Air Conditioner	0.0763
Flat Glass	2.4913	Plastic Cloth	1.0745	Poly-silk	3.0062	Generator	0.0019
Fibreglass	0.5105	Pulp	0.6882	Shuttled Cloth	3.1708	Motor	0.0034
Tile	2.5035	Wooden Furniture	0.3690	Cotton Cloth	0.7607	Electric Motor	0.6042
Total:	109.225						

N_2O emissions mainly stem from the burning of fossil fuel. To estimate the level of N_2O emission we first calculate NOx emissions which can be obtained by multiplying the energy used to manufacture building materials or the vehicle kilometre traveled(VKT) with their NOx emission factor. The N_2O emission volume can then be calculated by multiplying the NOx emissions of each type of energy with

the transformation rate of 0.01[4]. The annual N_2O emission from this sector is 1,180 tonnes and Nox emission is 118,038 tonnes (18.3% of Taiwan's total). Again, cement and steel production are the major agents. The manufacture of cement products accounts for 32.75% of the total emissions from this sector and 5.87% of Taiwan's total while steel production accounts for 4.3%. Figure 5-3 shows the N_2O emissions from the manufacture of each building material.

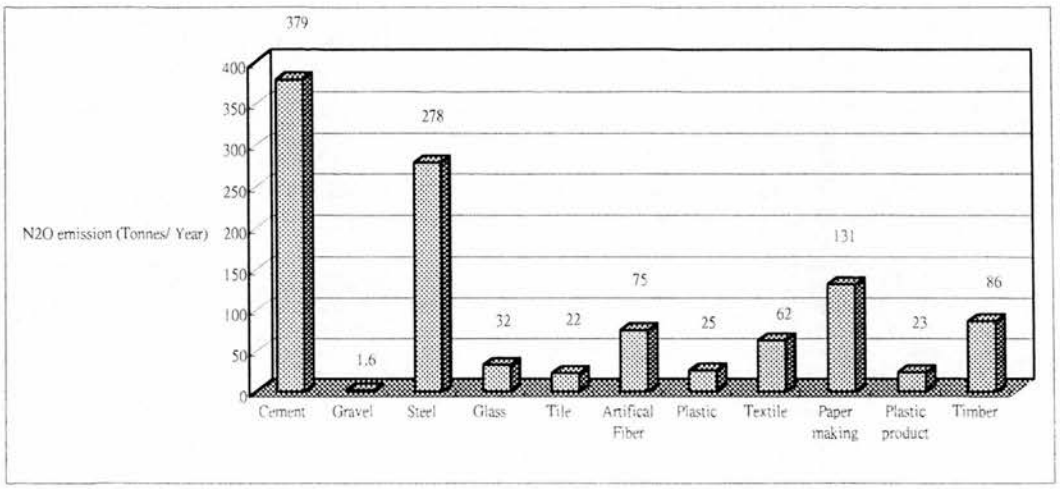

FIG. 5-3: N_2O Emissions from the Manufacture of the Major Building Materials

According to the results presented above, carbon dioxide emissions from building materials manufacture come to 27.95 million tonnes; methane 109 tonnes and dinitrogen oxide 1,180 tonnes. The exhaust level of GWP is 28.27 million tonnes - 1.15% more than that of carbon dioxide emissions. We can conclude that the carbon dioxide emitted from the manufacture of building materials is the greenhouse gas from this sector which most contributes to the global warming effect.

5.1.4 Effects on Acid Precipitation at the Manufacturing Stage

Acid rain comes from the mix of acidifying pollutants with rainfall. Apart from the acid material produced naturally such as the sulphides which erupt from volcanoes, human activities generate large amounts of sulphur dioxide (SOx) and nitrogen oxides (NOx). The NOx emissions from the manufacture of building materials were discussed in the previous section (118,038 tonnes) so in this section we will deal with SOx.

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[4] See Yang Hsuan Chao, 1996, p. 10

Of the major building materials, cement production emits the greatest level of SOx (41.6%) while steel production accounts for 20.4%, as shown in Fig 5-4. These two kinds of construction material are heavy energy and power consumers. The calculations show that SOx emission is 8,502 tonnes and Nox 118,038 tonnes. The Acid Potential (AP) is 91,129 tonnes, Nox accounting for 90.7% of total AP emissions.

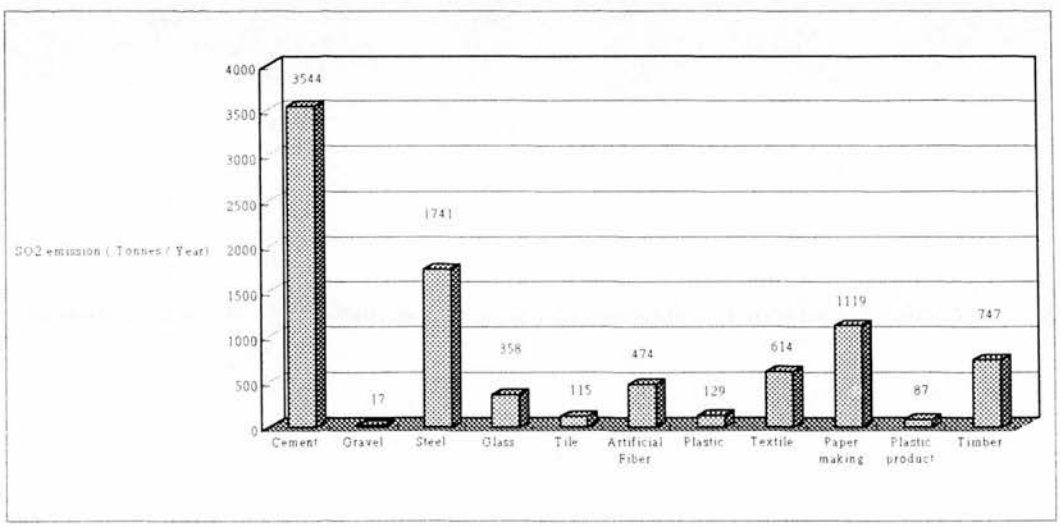

FIG. 5-4: SO_2 Emissions from the Manufacture of Major Building Materials

5.1.5 Photochemical Oxidant Formation and Eutrophication at the Manufacturing Stage

The main substances which contribute to photochemical oxidant formation are methane (CH_4), hydrocarbons (CxHy), n-hexane (C_6H_{14}), acetylene and benzene. To assess their environmental impact, each substance has to be transformed into equivalent ethylene using an equivalency factor.

Hydrocarbon (HC) emissions come from burning fossil fuel. Estimates of HC emissions from building materials manufacture can be obtained by multiplying the amount of each material manufactured with its HC emission factor. We find that this industrial sector emits 141,468 tonnes, or 22.5% of Taiwan's total. Amongst building materials, steel production accounts for the highest proportion (65.35%).

CH_4 emissions amount to 109 tonnes and, as we just saw, HC 141,468 tonnes. Thus, the level of POCP (equivalent ethylene) is 53,334 tonnes. This figure shows that building materials manufacture contributes significantly to photochemical oxidant formation.

Eutrophication is mainly a consequence of the presence of ammonia (NH_3), ammonium (NH_4+), chemical oxygen demand (COD), nitrogen (N), nitrogen oxide (NOx) and phosphate (PO_4^{3-}) in the water. An estimate of the level of COD effluent from the manufacture of building materials can be obtained by calculating the COD emitted from each kind of material with its effluent factor. COD effluent from this sector comes to 38,153 tonnes (stone production accounting for the highest proportion at 61.89%). As large amounts of COD and NOx are generated from building materials manufacture, the emission volume of NP (equivalent PO_4) can be found by multiplying the emission volumes of NOx and COD with the nutrification potential, i.e., 16,184 tonnes.

5.1.6 Effects on Human Toxicity at the Manufacturing Stage

Most building material production processes emit poisonous substances such as lead(Pb), mercury (Hg) and carbon monoxide (CO). This section only deals with those human toxicity (HT) substances which are emitted as a consequence of energy consumption so CO, Pb, NOx and SOx are the major poisons under discussion - CO being released by building materials manufacture as a result of the burning of natural gas, coal and fuel.

An estimate of the CO emissions from building materials manufacture can be obtained by multiplying annual output with the types of energy used and their emission factors. We arrive at a figure of 2,650 tonnes (0.177% of Taiwan's total). Amongst building materials, cement production generates the greatest CO volume (997 tonnes or 37.6%), followed by reinforced steel bar production at 942 tonnes or 35.5%. The Pb emissions from building materials manufacture only come to 0.5 tonnes (0.2 % of Taiwan's total Pb emissions).

While assessing the human toxicity of every substance, the HT potential first has to be transformed into the volume relative to 1kg of the human body. The HT from this sector comes to 102,384 tonnes with NOx generating the greatest HT volume of 92,069 tonnes (89.9% of the total).

5.1.7 Atmospheric Pollution at the Manufacturing Stage

The manufacture of building materials produces atmospheric pollutants, the main ones being total suspended particulates (TSP), SOx, NOx, CO, CH_4, HC and Pb.

The total annual TSP emissions from the manufacture of building materials is 96,878 tonnes, or 14.8% of Taiwan's total. Amongst building materials, cement and pre-mixed concrete production raises the most (52,635 tonnes) which accounts for 54.3% of the TSP emissions from this sector and 8.08% of Taiwan's total. Concrete aggregate production follows, accounting for 12.46% of the sector's TSP emissions. Figure 5-5 illustrates the volume of TSPs emitted as a consequence of the manufacture of the major building materials.

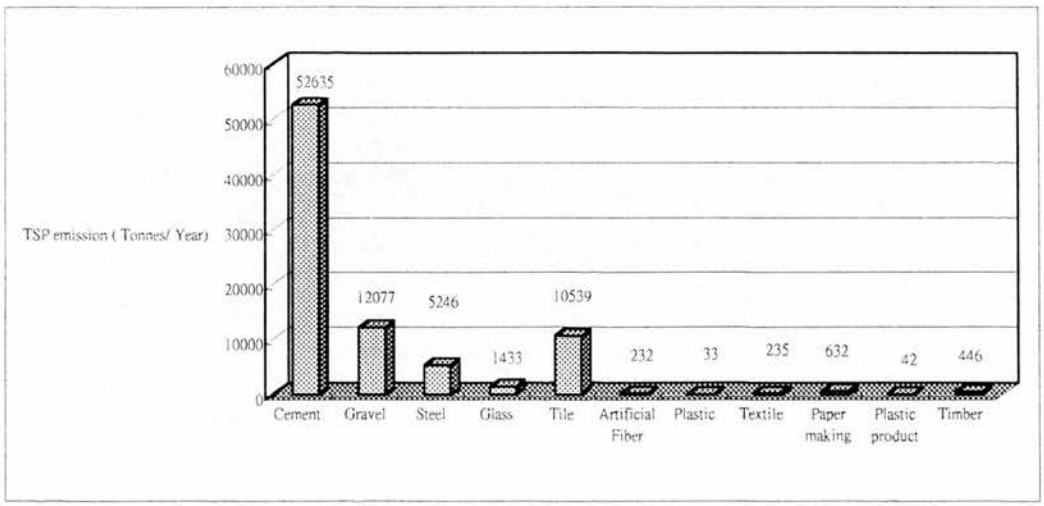

FIG. 5-5: TSP Emissions from the Manufacture of Major Building Materials

According to the critical dilution volume (CDV) formulation, the CDV of equivalent SO_2 (CDVA) is 313,042 tonnes. The level of the various air pollutants emitted from the manufacture of building materials is shown in Table 5-3. HC, at 22.5%, accounts for the highest proportion and NOx, at 18.26%, comes next.

Table 5-3: Emissions of Various Atmospheric Pollutants at the Manufacturing Stage

Material	Emission Volume (tonnes)	Rate of Total Emission Volume in Taiwan (%)
CO_2	27,950,000.0	16.40
CH_4	109.0	0.52
N_2O	1,180.0	17.92
SO_2	8,503.0	1.90
NO_x	118,038.0	18.26
CO	2,650.0	0.18
TSP	56,878.0	14.80
HC	141,468.0	22.50
Pb	0.5	0.20

5.1.8 Waterborne Waste at the Manufacturing Stage

The process of treating metal surfaces or electroplating metal products generates waste water containing heavy metals such as zinc, lead and cadmium which might result in soil pollution. There are 80,225 factories in Taiwan, 2,290 of them manufacturing products for the building trade (Liu 1994, p.26). In 1995, the manufacture of building materials generated 585.4 million tonnes of waste water with a BOD_5 emission volume of about 7,514 tonnes per year, as Table 5-4 shows. COD emission is 37,493 tonnes and SS 50,742 tonnes so the CDV of equivalent BOD (CDVW) at this manufacturing stage is 28,290 tonnes.

Table 5-4: Effluent from the Manufacture of Major Building Materials

Material	Waste water tonnes (million tonnes)	COD effluent (Tonnes)	BOD effluent (tonnes)	SS effluent (tonnes)
Gravel	506.99	23,616	3,573	35,714
Excavated stone	18.46	946		7,626
Steel	21.04	1,788	341	268
Aluminium door & window	0.07	13		268
Tile	5.49	281		1,829
Paint	33.36	10,849	3,600	5,294
Total	585.41	37,493	7,514	50,742

5.1.10 Effects on Landscape and Ecology at the Manufacturing Stage

Acquiring raw materials to make building products often adversely affects the natural ecology and landscape. Because of their greater production output, cement, gravel, glass and clay products have a greater environmental impact than other materials. Cement is the most commonly used material for building. It is the raw material for concrete and mortar and is mainly manufactured from limestone,

clay and shale. A power shovel is used to extract these raw materials from the hillside. They are then sent to factories with mine crushers/breakers to be broken into stones of less than 2.5cm and placed in storage warehouses before being further refined by grinding. The initial hillside quarrying destroys the natural landscape and ecology.

In 1950, Taiwan's total output of cement was only 390,000 tonnes. By 1994, 13 companies owning 18 cement factories with 38 production lines were producing 22.7 million tonnes annually - 58.2 times the output figure of 1950[5]. The distribution of cement factories is illustrated in Figure 5-6. Most are situated near limestone excavation sites and some of those mining areas are even in national parks. We can see that the limestone sites are mostly located in the mountains or near urban areas (e.g., Pan Ping Shan near Kaohsiung), affecting both natural and urban landscapes. [6]

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[5] In 1950, the Taiwan Cement Company had an annual output of 390,000 tonnes. Annual output reached 1 million tonnes in 1958 with 8 cement companies in business. By 1990, there were 13 cement companies with an annual output of 18.1 million tonnes. See Tsai et al.,1997, pp. 18-20.

[6] Pan Ping Shan is near downtown Kaohsiung. A flood of soil and stone occurred after excavation in 1995 which damaged the city. The mining field of the Central Mountains in Hualien is situated inside Troko National Park which, because of its influence on the region's ecology, has several times been a target of the environmental NGOs. In 1998, there was a dispute between the Construction & Planning Administration (CPA) and the Bureau of Mining Affairs over the excavation approval given to this site.

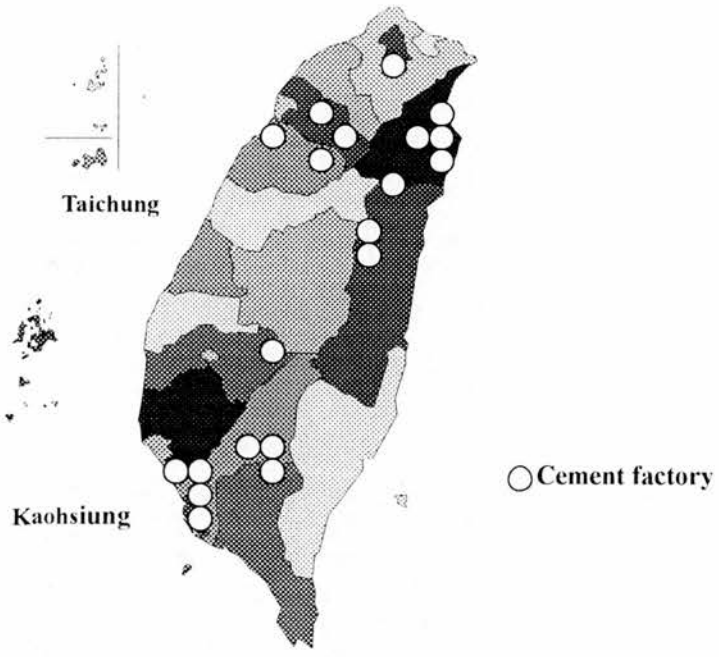

FIG. 5-6: Distribution of Cement Factories in Taiwan

About 26.1 million m^3 of pre-mixed concrete is produced in Taiwan every year. As 66%-78% of the components of concrete come from gravel etc.[7], this means that 17.6 million m^3 of aggregate is required per year. Excavation using explosives changes the ecology and landscape of river beds; hillside terrain is also altered radically since the process involves removing surface ground before excavation can begin. This baring of the ground erodes soil and increases the level of drainage water on the hills.

Taiwan's annual output of glass is 1.3 million tonnes. Glass is made either from a mix of acidic oxide and alkaline oxide or solely from one of those elements. After melting (at temperatures of 1400-1500°C) the glass is cooled, solidified and formed[8]. The materials that go into making glass also need to be mined. Two excavation methods are used in Taiwan, open and underground, the former being more common. There are currently more than 50 open excavation sites in Taiwan and these have a severe impact on the natural landscape.

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[7] See Lin, 1979, p. 173.

[8] See Tsai, 1997, p. 228.

Tiles and bricks are the most commonly used clay-based building materials, with an annual total output of 7.1 million cubic metres[9]. Clay is mainly found in the north and east of Taiwan. The noise and floating dust which result from excavating and calcimining clay also adversely affect the environment.

5.2 ENVIRONMENTAL ISSUES RELATING TO THE TRANSPORTATION OF BUILDING MATERIALS

Various pollutants are generated from the transportation of building materials. The major sources of input and output pollutants from this second stage of the building's life-cycle include the energy consumed, emissions (such as CO_2, CH_4, NO_x, TSP, SO_X, CO, Pb and HC), noise and traffic. Thus, we can group the environmental issues associated with this stage into the themes of energy consumption, raw material depletion, global warming, photochemical oxidant formation and eutrophication, acid precipitation, atmospheric pollution, noise, vibration and traffic.

Significant levels of pollutant are generated in this stage as a result of burning fossil fuel. Consequently, this section will mainly focus on estimating the emission volume of pollutants from the burning of petrol and diesel and the EPA's data on TSP emissions will also be considered.

5.2.1 Energy Consumption at the Transportation Stage

In 1994, the annual energy consumption of this activity came to 202.35 thousand kilolitres of oil equivalent, 0.31% of Taiwan's total energy consumption. Figure 5-8 illustrates that the transport of aggregate for construction consumes the most energy amongst building materials transportation (15.5%), followed by steel products (8.13%) and pre-mixed concrete (7.09%).[10]

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[9] Annual output is converted into a dimensional total output in compliance with the data of tiles and red bricks shown in Appendix D table D-2.

[10] See Yang, 1996, p. 12

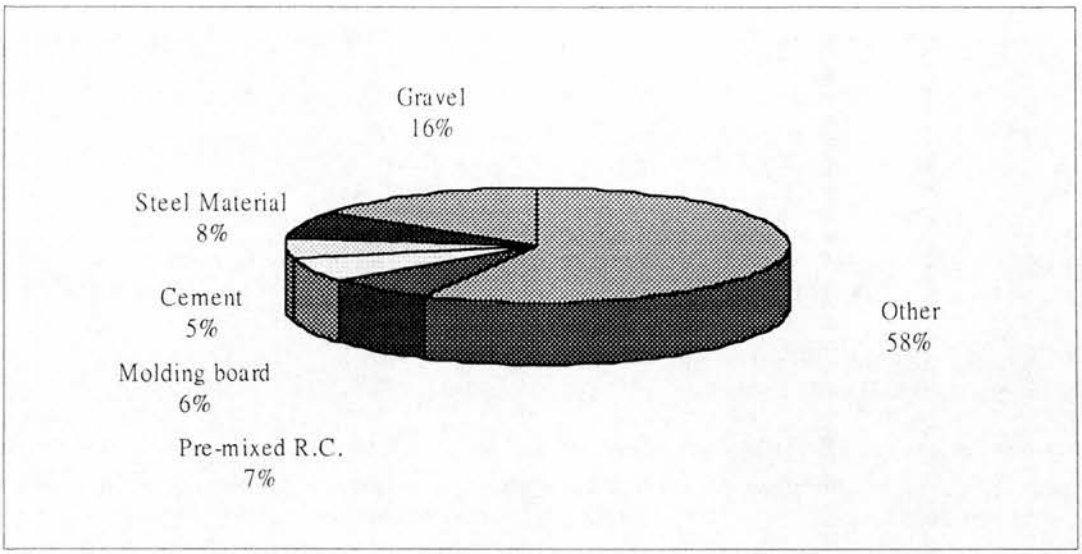

FIG. 5-8: Proportion of Energy Consumed by the Inland Transportation of Various Building Materials

5.2.2 Effects on Global Warming at the Transportation Stage

The prime contributor to global warming is the greenhouse gases emitted from the burning of fossil fuel (e.g., CO_2, CH_4, N_2O and CFCs), including that burned by vehicles. Quantified data on the global warming effect can be obtained by calculating how much petrol and diesel is consumed in relation to their emission factors, emission of CFCs and the equivalency factor of global warming.

Vehicles carrying building materials use petrol and diesel.[11] The level of carbon emissions can be obtained by first converting the amount of fuel used into a thermal value and then multiplying the respective carbon emission potential. The level of CO_2 emissions can be acquired by multiplying the total volume of carbon emissions with the carbon-oxidising rate and 44/12 (the weight ratio of CO_2 vs. carbon).[12]. Annual CO_2 emissions from this activity come to 558,266 tonnes (0.37% of Taiwan's total

[11] The consumption ratio between petrol and diesel is 1:36. See Yang, 1997, p.15

[12] Ibid, p. 15

CO_2 emissions and 2.01 % of the total of the transportation sector).[13]

Table 5-5: CH_4 Emissions at the Transportation Stage

Building Material	CH_4 Emission Volume (tonne/year)	Construction Material	CH_4 Emission (tonne/year)
Gravel	79.14	Paper-making	32.70
Steel	41.59	Plastic	7.19
Cement	27.32	Artificial Fibre Textile	5.79
Aluminium Products	13.44	Textile	3.04
Glass	9.07	Paint	12.15
Porcelain	18.22	Lighting Appliances	9.04
Timber	95.49	Electric Machinery	35.78
Concrete Products	44.12	Others	45.64
Brick	8.68		
Plastic Products	22.82	Total	511.22

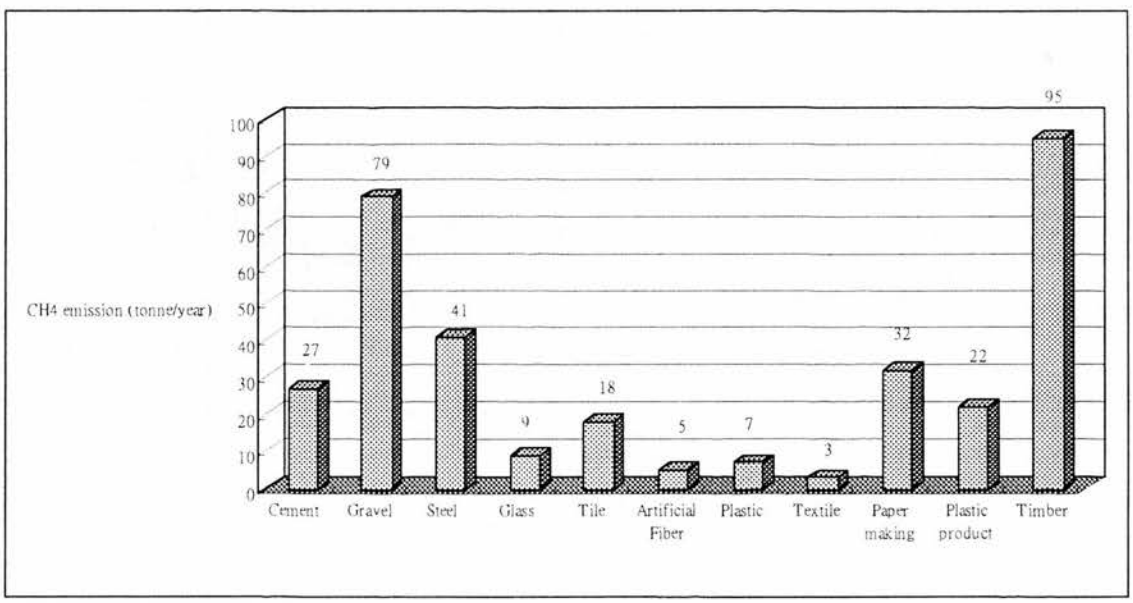

FIG. 5-9: CH_4 Emissions from the Transport of Various Building Materials

To estimate the level of NO_x produced from the transport of building materials we multiply the mileage of the various relevant transport trucks with the emission factor of dump trucks and vehicles to get the

[13] Ibid. p. 15

No_x and NO_2 emission as Table 5-6 show. The transport of building materials produces 29,276 tonnes of No_x which is 4.53% of Taiwan's total NO_x emissions and 7.90% of mobile pollution sources. Amongst building materials, the transportation of timber accounts for the largest proportion (5,469 tonnes or 18.68% of this activity's total) and second highest is gravel (4,529 tonnes).

The emissions of CFC_{11} and CFC_{12} come to 3.6 tonnes and 11.5 tonnes respectively (EPA 1998d). Following the GWP formula (GWP = 1* CO_2 + 9 * CH_4 +190*N_2O + 1500*CFC_{11} + 4500*CFC_{12}), the GWP emission (equivalent CO_2) is 675,641 tonnes.

Table 5-6: NO_x Emissions at the Transportation Stage

Construction Material	NO_x Emissions (tonne/year)	Construction Material	NO_x Emissions(tonne/year)
Gravel	4,529.78	Paper-making	1,875.51
Steel	2,377.92	Plastic	411.4
Cement	1,559.99	Artificial Fibre Textile	331.22
Aluminium Products	770.11	Textile	173.70
Glass	519.89	Paint	695.49
Porcelain/ Pottery	1,043.87	Lighting Appliances	517.99
Timber	5,469.48	Electric Machinery	2,048.76
Concrete Products	2,523.89	Others	2,622.30
Red Brick	498.27	Total	29276.18
Plastic Products	1,306.61		

5.2.3 Effects on Acid Precipitation at the Transportation Stage

Acid rain is the result of acidifying substances mixing with rain. It refers to the various processes by which man-made emissions of sulphur dioxide and nitrogen oxides come to be deposited on land and water, often at long distances from the source of pollution. Two major acidifying pollutants (SOx and Nox, whose acidification potential is 1.0 and 0.7 respectively) are associated with vehicle exhausts.

To estimate SO_x emissions from the transport of building materials we multiply the average SO_x emission factor of HDDT with the mileage traveled in carrying each building material, as Table 5-7 shows. The volume of emissions from transporting building materials per unit (kg) can be obtained by dividing the emission figure with the freight tonnage of each building material.

Table 5-7: SOx Emissions from Transporting Various Building Materials

Building Material	SOx Emission (tonne/year)	Building Material	SOx Emission (tonne/year)	Building Material	SOx Emission (tonne/year)	Building Material	SOx Emission (tonne/year)
Gravel	575.10	Timber	693.92	Artificial Fibre Textile	42.04	Porcelain	132.45
Steel	302.27	Concrete Products	318.66	Textile	22.08	Plastic	52.20
Cement	198.53	Brick	63.08	Paint	88.27	Others	331.66
Aluminium Products	97.68	Plastic Products	165.84	Lighting Appliances	65.71		
Glass	65.94	Paper-making	237.70	Electric Machinery	260.00	Total	3,713.13

The transportation stage of the building life-cycle emits 3,713 tonnes of SO_x (0.84% of Taiwan's total). Amongst building materials, transporting timber generates the largest proportion of emissions (693 tonnes or 18.66% of the SO_x emissions from this activity), while the transportation of gravel comes next at 575 tonnes (see Figure 5-10). As the emission of Nox is 29,276 tonnes and SOx 3,713 tonnes, the emission of equivalent SO_2 (AP) is 24,206 tonnes. Nox accounts for 84.6% of the total AP emission figure since the heavy vehicles used to transport building materials have a high Nox emission factor.

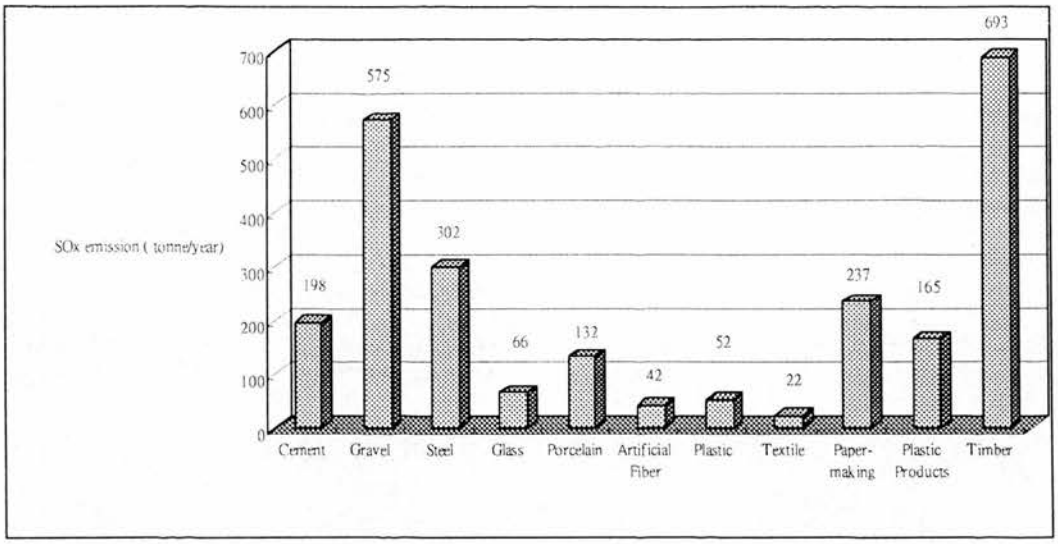

Fig. 5-10: SO_x Emissions from Transporting Major Building Materials

5.2.4 Effects on Photochemical Oxidant Formation and Eutrophication at the Transportation Stage

The main substances which contribute to photochemical oxidant formation at the transportation stage are CH_4 and hydrocarbon (HC). CH_4 emissions amount to 511 tonnes. The HC emissions from transporting building materials can be obtained by multiplying the average emission factor of HDDT with the freight mileage involved in transporting each building material. The HC emissions from transporting building materials come to 5,077 tonnes, 0.81% of Taiwan's total and 3.39% of the total of the road transportation sector.

Amongst building materials, the transportation of timber generates the highest volume of HC emissions (948.34 tonnes or 18.68% of the total for this activity), followed by gravel (785.95 tonnes or 15.49%). The equivalent ethylene (POCP) is 1,918 tonnes and HC emissions account for 99% of this.

While assessing the impact of this second stage on eutrophication, the equivalent phosphate (PO_4) must first be converted and then accumulated. Nox is associated with eutrophication. As we saw above, Nox emissions from this stage come to 29,276 tonnes and as this Nutrification Potential (NP) is 0.13,

the equivalent PO_4 (NP) is 3,806 tonnes.

Table 5-8: HC Emissions at the Transportation Stage (Unit: tonnes/year)

Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)
Gravel	785.95	Timber	948.34	Artificial Fibre Textile	57.45	Porcelain	181.00
Steel	413.08	Concrete Products	438.22	Textile	30.17	Plastic	71.32
Cement	271.31	Brick	86.21	Paint	120.63	Others	453.25
Aluminium Products	133.51	Plastic Products	226.65	Lighting Appliances	89.80		
Glass	90.11	Paper-making	324.84	Electric Machinery	355.31	Total	5077.15

5.2.5 Effects on Human Toxicity at the Transportation Stage

The transportation of building materials causes various toxic substances to be released including carbon monoxide (CO), lead (Pb), nitrogen oxide (NOx) and sulphur dioxide (SOx). To assess the toxic impact of these substances, the human toxicity potential (HT) has to be transformed and accumulated. We have already seen that Nox emissions amount to 29,276 tonnes and SOx emissions to 3,713 tonnes. In this section we will look at CO and Pb emission levels.

To estimate the CO emissions generated from the transportation of building materials, we multiply 11.1367 g/km - the average CO emission factor of big trucks - with the transportation mileage for each building material. The total figure comes to 16,135 tonnes (1.09% of Taiwan's total CO emissions). The transportation of timber accounts for the highest proportion (3,013 tonnes or 18.67% of the total emissions from transportation activities), followed by gravel (2,497 tonnes or 15.48%).

The Pb emissions from this second stage of buildings come to 0.7129 tonnes (0.22% of Taiwan's total). Again, the transportation of timber produces the greatest proportion within this building-related activity (0.1332 tonnes or 18.68%), followed by the transportation of gravel (0.1104 tonnes or 15.49%).

The emission of substances toxic to human beings has been assessed above. Total HT emissions

amount to 27,598.7 tonnes; NOx accounts for 82.7% of this total while Sox accounts for 16.1%.

5.2.6 Atmospheric Pollution at the Transportation Stage

Vehicles carrying building materials generate pollutants such as CO_2, CH_4, N_2O, NOx, SOx, CO, P_b HC and TSP from their burning of fossil fuel. The emission levels of most of these pollutants have already been calculated and discussed, so this section will focus on TSP emissions.

To estimate the TSP emissions generated from the transportation of building materials, we multiply the average TSP emission factor of HDDT with the transportation mileage for each building material. The figure comes to 4,347 tonnes - 7.05% of TSPs emitted by the road transport sector - though it does not include the fine floating particles thrown up by the movement of vehicles. This latter kind of emission comes to 17,080 tonnes. Hence, the total amount of TSPs emitted in this second stage is 21,428 tonnes (3.3% of Taiwan's total).

Table 5-9 lists the volume of each air pollutant. Nitrogen oxide (NO_x) has the highest rate (4.53% o Taiwan's total NO_x emissions); dinitrogen oxide (N_2O) accounts for 4.43% of Taiwan's total N_2C emissions; and TSP account for 3.3% of Taiwan's total TSP emissions.

Table 5-9: Emissions of Atmospheric Pollutants at the Transportation Stage

Substance	Emission (tonnes)	Rate of Total Emission in Taiwan (%)
CO_2	558266.00	0.3
CH_4	511.00	3.0
N_2O	292.00	4.4
SO_x	3713.00	0.8
NO_x	29276.00	4.5
CO	16136.00	1.0
Pb	0.71	0.2
TSP	21428.00	3.3
HC	5077.00	0.8

The CDV model can be applied to assess the effect of the second stage on atmospheric pollution Using the CDV formula, we find that the CDV of equivalent SO_2 at this stage is 643,348 tonnes, abou twice as much as that found at the first stage the building life-cycle.

5.2.7 Noise Pollution at the Transportation Stage

The experience of those subject to noise is influenced by three factors: the components of noise; the transmission path from the noise source to the receiver (i.e., direct sound, reflected sound and ground-borne vibrations); and the hearers themselves. Noise decreases with distance and increases by the increment of the noise source. Generally speaking, a doubling of the intensity of a sound leads to an increase of 3dB(A). An increase of 10dB(A) is usually heard by the human ear as a doubling of sound, while an increase of below 3dB is barely detectable[14].

Table 5-10 shows levels of noise pollution. Noise increase of less than 3dB is acceptable while increases of between 3-5dB have only a minor impact. Noise increase of over 5dB has moderately adverse impacts and requires that some mitigation measures be put in place. However, the environmental impact of traffic noise varies depending on location. For instance, regulations against noise pollution are more strict in the vicinity of hospitals and schools than they are in business districts. As the transportation of building materials involves a daily mileage of 3,696,791km, we can see that the noise of this activity is indeed significant.

Table 5-10: Noise Significance Criteria

Criterion	Construction Noise	Traffic noise
severe adverse	noise above traffic noise insulation thresholds for > 8 weeks; insulation or permanent rehousing required	> 15 dB increase
major adverse	noise above traffic noise insulation thresholds for < 8 weeks; insulation or temporary rehousing required	10-15 dB increase
moderate adverse	noise above ambient levels for > 8 weeks, but below traffic noise insulation thresholds	5-10 dB increase
minor adverse	noise above ambient levels for < 8 weeks, but below traffic noise insulation thresholds	3-5 dB increase
none	noise at or below ambient levels	< 3 dB increase

Data source: Morris, et al., 1995, P. 60.

[14] See Morris, et al., 1995, pp. 51-54

5.2.8 Traffic Impacts at the Transportation Stage

Building materials are mainly carried by road, and trucks are the vehicles most commonly used. The transportation of building materials accounts for a quarter of all the freight tonnage transportation in Taiwan - about 190,000 freight tonnes per day, i.e., each truck has a capacity of c.10 tonnes and there are about 19,000 of them moving on the roads each day.

Taiwan's traffic volume increases each year; the annual growth rate is around 8% (e.g., in 1996, it was 8.12%). Table 5-11 shows the road area available for each car in Taiwan between 1991 and 1996. In 1991, each car occupied an average of 23.72m^2 of road space but by 1996 this had decreased to 22.42m^2 per car. As traffic congestion becomes more common, there are not only more traffic jams and accidents but more energy is consumed too.

Table 5-11: Proportion of Road Area to Vehicles in Taiwan (1991-1996)

Year	Road Area (,000 m^2)	Number of Vehicles (car)	Road Area for Each Car (m^2/car)
1991	251,649	10,611,037	23.72
1992	270,310	11,268,253	23.98
1993	283,408	11,856,528	23.90
1994	296,707	12,377,084	23.97
1995	310,139	13,201,471	23.49
1996	319,757	14,273,465	22.40

5.3 ENVIRONMENTAL ISSUES RELATING TO THE CONSTRUCTION STAGE

During the third phase of the building life-cycle - the construction process - building work consumes energy (e.g. through the use of power machinery) and natural resources (e.g., water) and emits several kinds of pollutants. In addition, the construction process impacts on the surrounding environment with its noise, vibration and alteration of underground water courses. This section will analyse the main environmental issues associated with this third stage: energy depletion, consumption of water resources, global warming, acid precipitation, photochemical oxidant formation and eutrophication, human toxicity, atmospheric pollution, waterborne pollution, solid waste disposal, traffic, noise and vibration and socio-economic impacts.

5.3.1 Energy Consumption at the Construction Stage

According to data provided by the Energy Committee, the construction industry consumes 217,000 kilolitres of oil equivalent per year (0.4% of Taiwan's total energy consumption). Fuel oil accounts for the highest proportion (44.5%), followed by diesel (37.4%), electric power (15.6%) and petrol (2.5%). Liquid energy is the primary form of energy consumed in the construction stage, accounting for 84.4% of the total energy consumed by the building trade; the movement and installation of building materials and equipment on-site are mostly powered by liquid fuel, as are the earthwork machines. Though temporary electric power is also needed, the requirement is quite modest.

During construction, energy is used for building and civil engineering. Their respective rates of power and fossil fuel use are 30.89% and 69.11%. Thus, the amount of energy it takes to construct buildings is 6,7031kilolitres oil equivalent or 603,282 million kcal. During the construction stage, the energy consumed per unit floor area annually is 15,186 Kcal (equal to 1.69 litres/m^2 of equivalent oil).[15]

5.3.2 Water Consumption at the Construction Stage

During the construction process, water is needed for mixing reinforced concrete, sprinkling the site, washing cars and for various kinds of concrete engineering.

During the construction stage, the amount of water needed for concrete mixing is about 180kg/m^3 and for concrete curing about 220kg/m^3. The mixing of cement mortar per m^3 requires 270kg of water[16]. It is estimated that the volume of water needed in the construction stage in 1996 was 102.5 million m^3 (0.51% of Taiwan's total water consumption).

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[15] The energy costs of construction are £53.78m and civil engineering £120.32m, 30.89% and 69.11% respectively. See Yang, 1996, p. 12

[16] Estimated from data provided by Mr. Hsiao Chia Ching

5.3.3 Effects on Global Warming at the Construction Stage

The burning of fossil fuel generates greenhouse gases such as CO_2, CH_4 and N_2O. CO_2 in particular is a major greenhouse gas. CO_2 emissions at the construction stage can be converted into a thermal value unit using the energy consumption and then multiplied by the carbon emission factor and the oxidation rate of carbon to give us the level of carbon emissions. According to Yang (1996), the CO_2 emissions of a unit floor area during the construction stage is 4.48 (kg/m^2).[17]

Table 5-12 shows the level of CO_2 emissions from construction work, and its proportion of Taiwan's total (i.e., around 0.11%-0.17%) from 1990 to 1996. In 1990, CO_2 emissions from the construction process came to 140,094 tonnes (0.12% of Taiwan's total) but by 1996, this had increased to 204,778 tonnes - an increase of 46.17% over the figure in 1990. Despite this, CO_2 emissions from construction work that year only accounted for 0.12% of Taiwan's total exhaust volume. What this reveals is that national CO_2 emissions are greatly increasing and that the rate of increase nationally is higher than the rate found in the building sector.

Table 5-12: CO_2 Emissions at the Construction Stage

Year	Number of buildings	Total Floor Area (m^2)	CO_2 Emission (tonne)	Total CO_2 Emissions in Taiwan (thousand tonne)	Percentage of total emission in Taiwan(%)
1990	52,856	31,271,059	140,094	118,522	0.12
1991	50,146	31,995,034	143,337	127,987	0.11
1992	61,919	36,922,351	165,412	136,076	0.12
1993	72,872	47,542,986	212,992	147,078	0.15
1994	68,494	58,159,322	260,553	154,835	0.17
1995	60,854	55,262,803	247,577	165,394	0.15
1996	47,994	45,709,423	204,778	171,054	0.12

Construction work generates CH_4 emissions as a consequence of the energy it consumes. According to Yang (1996), the construction stage produces 1.542×10^{-4} kg/m^2 of CH_4 emissions per unit floor area.[18] The annual exhaust comes to 7.05 tonnes (0.041% of Taiwan's total).

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[17] See Yang, 1996, p. 16

[18] See Ibid., 1996, p. 16

The figure in 1990 was only 4.83 tonnes but, by 1994, this had increased to 8.97 tonnes - an annual growth rate of 21.4% between 1990 and 1994. After 1995, when the construction industry in Taiwan became bearish, CH_4 emissions also decreased. By 1996, 7.05 tonnes were emitted, a decrease of 17.3% on the previous year. The average annual growth rate from 1990 to 1996 was around 7.6%, indicating that CH_4 emissions from construction work is still on the increase despite the peculiarities of the market in the mid '90s.

According to Yang (1996), the construction process generates about 1.26×10^{-4} kg/m^2 of N_2O emissions per unit floor area,[19] which means that NO_X emissions amount to 1.26×10^{-2} kg/m^2. The figure in 1990 was 394 tonnes, increasing to 732 tonnes in 1994. After that, NO_X emissions began to decrease; by 1996, they amounted to 575 tonnes (0.09% of Taiwan's total).

The global warming potential (GWP) is related to 1kg of CO_2. Accordingly, the GWP of CO_2 is 1; CH_4 is 9; and H_2O is 190. As a result, the GWP at the construction stage is 205,981 tonnes and CO_2 accounts for 99% of that. It is clear that CO_2 is the dominant contributor to the global warming effect, far outstripping CH_4 and N_2O.

5.3.4 Effects on Acid Precipitation at the Construction Stage

As mentioned earlier, acid rain is produced by the mix of acidifying substances with rain. These substances mainly refer to SOx and NOx and also ammonia (NH_3).

The SO_X emissions of the construction stage are mainly due to the operation of construction machinery and the exhausts of transportation vehicles. The level of SO_X emissions from the use of construction machinery can be acquired by multiplying the operational duration of each machine with the emission factor. According to EPA data, construction machinery in Taiwan, used across all sectors, generates 284 tonnes of SO_X emissions. Construction machinery specifically related to the building trade

[19] See Ibid, 1996, p. 17

generates 88 tonnes (0.02% of Taiwan's total SOx emissions).

SOx emissions also come from the exhausts of transportation vehicles. At the construction stage, residual soil comes to 30,090,932 cubic metres.[20] If the loading capacity of dump trucks is $10m^3$ and the distance traveled is 30km (60km for a round trip) then the SOx emission is 463 tonnes.

The analysis above shows that SO_X emissions from the construction stage amount to 551 tonnes annually (0.124% of Taiwan's total) which means that each unit (m^2) of floor area generates 9.97×10^{-3} kg of SO_X. The AP (equivalent SO_2) comes to 954.4 tonnes, SOx accounting for 58.8% of that. We can see from this analysis that the construction stage does not significantly contribute to the acid rain effect.

5.3.5 Photochemical Oxidant Formation and Eutrophication at the Construction Stage

The primary substances which contribute to photochemical oxidant formation are CH_4 and hydrocarbons (HC). We have already estimated that CH_4 emissions from the construction stage come to 7.05 tonnes. Hydrocarbon emissions from construction work stem mainly from the evaporation of organic solvents (such as paint) and also from the operation of construction machinery and vehicles.

According to EPA statistics (1997a), the painting of buildings generates 54,121 tonnes of hydrocarbon emissions (8.617% of Taiwan's total); per unit of floor area (m^2) the average comes to 0.979 kg/m^2. The hydrocarbons emitted as a consequence of using construction machinery (from all sectors in Taiwan) amount to 349 tonnes, and 30.8% of these (108 tonnes) are accounted for by building-related

[20] To estimate the volume of earthwork, we multiply the number of excavated floors including all basements as per the data supplied by the Construction & Planning Administration with the excavated area. If there is one underground floor, the excavation depth is five metres; two underground floors, six metres; three, 11 metres; four or more, 15 metres. The excavated area is 20% of the total floor area. Buildings without basements are excavated to a depth of 1.5 metres and the excavated area is one third of the total floor area.

construction machinery. The hydrocarbon emissions from transportation vehicles can be obtained by multiplying the mileage of those vehicles with the average emission factor (3.504 g/km), giving us a figure of 633 tonnes. Accordingly, we find that hydrocarbon emissions from the construction stage come to a total of 54,862 tonnes. Paint work accounts for almost all of this (98%) and, on average, $1m^2$ of floor area generates $0.99kg/m^2$ of hydrocarbons. Consequently, the photochemical oxidant creation potential (equivalent ethylene) is 20,682 tonnes per year with hydrocarbon emissions accounting for 99.9% of it.

Eutrophication is caused by the effluence of pollutants into lochs and reservoirs. To assess the impact of this stage on eutrophication, the NP can be obtained by transforming NOx emissions into equivalent phosphate giving us a figure of 74.88 tonnes - only 0.46% of that produced in the first stage and 1.97% of the second. This shows that the construction stage has less impact on eutrophicatlon than the first two stages of the building life-cycle.

5.3.6 Effects on Human Toxicity at the Construction Stage

The pollutants toxic to humans which are emitted at the construction stage are mainly NOx, SOx (or SO_2) and CO. We have already looked at NOx and SOx emissions, so we will now discuss CO. The major source of CO pollution from construction work is the exhausts of plant machinery and construction vehicles. Thus, the emission volume from each must first be calculated separately prior to establishing a total volume.

CO emissions from the operation of construction machinery can be obtained by multiplying the duration each machine is used with its emission factor. According to EPA(1997a) statistics, CO emissions from all types of construction machinery in Taiwan is 3,647 tonnes, 1,127 tonnes of that emanating from building work. The CO emissions of vehicle exhausts can be obtained by multiplying the emission factor with mileage. The number of trips needed to transport soil comes to 3,009,093 so the CO emissions amount to 2,011 tonnes. Based on these estimates, total CO emissions from the

construction stage come to 3,138 tonnes (0.21% of Taiwan's total) and each $1m^2$ of floor area generates 0.057kg of CO on average.

Thus, the HT from this stage is 1,148 tonnes; SOx accounts for 57.6% of it and Nox 39.1%. Comparatively, the impact of the construction stage on the human toxicity effect is much less than that of the first two stages.

5.3.7 Atmospheric Pollution at the Construction Stage

Various air pollutants are released during the construction stage from the operation of machinery and vehicles and from the clearance of the surface of the construction site, the most important being TSP, SOx, NOx, CO and HC. We will focus in this section on TSP emissions as the others have already been considered in previous sections.

There are three sources of TSP from the construction process: floating dust from building activities; construction machinery exhausts; and dust raised by construction vehicles in motion. In addition to particulate pollutants, exhausts from construction machinery also emit CO, HC, NO_X and SO_X. Transportation also generates various air pollutants.

Using the 1995 data we have already mentioned, we find that TSP emissions from the construction stage amount to 39,000 tonnes (6.0% of Taiwan's total) and each unit of floor area generates 0.706kg of TSPs on average. Table 5-13 lists the emission volumes of the various pollutants associated with the construction stage. Construction-related HC emissions account for the highest proportion (from the construction stage) of Taiwan's total HC volume (8.7%) followed by TSP emissions from this stage which account for 6% of Taiwan's total TSP emissions. The CDV is obtained by dividing the emission volume of the various atmospheric pollutants with the emission standard(g/vol.), giving a CDV of equivalent SOx of 170,039 tonnes.

Table 5-13: Emissions of Various Atmospheric Pollutants at the Construction Stage

Substance	Emission (tonnes)	Rate of Total Emission amount in Taiwan (%)
CO_2	204,778	0.20
CH_4	7	0.04
N_2O	6	0.09
SO_x	551	0.12
NO_x	576	0.09
CO	3,138	0.21
TSP	39,000	6.00
HC	54,862	8.70

5.3.8 Waterborne Pollution at the Construction Stage

The main sources of waste water at the construction stage are from workers' sewage, site cleaning, car washing and concrete works. The greatest volume stems from the first two of these sources: the construction process generates 215,973 CMD of waste water from workers' needs and 401 CMD from cleaning. As the major component in the waste water that comes from cleaning is muddy sand, a precipitation pool is usually installed for recycling purposes. Construction workers living on-site produce 40g of BOD_5 per person per day while commuting workers produce 30g of BOD_5. As a result, the daily effluence volume of BOD_5 is 21.6 tonnes whose annual BOD5 emissions come to 7,883 tonnes.

Annual emissions of COD and SS from workers' waste water amount to 15,766 tonnes and 7,883 tonnes with respective emission concentrations of 200mg/l and 100mg/l. As for waste water from cleaning, BOD emissions come to 14.6 tonnes; COD 29.2 tonnes; and SS 14.6 tonnes. The total CDV of equivalent BOD is 16,111 tonnes.

5.3.9 Solid Waste Disposal at the Construction Stage

The sold waste from construction work can be grouped into two types: residual materials (e.g., moulding boards, mortar, tiles, glass, wood, bricks and reinforced steel bars) and general waste (e.g., packaging and the various trash of the staff). Some of this waste can be recycled (e.g. reinforced steel bars) but other types end up as rubbish. Of the 1,830,654 tonnes of residual waste, 898,464 tonnes of it is waste moulding boards; 183,020 tonnes waste mortar; 379,046 tonnes waste tiles; 3,016 tonnes waste

glass; 39,515 tonnes waste timber; 238,003 tonnes waste bricks; and 89,590 tonnes waste reinforced steel bars.

Staff's waste is set at 1kg per worker per day, giving 719,910 tonnes daily of this kind of rubbish at the construction stage. In 1996, the construction stage generated 2,550,564 tonnes of rubbish in total (29.31% of Taiwan's annual total) with each square metre of floor area generating an average of 55.8kg of waste. The excavation of basements and foundations also produces waste soil - about 30,090,932m^3 of it annually, using the earthwork estimates cited earlier.

5.3.10 Traffic Impacts at the Construction Stage

The construction stage attracts journeys by commuting workers and by construction vehicles. The mai traffic implications of construction work are deterioration in the LOS on nearby roads, obstructed traffi flow due to machinery temporarily occupying roads, and increased parking demands.

Looking first at LOS deterioration, our focus is on vehicles used for construction, transportation an commuting purposes. Construction vehicles do not contribute significantly to traffic volume except fo the short period when machinery is being moved. Transportation vehicles (i.e., earthmovers shippir waste soil) make 3,009,093 trips every year - on average, about 10,000 trips per day. The cars carryir commuting staff tend to affect LOS only at morning and afternoon rush hour, and the extent to whic they make a significant difference depends on the number of cars involved.

The impact of the construction stage on traffic flow is most marked during the foundation excavatic phase. Excavation entails construction machinery and materials being left temporarily on the roadsid In addition, as the excavation phase coincides with the lifting and shipping of construction material cranes usually occupy a large portion of the road space during that phase, reducing the number available car lanes.

5.3.11 Noise and Vibration at the Construction Stage

Noise at the construction stage comes from building lorries (e.g. earthmovers and vehicles carrying plant) and machinery (e.g., cranes, power shovels and pumps for concrete). Though the noise of construction work is temporary, ceasing on the completion of each particular procedure, some of it can be deafening nevertheless. Piling machines can reach 97-107 dB(A) and pumps for concrete 86-92 dB(A), as we saw in Chapter Nine. The noise of transportation vehicles depends on how many there are on the site; how many journeys they make; how long those journeys take; and the distance they must travel.

The main sources of vibration in the construction stage are from machinery (e.g. compressors and piling machines) or from the roads (caused by the heavy dump trucks moving shifted soil, for example). As Taiwan has no specific regulations governing the nuisance of vibration, noise controls are usually enforced to decrease the impact of vibration. In Chapter Eight, we saw the impact of vibration on neighbouring buildings and local residents. Vibration can have a greater or lesser impact on surrounding buildings and local people's well-being depending on how near the receiver is to the groundborne vibration. Serious vibration damage may include structural fissuring and cracking in nearby buildings. The comfort of local residents, while awake or asleep, may also be compromised.

5.4 ENVIRONMENTAL ISSUES RELATING TO THE OCCUPANCY STAGE

The environmental impact of buildings is more critical at the occupancy stage than at any other phase in the building life-cycle; the sheer length of this stage makes buildings' accumulated impacts more significant. The main environmental issues associated with this stage are: energy consumption, water consumption, effects on global warming and depletion of the ozone layer, acid rain, photochemical oxidant formation and eutrophication, human toxicity, atmospheric pollution, waterborne waste, solid waste disposal, traffic and noise and vibration.

5.4.1 Energy Consumption at the Occupancy Stage

Electric power is the dominant way energy is consumed during this stage. The extent to which other forms of energy are used depends on the purposes of the buildings. For example, although electricity is the main energy source for houses, some fossil fuel is also burnt, e.g., natural gas or liquefied petroleum gas (LPG).

In 1995, the energy consumption of residential buildings was 8.25 million kilolitres of oil equivalent (11.8% of Taiwan's total energy consumption).[21] Electric power is the dominant energy source (74%), followed by LPG (17.7%) and natural gas (8.3%).[22] If we divide residential energy consumption by the number of households, then the average amount of energy used by each household is 12,790,067 Kcal (i.e., 1.42 kilolitres of oil equivalent per household year). Households use electricity mainly for lighting, air-conditioning and electric appliances while gas fuel is used for cooking and hot water. Energy consumption per unit of floor area can be obtained by dividing total residential energy consumption with total residential floor area, giving us a figure of 114,195 Kcal/m^2.per year.

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[21] In 1990, the energy consumed by households was 5.93 million kilolitres of oil equivalent (or 11.4% of Taiwan's total). The difference in proportion between 1990 and 1995 indicates that households' consumption share is increasing annually. See MOE, 1996, pp.28-32.

[22] See Yang, 1996, p. 17

Table 5-14: Energy Consumption of Various Types of Building in Taiwan

Type of Building	Type of Consumed Energy	Consumed Energy of a Unit Floor Area (kcal/m^2.yr)	Rate	Fuel Consumption of a Unit Floor Area
Residence	Power	84,504	74.00	38.83 KWH/m^2Year
	LPG	20,212	17.70	3.37 l/m^2Year
	Natural Gas	9,479	8.30	1.05 m^3/m^2Year
	Total	114,195	100.00	
Office	Power	141,335	100.00	65.22 KWH/m^2Year
commerce	Power	308,839	99.74	142.0 KWH/m^2Year
	Natural Gas	805	0.26	0.09 m^3/m^2Year
	Total	309,644	100.00	
Hotel	Power	176,374	40.90	81.05 KWH/m^2Year
	Fuel for Boiler	111,098	25.70	12.6 l/m^2Year
	Fuel	103,752	23.90	11.28 l/m^2Year
	Natural Gas	41,067	9.50	4.6 m^3/m^2Year
	Total	432,291	100.00	
Hospital	Power	185,173	62.08	85.10 KWH/m^2Year
	Fuel for Boiler	7,248	2.43	0.82 l/m^2Year
	Fuel	77,553	26.00	8.43 l/m^2Year
	Diesel	4,356	1.46	0.50 l/m^2Year
	Natural Gas	23,952	8.03	2.66 m^3/m^2Year
	Total	298,282	100.00	
School	Power	43,998	100.00	20.22 KWH/m^2Year

Electricity is the dominant energy source of office buildings (99.74%). In summer, air conditioning consumes 58,188 Kcal/m^2 Per Year (26.74 KWH/m^2Year)[23], (41% of office buildings' total energy use). The annual energy consumption of commercial buildings is 1.22 million kilolitres of oil equivalent (see Figure 5-11), which represents 1.74% of Taiwan's total.

[23] See Pan, 1999, p. 42.

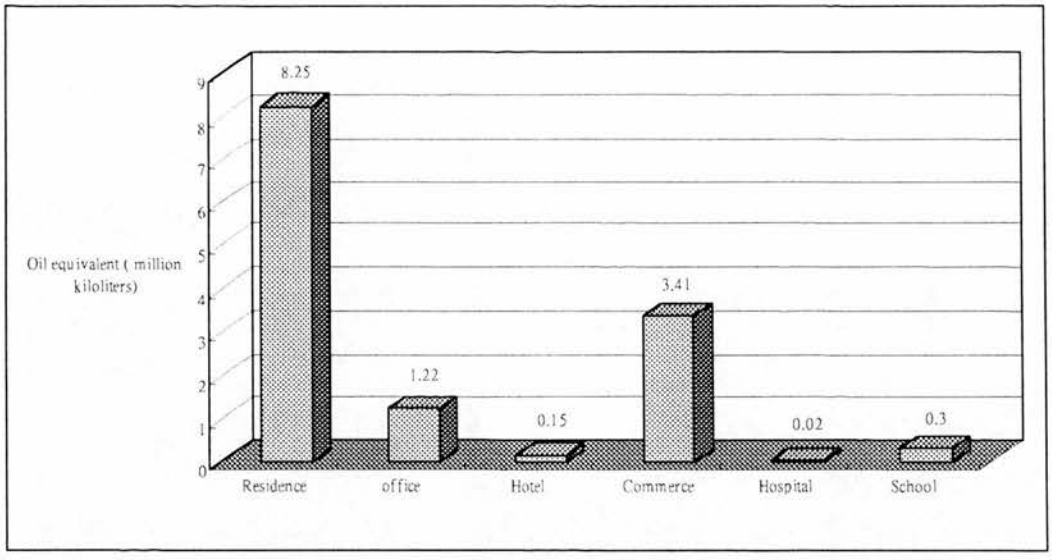

FIG 5-11: Energy Consumption of Various Types of Building

On average, the energy consumption of commercial buildings per unit floor area is 309,644 Kcal/m^2 Year (see Table 5-14). Their annual energy consumption is 3.41 million kilolitres of oil equivalent (4.87% of Taiwan's total).

As hotels provide a round-the-clock service most of their consumed energy is spent on providing hot water and restaurants, using liquid and gas fuel energy sources. Electricity meets their air conditioning, lighting and equipment needs. Hotels' energy consumption per unit floor area is 432,291 Kcal/m^2 Per year (3.8 times greater than the equivalent measure for residential buildings). Their annual energy consumption is 148,000 kilolitres of oil equivalent (0.19% of Taiwan's total).

Hospitals are like hotels in that they provide 24-hour care, consuming energy in the form of electric power, fuel (26%) and natural gas (8.03%). Their energy consumption per unit of floor area is 298,282 Kcal/m^2 per year. Generally speaking, their annual energy consumption is 21,200 kilolitres of oil equivalent (0.03% of Taiwan's total).

Electricity supplies lighting and air conditioning for school buildings and their energy consumption per unit of floor area is 43,998 Kcal/m^2 Per Year. Their annual consumption is 292,000 kilolitres of oil

equivalent (0.42% of Taiwan's total).

The analysis conducted in this section shows that energy consumption at the occupancy stage accounts for 19.05% of Taiwan's total. Residential buildings use the highest proportion (11.8%) followed by commercial buildings (4.87%) and offices (1.74%). The total energy used at this stage comes to 13.34 million kilolitres of oil equivalent.

5.4.2 Water Consumption at the Occupancy Stage

During this stage, water is mainly used for daily living and for generating power. For the most part, surface water is the source. In 1993, the volume of water used for daily living in Taiwan was 2,771 million m^3, 16.20% of the total annual water volume, with each person using 132.3m^3 on average. It is estimated that by 2001 the water needed annually for daily living will be 3,479 million m^3 or 16.86% of Taiwan's total water volume (EPA 1997a, p.105).

5.4.3 Effects on Global Warming at the Occupancy Stage

The volume of CO_2 emissions per unit floor area and total CO_2 emissions associated with various types of building are listed in Table 5-15.

Table 5-15: CO_2 Emissions from Various Types of Building at the Occupancy Stage

Type	CO_2 Emissions Per Unit Floor Area (kg/m^2 year)	CO_2 Emissions (thousand tonnes/year)	Rate of CO_2 Emission in Taiwan (%)
Residence	30.67	19,942	12.05
Office	38.84	3,022	1.83
commerce	84.76	8,919	5.39
Hotel	126.03	388	0.23
Hospital	85.03	54	0.03
School	12.04	720	0.37
Total		33,045	19.90

Of the different types of building, residential buildings emit the most CO_2, (12.05 % of Taiwan's total CO_2 emissions), followed by commercial buildings (5.39%). Overall, the CO_2 emissions from occupied buildings account for 19.9% of Taiwan's total. Hotels emit the highest level of CO_2 per unit

floor area (126.03kg/m^2 per year), followed by hospitals (85.03kg/m^2 per year) and commercial buildings (84.76kg/m^2 per year).

To estimate the volume of CH_4 emitted, we multiply the energy consumed with each kind of emission factor (i.e., based on whether the building is commercial or residential).

Per unit of floor area per year, hotels emit the highest volume of CH_4 (1.43×10^{-3} kg/m^2), followed by commercial buildings (1.15×10^{-3} kg/m^2), while schools emit the least (1.63×10^{-4} kg/m^2). In terms of total volumes, residential buildings emit the most (295.84 tonnes/year), accounting for 63.5% of the volume emitted at the occupancy stage.

To estimate N_2O emissions we multiply the volume of NO_x emission with the transformation factor and this volume can be obtained by multiplying energy consumed with the associated emission factor. The N_2O emissions of each type of building. Per unit of floor area per year, hotels emit the most(2.05×10^{-3} kg/m^2) followed by commercial buildings and hospitals (1.63×10^{-3} kg/m^2), while schools emit the least (2.33×10^{-4} kg/m^2).

Residential buildings emit the most N_2O (324.45 tonnes/year), accounting for 54.06% of the total N_2O emitted at this stage; commercial buildings emit 161.91 tonnes/year (26.98%); and offices 58.35 tonnes/year. These three kinds of building account for 90.76% of the N_2O emitted from occupied buildings.

According to EPA statistics on CFC_s consumption in Taiwan (EPA, 1998d), CFC_{11} and CFC_{12} come to 96 tonnes and 89 tonnes respectively. $HcFc_{22}$ comes to 4,233 tonnes and $HcFc_{123}$ 3,419 tonnes. Central air conditioners are the application most responsible for generating CFCs.

The main greenhouse gases emitted at the occupancy stage are CO_2, CH_4, N_2O, CFC_{11}, CFC_{12}, $HCFC_2$

and $HCFC_{123}$. Thus, the GWP amounts to 33,443 thousand tonnes/year.

5.4.4 Effects on Ozone Depletion at the Occupancy Stage

Taiwan started to control its production and consumption of CFCs in July 1989. The import of CFC equipment was banned in 1996 and stocks remaining in the country are subject to approval and control before they can be used. According to EPA statistics of 1998, CFC_{11} and CFC_{12} emissions only came to 96 tonnes and 89 tonnes respectively. Hydrochlorofluorocarbons (HCFCs) with a low ODP are also included in the Montreal Protocol as a control material, so the volume of HCFCs has also been limited.

To estimate the threat posed by ODSs like CFC we can take the ozone depletion potential (CFC_{11} = 1) as the basis. The formula for calculating CFC_{11} equivalent (ODP) is as follows:

$$ODP = 1 \times CFC_{11} + 1 \times CFC_{12} + 0.05 \times HCFC_{22} + 0.014 \times HCFC_{123}$$

The rate of emission to the atmosphere is about 10%. According to the formula above, the CFC_{11} equivalent during the occupancy stage comes to 44.5 tonnes and its major source is $HCFC_{22}$.

5.4.5 Effects on Acid Precipitation at the Occupancy Stage

Commercial buildings emit the greatest amount of SO_2 per unit floor area per year (0.27 kg/m^2) followed by hospitals at 0.16 kg/m^2. Nevertheless, in terms of total annual emissions from occupied buildings, residential buildings head the league at 45,514 tonnes (10.21% of Taiwan's total). The major source is from the use of electric power. LPG, which accounts for 17.7% of households' energy consumption, only generates 848 tonnes/year (a mere 1.8% of the SO_2 emissions from residential buildings). Natural gas, which accounts for 8.3% of households' energy consumption, only generates 8 tonnes per year (0.02% of the SO_2 emissions from residential buildings). This data shows that electricity used by residential buildings is the main cause of their SO_2 emissions. Commercial buildings generate the second highest emission of SO_2 at 26,818 tonnes/year (6.02% of Taiwan's total). In total, occupied buildings account for 19.43% of Taiwan's total SO_2 emissions.

The AP (equivalent SO_2) is 128,624 tonnes/year. SO_2 accounts for 67.3% of AP and the occupancy stage produces the most AP within the building life-cycle. As the consumption of electricity is the main source, reducing power demand is the critical path towards alleviating buildings' contribution to acid rain.

5.4.6 Photochemical Oxidant Formation and Eutrophication at the Occupancy Stage

The equivalent ethylene (POCP) at the occupancy stage is 744 tonnes/year; hydrocarbons accounting for 99%. When we compare each stage of the building life-cycle, we see that the manufacturing stage generates the most equivalent ethylene (POCP) at 53,334 tonnes/year, followed by the construction stage at 20,682 tonnes/year. In contrast, the occupancy stage only generates 744 tonnes of equivalent ethylene per year, a mere 1.4% of that found at the manufacturing stage.

The prime contributors to eutrophication are NO_x and COD. The former is emitted by occupied buildings at a volume of 60,014 tonnes, as we estimated earlier. Emissions of the latter will refer here to COD from the waste water of daily living as the COD emitted from factories more properly belongs to the category of industrial waste water and the COD which stems from agriculture to dairy waste water. In Taiwan, each person generates about 60g of COD per day as they meet their daily needs (Chang 1998, p.42), resulting in annual COD emissions of 466,561 tonnes. However, after treatment in sewage plants and waste water treatment centres, the volume of COD from daily living falls to 407,307 tonnes (744 tonnes per day).[24]

Equivalent PO_4 (NP) needs to be converted before evaluating the impact of occupied buildings on eutrophication. The transformation coefficient is based on the nutrification potential (NP). Accordingly, NP (equivalent PO_4) at this stage is 16,762 tonnes; NO_x and COD account for 54% and 46% of equivalent PO_4 respectively.

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[24] See EPA, 1997a, pp.120-121, The reduction rate is 12.7%.

5.4.7 Effects on Human Toxicity at the Occupancy Stage

Occupied buildings cause the emission of various substances toxic to human beings such as benzene, cadmium, carbon monoxide (CO), lead (Pb), mercury (Hg), nitrogen oxide (NO_x), sulphur dioxide (SO_2, SO_x).

Hotels emit the most CO per unit floor area per year (7.26×10^{-2} kg/m^2) while hospitals emit 1.62×10^{-2} kg/m^2 Per year. As to volume, residential buildings emit the most CO (3,348.5 tonnes/year) while commercial buildings generate 1,480 tonnes/year. Generally speaking, CO emissions from this stage come to 6,687.4 tonnes/year (0.45% of Taiwan's total).

The Pb emitted from incineration of waste accounts for 83.5% of Pb emissions at this stage. Another source of Pb emissions from occupied buildings is electricity consumed (natural gas, LPG and coal emit very little Pb). Consequently, commercial buildings, followed by hotels, emit the most Pb per unit floor area as they consume the most power. In total, the volume of Pb emissions (15.12 tonnes) from this stage accounts for 4.711% of Taiwan's total.

HT from this stage comes to 153,247 tonnes; SO_2 generates 67.8% of that and NO_x 30.5%. SO_2 and NO_x account for 98.3% of equivalent human toxicity.

5.4.8 Atmospheric Pollution at the Occupancy Stage

Table 5-16 lists the volumes of each air pollutant emitted by occupied buildings. CO_2 accounts for the highest proportion (21.34%), followed by SO_2 (19.43%).

To assess the impact these air pollutants have on air quality, we use the CDV concept. This method transforms and accumulates the main stressors of air quality with their critical dilution volume(CDV) to measure their impact. Using this method, we find that the equivalent CDV of air pollutants from this stage comes to 387,064 tonnes of CDV equivalent SO_2.

Table 5-16: Emission Volumes of Various Atmospheric Pollutants at the Occupancy Stage

Substance	Emission (tonnes/year)	Rate of Total Emissions in Taiwan (%)
Carbon Dioxide (CO_2)	33,045,000.00	19.90
Methane (CH_4)	465.95	2.29
Nitrous Oxide (N_2O)	600.14	9.29
Sulphur Oxides (SO_2, SO_x)	86,614.00	19.43
Nitrogen Oxide (NO_x)	60,014.00	9.29
Carbon Monoxide (CO)	6,687.40	0.45
Lead (Pb)	15.12	4.71
Total Suspended Particulate (TSP)	10,166.00	1.56
Hydrocarbons (HC)	1,965.00	0.32

5.4.9 Waterborne Pollution at the Occupancy Stage

The residents and/or staff of occupied buildings produce waste water, though our discussion here will be limited to municipal sewage and will exclude consideration of the waste water from farms and factories.

COD, at 524,762 tonnes/year, accounts for the greatest volume, followed by suspended solids (SS) at 464,813 tonnes/year. The CDV at the occupancy stage can be acquired using the effluent volume of various pollutants and their equivalent CDV relative to BOD, giving us 2,626,380 tonnes of equivalent BOD.

5.4.10 Solid Waste at the Occupancy Stage

The solid waste from occupied buildings covers the general rubbish of households and commercial businesses. The waste of special categories of building such as hospitals or factories more properly should be considered enterprise waste and will not be considered here.

The management of solid waste is a common problem for buildings. As living standards improve and life-styles change accordingly, the volume of solid waste has increased accordingly. In 1995, Taiwan generated 870,000 tonnes/year of general solid waste. The volume of daily rubbish per person is 1.14kg and is growing annually at a rate of 5%.

5.4.11 Traffic Impacts at the Occupancy Stage

According to a survey conducted by the Taichung City Government in 1993 of rush hour trips to Taichung's main business facilities (Taichung City Government 1993, p.138), the following formula can be applied:

$$T = 10.31 \times D + 1.48 \times H + 3.62 \times C + 44.29 \times B + 2.01 \times O + 5.83 \times R$$

D: floor area of department stores (a unit is 100 m^2)
H: floor area of hotels (a unit is 100 m^2)
C: floor area of business buildings (a unit is 100 m^2)
B: floor area of banks (a unit is 100 m^2)
O: floor area of office buildings (a unit is 100 m^2)
R: floor area of restaurant buildings (a unit is 100 m^2)

Using this formula, we find there are 5,173,548 rush hour journeys made in Taiwan.[25]. To estimate the proportion of public transport vehicles to private cars, we multiply the model split rate of various buildings with the volume of trips they attract. When assessing the traffic impact of buildings, private cars are usually the main concern. The calculation shows us that there are 2,437,805 passenger car units (PCUs) at rush hours to and from business and office buildings, which suggests that these buildings have a sizable impact on traffic.

Another traffic implication of occupied buildings is parking. As parking spaces in cities are always insufficient, cars must park on roadsides reducing the number of available lanes and worsening the flow of traffic. The formula for calculating the parking requirements of buildings is as follows:[26]

$$P = 0.36 \times A + 0.96 \times O + 1.23 \times C + 0.48 \times H + 1.08 \times I + 0.45 \times S + 0.26 \times F$$

A: floor area of residential buildings (a unit is 100 m^2)
O: floor area of offices (a unit is 100 m^2)
C: floor area of business buildings (a unit is 100 m^2)
H: floor area of hotels (a unit is 100 m^2)

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[25] The trips made at rush hours were estimated in relation to commercial buildings. For the purposes of the exercise, hospitals and hotels were counted as one category.

[26] Obtained in compliance with the requirement coefficient of the Institute of Transportation within the Ministry of Transportation & Communication. See Taichung City Government, 1993, p.149

I: floor area of hospitals (a unit is 100 m^2)

S: floor area of schools (a unit is 100 m^2)

F: floor area of factory buildings (a unit is 100 m^2)

According to this formula, occupied buildings in Taiwan generate the need for about 5,050,000 parking spaces. Based on the survey data of the Construction & Planning Administration, Taiwan's actual parking spaces only come to about 25% of this figure so parking is a major issue posed by buildings at the occupancy stage.

5.5 ENVIRONMENTAL ISSUES RELATING TO THE DEMOLITION STAGE

As the occupancy stage endures for decades or even centuries, it is difficult to access reliable information about this final stage of the building life-cycle and so the impact assessment task is full of uncertainties. Consequently, this section will restrict its focus to analyses of energy consumption, air pollution and treatment of waste at the demolition stage. The inventory of environmental themes associated with this stage include energy consumption, global warming, acid rain, photochemical oxidant formation, eutrophication, human toxicity, atmospheric pollution, treatment of solid waste and resource recycling.

5.5.1 Energy Consumption at the Demolition Stage

The demolition of buildings with steel structures is quite rare as yet. Most of the buildings in Taiwan which have been demolished have been less than seven storeys high and have been made of reinforced concrete, so this assessment is mainly targeted at them.

Energy consumed at the demolition stage is mainly via diesel- or petrol-powered machinery, e.g. bulldozers, trucks etc. To simplify the estimation task, demolition can be divided into two procedures the actual demolition (including decomposition and loading of materials) and the transportation o demolition waste. 0.8 litre of diesel is needed for every square metre of floor area, about 7,040 Kcal.

The energy used by vehicles transporting the demolition waste of $1m^2$ floor area is 5,766 Kcal/m^2 - 0.02 litres of petrol and 0.64 litres of diesel as Table 5-17 indicates.

Table 5-17: Energy Consumed at the Demolition Stage (per m^2 of Floor Area)

Operation Item	Energy Consumption (litre)	Thermal Value (Kcal)	Oil Equivalent (litre)
Decomposition Procedure	0.80 litres of diesel	7,040	0.76
Transportation of Wastes	0.02 litres of petrol; 0.64 litre of diesel	5,766	0.64
Total	0.02 litre of petrol; 1.44 litres of diesel	12,806	1.40

The amount of energy consumed at the demolition stage in Taiwan is shown in Fig. 5-12. In 1996, this total was 2.4 times more than the figure in 1995, which shows that demolition work is a growth area. Demolition not only consumes a great deal of energy but also wastes large amounts of natural resources, like tiles and roof tiles.

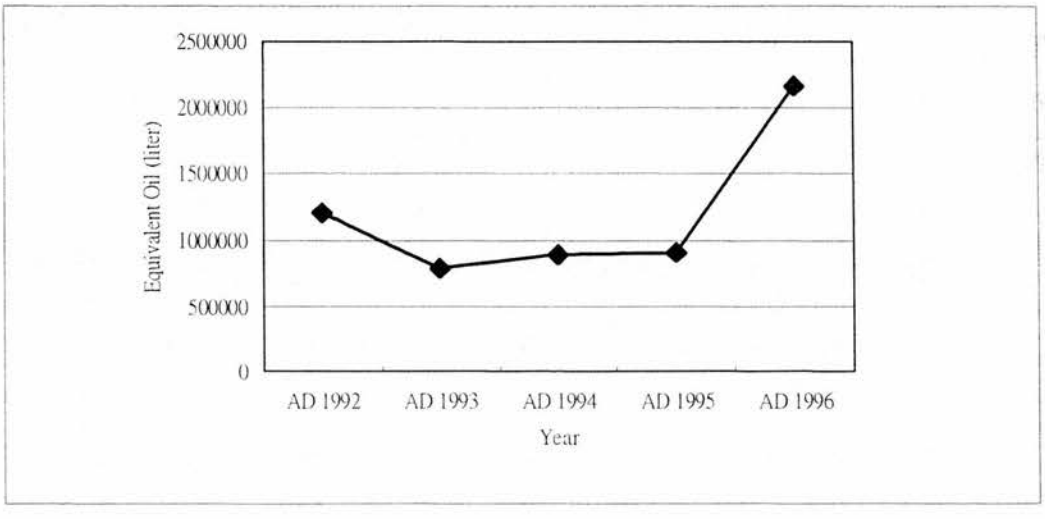

FIG. 5-12: Energy Consumption at the Demolition Stage by Year

5.5.2 Effects on Global Warming at the Demolition Stage

Greenhouse gases are emitted at the demolition stage from the use of construction machinery and from the transportation of demolition waste. The volume of CO_2 emissions is estimated by multiplying the energy used for the task (its thermal value unit) with the carbon emission factor and incomplete burning coefficient. The corresponding CO_2, CH_4 and NO_x can be obtained by multiplying the energy used

with their emission factors. The volume of N_2O emissions can be acquired by multiplying NO_x with the transformation coefficient. One square metre of floor area produces 3.9kg of CO_2 (Chang, 1997); 0.003kg of CH_4; and 0.002kg of N_2O, as Table 5-18 shows.

Table 5-18: Greenhouse Gas Emissions at the Demolition Stage (Unit: 1m² floor area)

Greenhouse Gas	CO_2 (kg/m²)	CH_4 (kg/m²)	N_2O(kg/m²)	GWP(kg/m²)
Emissions	3.9	0.003	0.002	4.3

Notes: The emission coefficient of CH_4 is based on the transportation activity. The estimation of N_2O emissions from demolition work is based on the emission factor of power shovels, and the volume of emissions from a truck is based on the assumption of a 20 tonne load traveling 10km.

Demolishing one square metre of floor area produces 4.3kg of CO_2 equivalent. As a result, 90% of GWP emissions come from CO_2; CH_4 and N_2O between them only account for 10%. In total, the task of demolishing buildings in Taiwan in 1996 generated 6,638 tonnes/year of GWP - 0.02% of the level found at the occupancy stage.

5.5.3 Effects on Acid Precipitation at the Demolition Stage

Acidifying substances produced during the demolition stage mainly refer to NO_x and SO_x, whose major source is the liquid energy used by construction machinery and trucks. To assess the impact of demolition on acid rain we estimate the volume of acidifying substances emitted. The volume of NO_x emissions can be transformed from the N_2O figures mentioned above; SO_x emissions are the same as N_2O. Table 5-19 shows the emission volumes from construction machinery and trucks.

Table 5-19: Emissions of Acidifying Substances at the Demolition Stage (Unit: 1m² of floor area)

Procedure	NO_x (kg/m²)	SO_x(kg/m²)	AP(kg/m²)
Demolition	0.14	0.017	0.115
Waste Transportation	0.02	0.002	0.016
Total	0.16	0.019	0.131

Therefore, the volume of AP emitted as a result of demolishing 1m² of floor area is 0.131kg/m². The AP produced from demolition work in 1996 was 202 tonnes / year - 0.16% of the volume found in the occupancy stage, showing that demolition causes the least emissions of any stage of the building life-cycle.

5.5.4 Photochemical Oxidant Formation at the Demolition Stage

The demolition of buildings contributes to photochemical oxidant formation through the CH_4 and hydrocarbons (HCs).which are emitted by construction machinery and trucks. The level of HC emissions can be obtained by multiplying the length of time construction machinery and trucks are in use with their respective emission factors (see Table 5-20).

Table 5-20: Emissions of Photochemical Oxidant Formation Substances at the Demolition Stage

Procedure	CH_4 (kg/m^2)	HC (kg/m^2)	POCP(kg/m^2)
Demolition	0.002	0.01	0.004
Waste Transportation	0.001	0.003	0.001
Total	0.003	0.013	0.005

In 1996, the task of demolishing buildings generated 7.72 tonnes of equivalent ethylene (POCP), 88% of it from HCs. Comparing the effect of different stages of the building life-cycle on photochemical oxidant formation we see that the demolition stage only has 1% of the effect that the occupancy stage has.

5.5.5 Effects on Eutrophication at the Demolition Stage

NO_x is the main substance related to eutrophication which is produced at the demolition stage. Generally, it is transformed into the relative weight of phosphate (PO_4). As we know, the demolition of 1m^2 of floor area produces 0.16 kg/m^2 of NO_x, which equals 0.021 kg/m^2 of phosphate (see Table 5-21). In 1996, building demolition generated 33 tonnes of equivalent phosphate (NP) - only about 0.2% of the NP generated at the occupancy stage. Of all the stages of the building life-cycle, the demolition stage emits the lowest volume of NP.

Table 5-21: Emissions of Nutrifying Substances at the Demolition Stage (Unit: 1m^2 of floor area)

Procedure	NO_x (kg/m^2)	NP (kg/m^2)
Demolition	0.14	0.019
Waste Transportation	0.02	0.002
Total	0.16	0.021

5.5.6 Effects on Human Toxicity at the Demolition Stage

The substances produced at the demolition stage that are toxic to people are NO_x, SO_x and CO and they

stem from the use of construction machinery and trucks. Emission volumes can be obtained by multiplying the length of time the machinery is in use, or the mileage clocked up by the demolition trucks, with the emission factors. Table 5-22 shows the volumes emitted per unit area (1m^2 of floor area).

Table 5-22: Emissions of Substances Toxic to Humans at the Demolition Stage (Unit: 1m^2 of Floor Area)

Procedure	No_x (kg/m^2)	So_x (kg/m^2)	CO (kg/m^2)	Human Toxicity Equivalent (kg/m^2)
Demolition	0.14	0.017	0.05	0.13
Waste Transportation	0.02	0.002	0.01	0.01
Total	0.16	0.019	0.06	0.14

Per unit area (m^2), the demolition stage generates 0.14kg of HT; NO_x accounts for 89% of that figure. Demolition procedures account for more than 90% of the demolition stage's HT emissions. The volume of HT emissions in 1996 was 216 tonnes.

5.5.7 Effects on Atmospheric Pollution at the Demolition Stage

Atmospheric pollutants produced at the demolition phase include sulphur oxide (SO_x), hydrocarbons (HC), methane (CH_4), carbon monoxide (CO) and particles. The estimation of total suspended particles (TSPs) is done in two parts: the first relating to demolition procedures on-site and the second to emissions from trucks carrying demolition waste.

The volume of TSPs emitted per unit floor area (m^2) at the demolition stage is 0.2883 kg/m^2, as Table 5-23 shows.

Table 5-23: TSP Emissions at the Demolition Stage

Operation Item	Emission Factor (kg/m^2)
Decomposition of Materials	0.0959
Moving Trucks Stir Dust from the Site	0.1800
Truck Exhausts	0.0024
Moving Trucks Stir Fugitive Dust	0.0100
Total	0.2883

The emission volumes of each air pollutant per unit floor area is listed in Table 5-23. From this table, we see that TSPs have the greatest emission factor. A comparison of the total volumes of various air

pollutants at the demolition stage is shown in Table 5-24. From this table, we see that CO_2 is the most voluminous.

Table 5-24: Total Emission Volumes of Various Air Pollutants at the Demolition Stage

Substance	Unit Emission Volume (kg/m^2)	Emission Vol. (tonne/year)	Proportion of Total Emission Vol. in Taiwan (%)
CO_2	3.900	6,020	3.900
CH_4	0.003	5	0.020
N_2O	0.002	3	0.050
SO_x	0.019	30	0.007
NO_x	0.160	247	0.040
CO	0.060	93	0.006
TSP	0.288	445	0.070

To estimate the impact of each air pollutant on air quality, we use the CDV concept. Each pollutant is transformed into SOx CDV [CDVA].

$$CDVA\ (SOx) = 1 \times SO_x + 0.61 \times NO_x + 36.5 \times CO + 1.4 \times TSP$$

The CDVA (SOx) per unit area at the demolition stage is 2.71 kg/m^2 of equivalent Sox, which also means that the CDV is 7.42 million m^3. In 1996, the atmospheric pollution CDV was 4,198 tonnes CDVA (E). 1.08% of that generated at the occupancy phase.

5.5.8 Solid Waste at the Demolition Stage

A tremendous quantity of solid waste is generated at the demolition stage which has a severe adverse impact on the environment if it is not properly taken care of. The issues posed by demolition waste include pollution, the costs of disposal and the difficulty of finding suitable sites to deposit and treat it.

Disposing of $1m^3$ of demolition waste costs £12 (see Table 5-25) and takes up $0.06m^2$ of landfill space. It costs £13.10 to dispose of $1m^2$ of floor area of a low-rise residential building. In 1996, the volume of demolition waste was 1.69 million m^3 which cost £15.55m to dispose of and which used up 10.1 hectares of landfill space.

Table 5-25: Disposal Costs of Demolition Waste (unit volume)

Item		Unit cost
Cost	Construction Cost of Landfills (including lands)(pound/m^3)	8.40
	Operation Cost of Burial (pound/m^3)	1.80
	Cost of Closing Landfills (pound/m^3)	1.80
	Total	12.00
Required area for landfill (m^2/m^3)		0.06

Note: This table was devised from the cost of landfill of 27 hectares in Taichung City

5.5.9 Resource Recycling at the Demolition Stage

Much of the waste from demolition can be recycled, e.g., metal, glass and timber. If these materials continue to be treated as waste, not only do they pose an environmental hazard but they make no contribution to the recycled or "Green" building programme. Given the practical constraints imposed by economic and technological considerations, the demolition waste which is currently most likely to be recycled is waste steel bars, steel products and metals.

Most Taiwanese buildings' structures are made from steel-framed reinforced concrete (SRC), reinforced concrete (RC) and steel-scaffolded concrete (SSC). In 1996, these three structural types accounted for 96.7% of total building floor area (CPA 1997, p.332). For this reason, this section will deal mainly with the recycling of waste metal and steel as they are the main materials used in these types of structure.

There are two direct benefits to the environment from the recycling of waste metal and steel, apart from the obvious benefit of savings on disposal costs. First, recycling limits the depletion of natural resources caused by the excavation of new mines. Second, recycling enables new products to be manufactured which, since the process is not starting from scratch, will consume less energy and so emit less greenhouse gases.

To estimate the energy saved by recycling waste steel and metal (i.e., the recycling economy effect) we calculate the difference in energy needed to refine metal in a high temperature electric resistance

furnace (iron ore material) and in an electric arc furnace (waste steel). However, to gauge the real recycling economy effect we also need to calculate and deduct the amount of energy needed to transport the waste steel and metals to the treatment furnace. Table 5-26 indicates that recycling one tonne of waste metal and steel can save 63.7 litres of oil equivalent, which means that 1,472 Kcal per kg can be saved with a related decrease in CO_2 emissions of 0.41kg.

Table 5-26: Energy Savings[27] from Recycling Waste Metal and Steel

Procedure Item	Consumed Energy (equivalent oil l/tonne)	Thermal Value (Kcal/kg)
A. Steel Refining Using Ironsand (new)	314.49	2830.00
B. Steel Refining (electric arc furnace)	149.98	1350.00
C. Transportation of Waste Steel & Metal	0.81	7.26
Saved Energy (A-B-C)	163.70	1472.00

When we compare the volume of CO_2 emissions from the recycling of waste steel and metal with the volume emitted from manufacturing reinforced steel materials at the manufacturing stage, we find there is a reduction of 70% which could make an enormous contribution to reducing the building life-cycle's effect on global warming and natural resource depletion. Clearly, recycling demolition materials can lessen the burden that buildings impose on the environment.

5.6 A COMPARISON OF THE ENVIRONMENTAL IMPACTS ASSOCIATED WITH EACH STAGE OF THE BUILDING LIFE-CYCLE

Of the environmental impacts of the building life-cycle, some can be quantified (e.g., pollutants emitted) and some cannot (e.g., aesthetic effects).

On the issue of natural resource depletion, the building sector consumes 18.3 million tonnes of gravel and stone each year, 1.79% of the usable gravel and stone in Taiwan's rivers.[28] At that rate, the

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[27] The calculation of energy needed to refine steel is based on Yang, 1996, p.41. The transportation costs of waste steel and metal are based on Chang, 1997, p. 19.

[28] In 1990,12.2 billion m^3 of gravel in Taiwan's rivers were reserved. See EPA, 1997, p. 276.

aggregate of concrete reserved in rivers will be used up in 55 years time. The construction process uses 8.4 million tonnes of reinforced steel every year and 22.7 million tonnes of cement, 90% of which comes from limestone excavated from the central mountains of Taiwan. In addition, 41,430 tonnes of aluminium doors and windows and 1.50 million window-style air conditioners are installed annually during construction. As we can see, the building sector is a major consumer of natural resources.

Power is consumed in vast quantities by the building sector, from the initial manufacture of building materials to the final disposal of demolition waste. Table 5-27 shows that the building sector consumes 217,204 billion Kcal of energy each year (about 24,133 million litres of oil equivalent) which represents 34.4% of Taiwan's total energy consumption (as compared with 47% in the UK, 6.8% in Japan and 51.7% in the US).

Table 5-27: Comparison of Environmental Impacts of Emitted Pollutants at Each Life-Cycle Stage

Environmental Impact Inventory	Stressor	Unit	Manufacture phase	Transportation phase	Construction Phase	Occupancy Phase	Demolition Phase	Total	Proportion of National Emission Volume (%)
Energy Consumption	Fossil fuel, electricity, natural gas	Million kcal (%)	94689000 (43.4)	1821150 (0.9)	603282 (0.3)	120070800 (55.3)	20000 (0.1)	217204232 (100)	34.40
Global Warming	CO_2, CH_4, N_2O,CFC_{11} CFC_{12}, $HCFC_{22}$, $HCFC_{123}$	Relative to 1 tonne CO_2 (%)	28270000 (45.1)	675641 (1.1)	205981 (0.3)	33443000 (53.4)	6638 (0.1)	62601260 (100)	36.90
Acid Rain	NO_x SO_x	Relative to 1 tonne SO_2 (%)	91129 (37.1)	24206 (9.9)	954 (0.4)	128624 (52.5)	202 (0.1)	245115 (100)	27.30
Ozone Depletion	CFC_{11} ,CFC_{12} $HCFC_{22}$, $HCFC_{123}$	Relative to 1 tonne CFC_{11} (%)	* (0.0)	15 (25.2)	* (0.0)	44.5 (74.8)	* (0.0)	59.5 (100)	21.74
Photochemical Oxidant Formation	CH_4 HC	Relative to 1 tonne ethylene (%)	53334 (69.8)	1918 (2.4)	20682 (26.7)	744 (0.9)	8 (0.1)	76686 (100)	32.40
Nutrification	NO_x ,COD, PO_4	Relative to 1 tonne PO_4 (%)	16184 (43.9)	3806 (10.3)	75 (0.2)	16762 (45.5)	33 (0.1)	36860 (100)	7.80
Human Toxicity	SO_x ,NO_x ,CO ,CFC_{12} Pb	Relative to 1 tonne human body (%)	102384 (36.0)	27599 (9.7)	1148 (0.4)	153247 (53.8)	216 (0.1)	284594 (100)	25.60
Atmospheric Pollution	SO_x NO_x CO, Pb TSP, PM_{10}	Relative to CDV of NO_x (%)	313042 (20.6)	643348 (42.4)	170039 (11.2)	387064 (25.5)	4198 (0.3)	1517691 (100)	2.70
Waterborne Pollution	BOD ,COD SS	CDV of BOD (%)	28290(1.1)	*	16111 (0.6)	2626380 (98.3)	*	2670781 (100)	40.13

The occupancy stage accounts for 19.0% of Taiwan's total energy consumption and 55.3% of the total consumed by the building sector (see Figure 5-13). The manufacture of building materials accounts for 43.4% of the energy consumed by the building sector while the remaining phases only account for 1.3% of this total

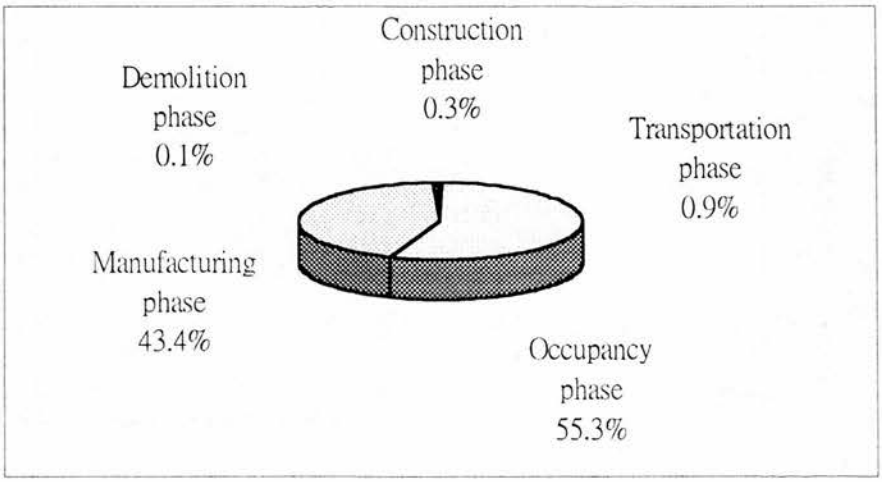

FIG. 5-13: Energy Consumption at Each Stage of the Building Life-Cycle

The emission of greenhouse gases from the burning of fossil fuel is the key reason why this century has seen clear and dangerous signs of global warming. As the building sector consumes energy from cradle to grave, a large amount of fossil fuel is used in the process. The building sector in Taiwan emits 62.62 million tonnes of equivalent CO_2 (GWP) every year, which accounts for 36.9% of Taiwan's greenhouse gas emissions (equivalent CO_2) - a percentage which is higher than Japan's 34% but lower than the UK's 48.6% and the United States' 50.1%. The occupancy stage accounts for 20% of Taiwan's total equivalent CO_2 emissions and, of all the life-cycle stages, is the major source of greenhouse gas emissions (see Figure 5-14).

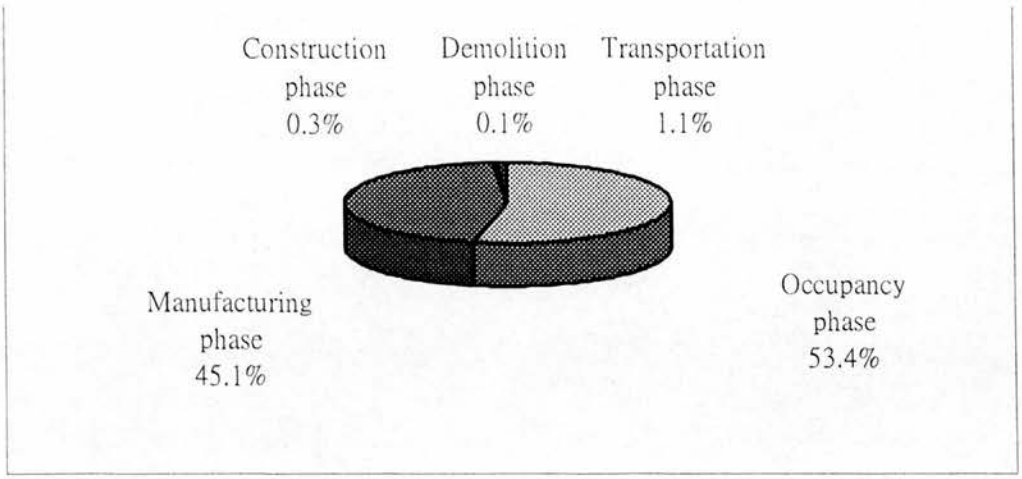

FIG. 5-14: Effect on Global Warming by Each Life-Cycle Stage

The acidifying substances, SO_2 and NO_x, which contribute to the formation of acid rain come from burning fossil fuels at high temperatures. Annual emissions of equivalent SO_2 from the building sector come to 245,000 tonnes, accounting for 27.3% of Taiwan's AP emission volume. Of this figure, the occupancy stage accounts for 52.5%; the manufacturing stage 37.1%; and the transportation stage 9.9%, as Fig. 5-15 shows.

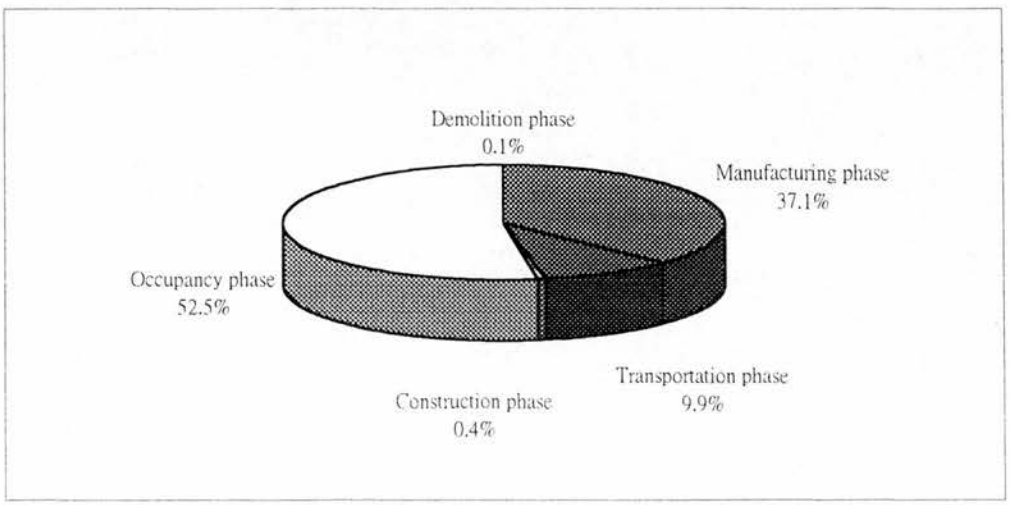

Fig. 5-15: Impact on Acid Rain of Each Life-Cycle Stage

The depletion of the ozone layer is a global problem which is being addressed by a stage-by-stage reduction in ODS emissions. Following the spirit of the Montreal Protocol on Substances that

Depleting the Ozone Layer, Taiwan has prohibited the production and importation of CFC_s since Jan. 1, 1996, though stockpiled items which emit this chemical can still be used. HCFC emissions will be subject to control from 2004. The annual ODS emissions from the building sector account for 21.74% of Taiwan's total. The occupancy stage accounts for the highest proportion of this: 16.2% of Taiwan's total and 74.8% of the total emitted from the building sector. The remaining 25.2% is generated at the transportation stage.

CH_4 and HCs become poisonous secondary air pollutants through photochemical reaction in the air. The emission volume of equivalent ethylene (POCP) from the building sector is 76,686 tonnes, 32.4% of Taiwan's total POCP emissions. The manufacturing stage accounts for 69.8% of this figure and the construction stage 26.8%, as Figure 5-16 shows.

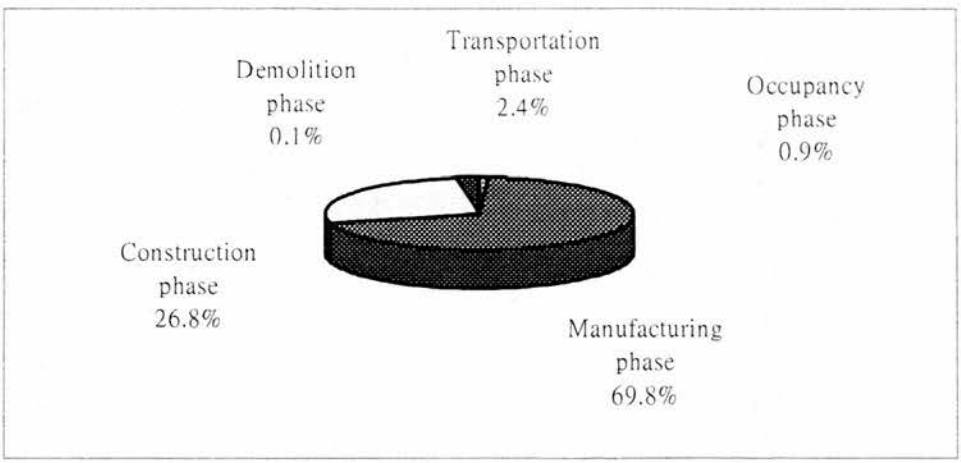

FIG. 5-16: Proportion of Photochemical Oxidant Formation at Each Life-Cycle Stage

Eutrophication in reservoirs is a consequence of phosphate and nitrogen pollution. The building sector generates nutrification potential (NP) substances like NO_x, COD and PO_4. Its annual emission volume is 36,860 tonnes of equivalent phosphate (NP), which accounts for 7.8% of Taiwan's total. The occupancy stage accounts for the greatest proportion of this (45.5%) followed by the manufacturing stage, as Figure 5-17 shows.

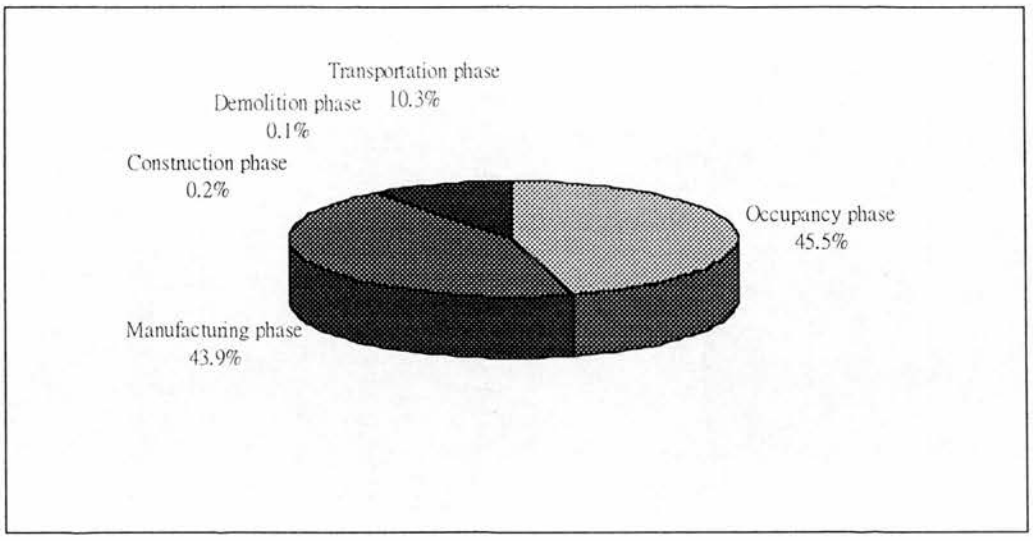

FIG. 5-17: Impact on Eutrophication at Each Life-Cycle Stage

As for atmospheric pollution, Taiwan has seven index pollutants which it uses to assess air quality (TSP, PM_{10}, SO_2 (SO_x), NO_2 (NO_x), CO, O_3 and Pb), and an integral assessment of them is conducted using the concept of critical dilution volume (CDV). The building sector only accounts for 2.7% of the CDV in Taiwan because Taiwan's CO emissions are high (1,489,543 tonnes/year) and largely caused by cars and scooters (accounting for 75.88% of Taiwan's total). However, the building sector's emissions of individual air pollutants account for between 20% to 40% of Taiwan's total, as Figure 5-18 shows. CO_2 accounts for the largest proportion (36.9%) and CO the smallest (2.0%). The impact on atmospheric pollution of each stage of the life-cycle is shown in Figure 5-19.

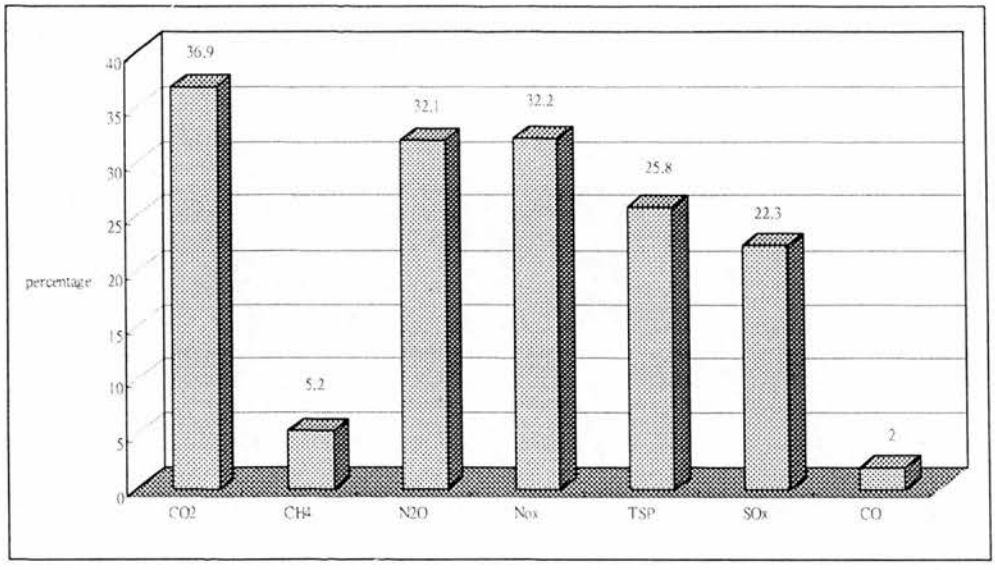

FIG. 5-18: Proportion of Each Air Pollutant to Taiwan's Total Volume of Emissions

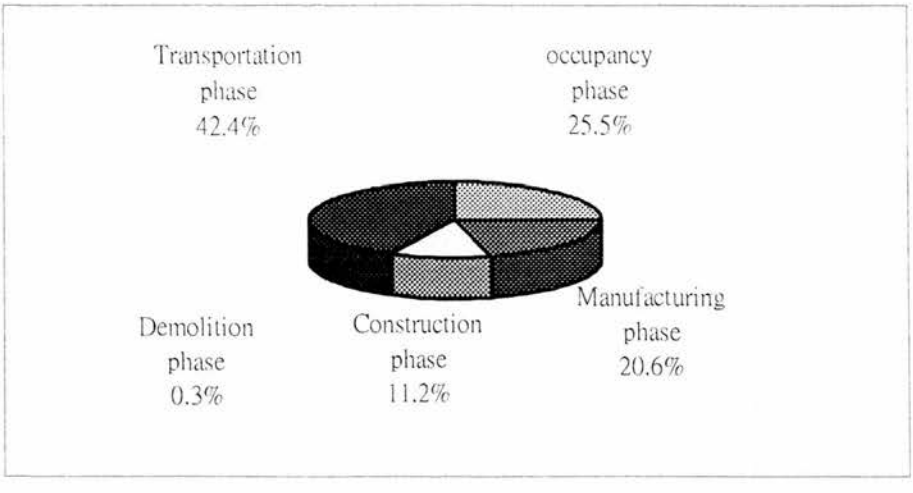

FIG. 5-19: Impact on Atmospheric Pollution at Each Life-Cycle Stage

The volume of energy consumed by each type of building together with the pollutants emitted by eacl type can be estimated by examining the kinds and quantities of building materials used by each type.

Buildings of over 13 floors with an SRC structure consume the most energy at the manufacturing stag (each square metre of floor area uses 700.435 Kcal), followed by mid-rise buildings (5 to 12 floors

with an RC structure, while the lowest energy consumers are buildings of less than four floors, as Figure 5-20 illustrates.

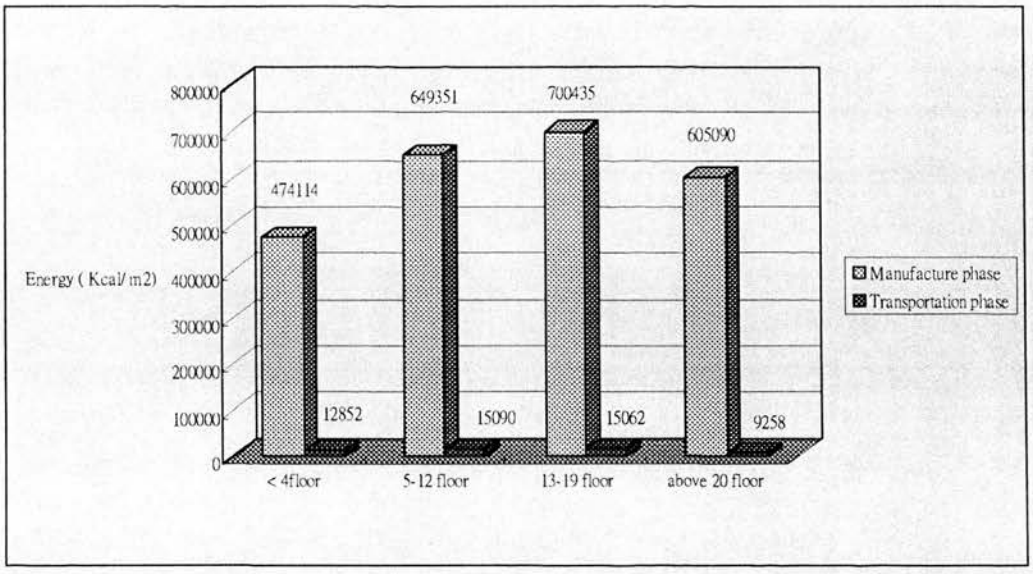

FIG. 5-20: Energy Consumed by Various Types of Building at the Manufacturing and Transportation Stages

Buildings with an SS structure consume less energy than those with an RC structure because the latter demands a large amount of reinforced steel, concrete and gravel whereas the former only requires plenty of reinforced steel and steel frames.

For the two phases of manufacture and transportation of construction materials, the former consumes more energy than the latter. Generally speaking, the energy consumed at the transportation phase only accounts for 2.5% of that needed for the manufacturing stage. Buildings with an SS structure also consume less energy at the transportation phase, only 1.6% of the energy they require at the manufacturing stage.

As for building life-cycle's impact on waterborne pollution, the annual emissions from the building sector account for 40.13% of the Taiwan's total volume of BOD, COD and SS emissions. The occupancy stage accounts for most of this, as most of these pollutants result from people's normal daily

water needs.

In addition to the environmental themes discussed above, the building sector also impacts on local ecologies, landscapes and culture. For instance, acquiring raw materials for building affects the ecological landscape; transporting materials affects traffic; and occupied buildings affect the local socio-economic environment.

5.7 SUMMARY

The whole life cycle of the construction industry can be divided into the phase of manufacturing of building materials, the phase of transporting of building materials, the phase of constructing, the phase of occupancy and the phase of demolishing. Primary environmental effects include energy depletion, water resource consumption, global warming, acid rain, ozone layer depletion, photochemical oxidant formation, eutrophication, human toxicity, atmospheric pollution, waterborne pollution, socio-economic environmental impact and ecology.

For energy depletion, major sources come from consumption of fossil fuel, natural gas and electricity. 217,204 billion Kcal of consumed energy annually for the building accounts 34.4% of the total final energy consumption in Taiwan, which is lower than 47% in the UK (Shorrock et. al. 1990, p.35), 36.8% in Japan and 51.7% in America (Liu 1994, p.105). It is related to the fact that no heating is required and proportion for industrial consumed energy is greater in Taiwan. Among all of the phases in the construction industry, the occupancy phase consumes the greatest amount of energy, 55.3% of the consumed energy in the building sector and the next is the phase of manufacturing construction materials.

As for abiotic resource depletion, the building construction consumes 8.4 million tonnes of steel bars

and 1.5 million tonnes of formed steel, 41,430 tonnes of aluminum and 1.5 million window-style air conditioners annually. The consumption volume of abiotic resources is quite great. As for natural resource depletion, the building construction industry consumes 18.3 million tonnes of gravel annually, which accounts 1.79% of the reserves amount of gravel in the rivers of Taiwan. Gravel can be supplied for another 55.8 years (not including other projects). It goes without saying that extraction of the gravel on the land and the hills will surely become a great challenge against the ecological environment.

As for the aspect of global warming, greenhouse gases include CO_2, CH_4, N_2O and CO_2 emission accounts more than 90% of global warming potential. CO_2 emission from the building is 61.7 million tonnes, which accounts 36.1% of the total CO_2 emission volume in Taiwan, lower than 48.6% in the UK (Shorrock et. al. 1990, p.35) and 50.1% in the US, but higher than 34.0% in Japan (Liu, 1994,p.105). CO_2 emission volume during the occupancy phase has the highest proportion of 53.3% and the next is the phase of manufacturing construction materials, which accounts 45.3% of the total amount. As for the emission of global warming potential (GWP), the building sector accounts 36.9% of the total GWP in Taiwan.

As for acid rain, major precursor substances are NO_x and SO_x. The emission of acidification potential (AP) from the building accounts 27.3% in Taiwan. The occupancy phase has the highest emission proportion of 14.3%, manufacturing phase of construction materials 10.1% and transporting phase of construction materials 2.7%. As a result, for the emission of acidifying pollutants, the occupancy phase has the greatest emission.

Major substances for ozone layer depletion are CFC_s, HCFC and halon, etc. CFC_s and halon are phased out. Thus, the ozone depleting substance emitted by the building sector is based on $HCFC_s$, which accounts 21.74% of the total ozone depletion potential (ODP) in Taiwan. The occupancy phase

accounts 16.2% and transporting phase of construction materials also accounts 5.5%. Besides, for the aspect of photochemical oxidant formation, major driving substances are methane and hydrocarbon, etc. The photochemical oxidant creation potential (POCP) emitted by the building sector accounts 11.3% in Taiwan. The constructing phase has the greatest proportion of 9.5%. And the major source comes from proliferated HC emitted by organic solvents during construction. Besides, the transporting phase of constructing materials also accounts 0.8%.

As for eutrophication, precursor substances consist of chemical oxygen demand (COD), phosphate (PO_4) and NO_x, etc. Nutrification potential (NP) of COD, PO_4 and NO_x substances emitted by the building sector accounts 7.8% of the total amount in Taiwan. The occupancy phase accounts 3.5% and the manufacturing phase of construction materials takes 3.3%. Besides, as for human toxicity, primary substances refer to SO_x, NO_x , CO, CFC_2 and Pb, etc. Human toxicity (HT) emitted from the building sector is 284,515 tonnes, 25.6% in Taiwan and the occupancy phase has the greatest proportion o 13.7% and the manufacturing phase of construction materials 9.7%.

Atmospheric pollution has already become the most essential environmental issue in Taiwan. Th number of days with bad air quality within a whole year is 6.08% of the total number of days. Th concept of critical dilution volume (CDV) is applied in this chapter to make a comparison with the tota critical dilution volume. The CDV of atmospheric pollutants emitted by the building sector account 2.7% of CDV in Taiwan. The occupancy phase and the manufacturing phase account 0.6% respectively which indicates the construction industry also plays an influential role for air quality. Among a atmospheric pollutants, total suspended particulates (TSP) accounts 25.8% of the total emission volum in Taiwan, sulfur dioxide 22.4%, nitrogen oxide 32%, and carbon monoxide 2.0%, which reveals tha the emission of various atmospheric pollutants generated from the building sector takes 20%-40% o the total emission in Taiwan (except CO).

As style and height for each type of building differ, consumed materials vary as well. Energy consumption volumes are different between the manufacturing and the transporting phases of construction materials. Buildings with the steel reinforced concrete structure between 13^{th} and 20^{th} floors consume the greatest energy as 1 m^2 floor area requires 715,497 Kcal/m^2; however, buildings above 20 floors with the steel structure only consume 654,348 Kcal/m^2, which is only 91% of that for SRC. It indicates that SRC structure requires a large amount of steel and concrete, which consumes great energy.

Environmental impact themes imposed by the construction industry at each phase are assessed through the concept of LEIA in this chapter. However, targets of study cases (So-Go & Formosa buildings) will be aimed for evaluation and comparison of environmental impacts at each phase in the chapter twelve.

CHAPTER SIX: THE HISTRICAL DEVELOPMENT OF THE EIA SYSTEM IN TAIWAN

6.1 INTRODUCTION

Over the past 50 years, Taiwan has gained a world-wide reputation as an economic miracle, earned as a result of the Taiwanese government's commitment to economic development as well as the Taiwanese people's industry (Lee et al. 1994, p.109). Its national income has increased impressively year on year, reaching $13,000 per capita in 1998. Though the economy has been thriving and Taiwan is undoubtedly now a wealthy country, development has not been achieved without cost. Economic growth has been blighting Taiwan's environment. Pollution, noise, traffic etc. have increasingly damaged the nation's quality of life - to such an extent, in fact, that the government have been obliged to address Taiwan's environmental problems as a matter of urgency. By now, the general public is in favour of economic policies which treat environmental protection as an duty equal to wealth creation.

This change in public opinion has been formenting since the 1980s. As organisations and industrial sectors continued to expand, they did so almost solely in terms of the feasibility of their techniques and the soundness of their financial planning. As a result, many development programmes had severe environmental knock-on effects: instances of pollution, damage to property and public health risks increasingly triggered angry responses from the public (Chang 1993, p.8). As the number of protests increased, so too did the membership of existing and newly-founded environmental protection movements (Liu 1995, p.1).

Since its inception, the Environmental Impact Assessment (EIA) System has occupied an important position in Taiwan's environmental policy planning. In 1975, the Economic Planning Council (EPC)

borrowed the US's EIA system and published it in the *Free China's Industry*[1]. The following year, th Chinese Engineers' Association discussed the EIA in its seminar on Modern Industrial Techniques. Th environmental pollution team within the Executive Yuan, holding its first scientific meeting in 1978 suggested the government promote the EIA system as soon as possible. A pilot project - the EI Demonstration Project at Coastal Industrial Areas in Northern Taiwan - was conducted in 1980. By 1985 the Health Administration had drawn up a programme to strengthen the EIA's remit and announced a follow-up programme along the same lines in 1991. Thus, by the time the EIA Act became law on 31s December 1994, Taiwan had accumulated many years of practical experience implementing the system and the EIA's pervading influence on Taiwan's environmental policies has proved crucial.

High-rise developments have flourished in Taiwan because of the burgeoning demand for commercial an residential properties, the soaring price of land and technological developments in construction technique and equipment. Estate agencies vie for floor space on limited land sites in order to yield the highes investment benefits. However, the first flurry of high-rise development was characterised by a lack o environmental planning and the result was inadequate provision of public amenities in the buildings vicinity, chaotic urban development, and a consequent deterioration in the quality of life in and around th high-rises. Furthermore, the two EIA programmes which were in place in Taiwan during the 1980 excluded high-rise developments from their remit. However, recognising the environmental consequence of the high-rises springing up in their midst, the city governments of Taipei, Taichung and Kaohsiun gradually began to formulate their own guidelines for conducting an EIA on high-rises located within thei city boundaries. Eventually, with the enactment of the EIA Act in 1994, it was formalised that all high rise proposals must submit to the EIA process.

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[1] The EPC, a predecessor of the Council for Economic Planning and Development, was a department within the central government's committee system.

In order to understand the setting-up and implementation of the EIA system, we identify four periods in its evolution: the germination of the concept; the preparatory groundwork on codifying its terms; the establishment of the system; and the EIA in action. Throughout, we look at the social and economic environment within which the emergent EIA system was embedded: the gradual development of environmental policies and environmental management systems and the transformation of administrative organisation across the phases of its evolution.

The first phase - the concept germination stage - is pre-1980. It was during this phase, as mentioned above, that the EPC introduced the US version of the EIA system into Taiwanese government and industrial circles, and the first pilot study of the system was conducted at the prompting of the specialist environmental group within the Executive Yuan.

The second phase - laying the legal groundwork - lasted from 1980 to 1990. During this period, the government set up an EIA research team who initiated the task of establishing the EIA's parameters and who selected several projects for testing them out. As valuable experience was gained, the Executive Yuan was ready by 1985 to announce a programme for strengthening the EIA system, using 14 major projects as test cases. As a result of this endeavour, the Environmental Protection Administration (EPA) was established in 1987; by 1988 the first draft of the proposed EIA Act was deliberated on; and by 1989 the EPA had submitted a draft of the Act to the Executive Yuan for approval.

The third phase (1990 to 1995) was the period when a formal EIA system was established. In 1990, the Executive Yuan examined the draft EIA Act and passed it on to the Legislative Yuan who, in turn, submitted it to the Committee of the Interior, the Economy and the Judiciary in the 86th session. Meantime, the EPA continued to strengthen the EIA system by initiating a follow-up programme. Throughout this period, migration into the cities continued apace and the demand for urban dwellings and

workplaces continued to boom. High-rises increasingly represented a way of balancing high urban population densities with expensive land prices. In an effort to forestall some of the worst environmental damage caused by high-rises, some of the bigger cities began to insist on them submitting to an EIA examination. Thus, during this phase, both central and local governments were actively seeking ways to legalise the EIA system. By the end of 1994, the EIA Act came into law and the legal groundwork was almost complete. Indeed, this Act was selected by Taiwan's environmental protection groups as one of its top ten news items (Liu 1995, p.62).

Once the Act became law, the Executive Yuan announced at the end of 1995 how its terms should be implemented so that the EIA system could operate smoothly. Its coverage was also extended from the original three development types to 16 categories. The central EPA and local environmental agencies al set up EIA committees to conduct reviews, borrowing some of the procedural practices used in Europe and the US. In 1997, review guidelines were issued by the SEA, and the "3 Ps" (Policy, Plan and Programme) were incorporated into the EIA system's targets. In December 1997, a conference on globa climate change was held in Kyoto, Japan which reached several agreements to reduce CO_2 emissions. In 1998, Taiwan responded by calling a National Energy Meeting which resolved that assessing the CO emissions of all major development proposals would be included in the EIA's scope (Central Daily News 1998, p.3).

6.2 THE FIRST PHASE (PRE-1980): THE GERMINATION OF THE EIA CONCEPT

A concern with environmental protection only began to emerge in the '70s; prior to this there were few laws (or policies, since the two tend to go hand-in-hand) regulating levels of pollution or advocating management of the environment. Until 1980, economic development policies were paramount over al others; the government spared no effort in improving economic growth, enhancing export trade and

raising national living standards.

Environmental policies were neglected both by the government and by the general public, though - drawing on the US's establishment of an EIA system in 1969 - by 1975, Taiwan's EPC had started to float the idea by publishing an outline of the EIA concept in Free China's Industry[2]. As mentioned earlier, the Chinese Engineers Association first discussed the concept in 1976 at a seminar on Modern Industrial Techniques and, by 1978, a committee of the Executive Yuan had decided to promote the EIA idea. However, at this early stage, the EIA was viewed as a set of scientific techniques rather than as a holistic approach to environmental protection. In order to understand how it began to evolve into the more rounded framework that is evident today, we need to examine the shifts which occurred in Taiwan's political, economic and social environment during this first phase.

6.2.1 National Economic Policy Development

Taiwan is a 36,000km^2 island in the Pacific Ocean off the Southeast coast of mainland China. It is mountainous - over half its area is hills and mountains over 500m high (See FIG. 6-1).

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[2] Free China's Industry: 1975, pp. 19-25. This was the first article to appear on Taiwan's nascent EIA system.

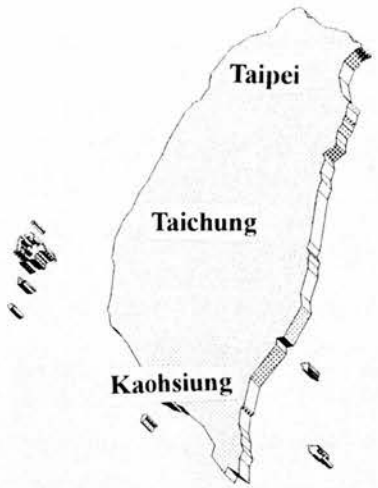

FIG. 6-1: Map of Taiwan

A Japanese colony from 1895 to 1945, Taiwan's economy was thoroughly entwined with Japan's and wa subject to the colonial policy of "Industrial Japan, Agricultural (Material) Taiwan" such that eac economy relied heavily on the other. For instance, Taiwan's Peng Lai rice and cane sugar was exported t Japan while other Japanese products were imported. When Taiwan was recovered in 1945, its econom was separated from Japan's and became part of China's. However, by 1949, Mainland China wa controlled by the Communist Party so Taiwan's economic basis suddenly turned from a colonial one to a independent island economy. Losing its original backing, the economy quickly entered a period of turmo (Lee et al. 1994, p.9).

In order to stabilise affairs so as to encourage industrial development, Taiwan accepted economic aid fro the US between 1951 and mid-1965, averaging c. $100m over those 15 years with an average amount pe capita of c. $10 annually. In the 1950's, Taiwan's annual exports only came to $120m so US aid wa particularly helpful in balancing imports and exports (Lee et al. 1994, p.24). Much of the aid monie (37.3%) were invested in infrastructural development which accelerated Taiwan's economic development

Between 1949 and 1980, the number of Taiwanese service industry and industrial products grew rapidl

and the structure of the economy altered. In 1952, agricultural products accounted for 35.9% of Taiwan total production while industrial products only accounted for 18%. By 1980, the balance had shifted: industrial products accounted for 45.3% and agriculture products had fallen to 9.3%(as figure 6-2).[3]

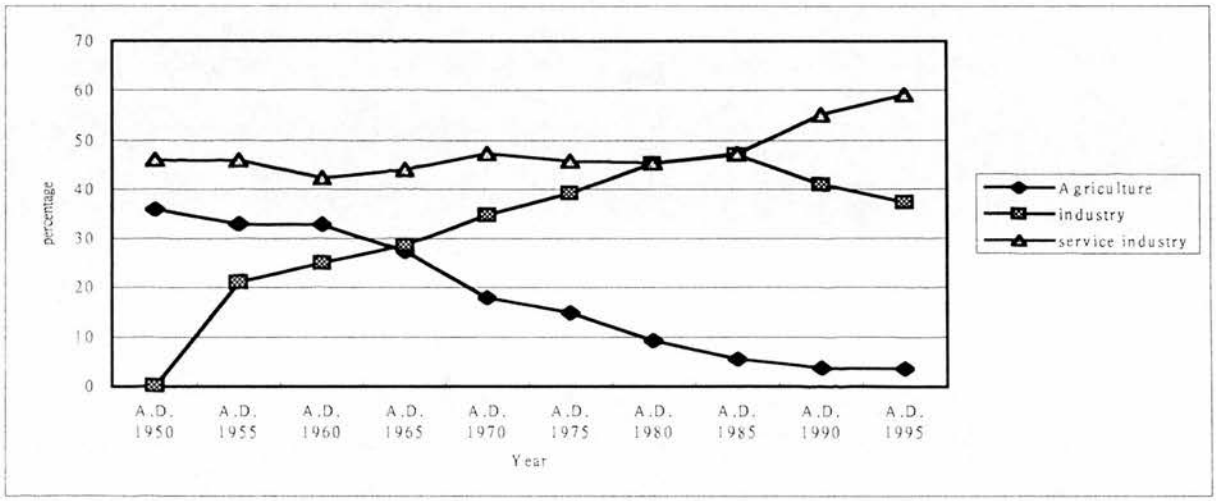

FIG. 6-2: Changes to Taiwan's Industrial Structure (1950-1995)

As the balance shifted, the number of agricultural workers dropped rapidly. In 1952, 56.1% of those employed worked in agriculture; by 1980, only 19.5% did so. As these workers moved into other rapidly-growing industries, unemployment was never a significant problem.

Rapid industrial growth also brought with it a demand for land to be put to commercial use. In particular, manufacturing industry needed more space. As the economy's leading sector (in 1952, it accounted for 60.2% of Taiwan's industrial base rising to 75.2% by 1980) with a huge manpower requirement, most labour-intensive factories were located in city suburbs. To encourage factories to purchase machinery and manufacturing sites, the government promoted an investment package to develop 61 industrial parks, covering 9,536 hectares (CEPD 1996b, p.68). However, as there was no regional planning prior to 1983, the distribution of population and of industrial activities was extremely uneven. Urban development

[3] In 1963, industrial products (at 28.2%) overtook agriculture (26.7%) for the first time. This was the turning point in Taiwan's economic pattern. See Lee et al., 1994, p.39.

concentrated at the north and south of Taiwan.

Under Kuomintang (KMT) rule, the emphasis was on economic development and social stability. From 1952 to 1980, average annual economic growth reached 8.9% (see FIG. 6-3). Growth in the '60s was extremely fast, averaging 9.53%. The '70s also averaged 9.70% growth despite the slowdown of 1974 and 1975 (i.e., the time of the two global energy crises) when the rate only reached 1.12% and 4.24% respectively. By the end of that decade, annual economic growth was topping 10%.

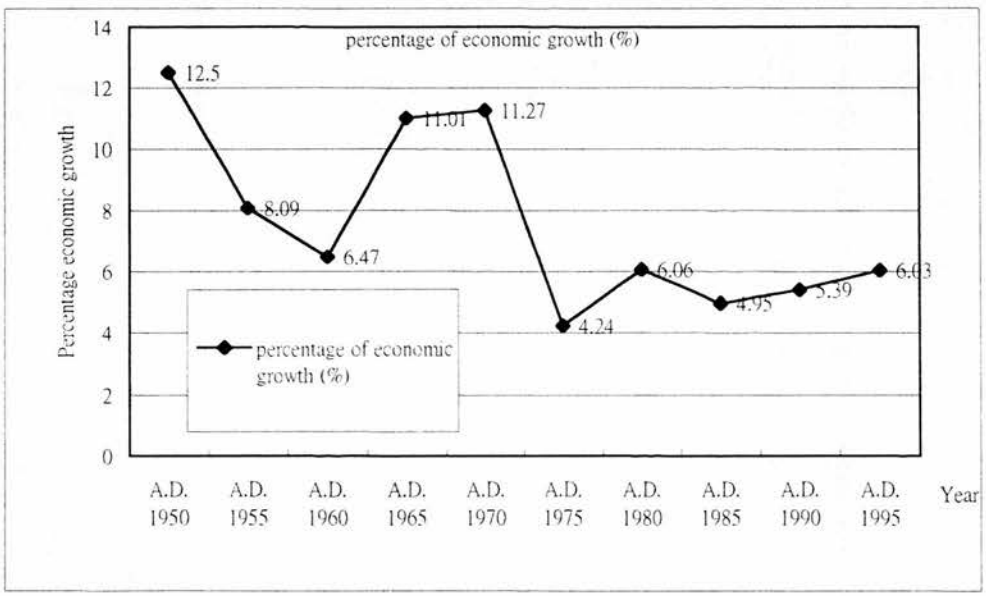

FIG. 6-3: Taiwan's Economic Growth (1950-1995)

When the central government retreated to Taiwan in 1949, its overwhelming imperative was to raise livin standards and strengthen Taiwan's ability to counterattack Mainland China so no effort was spared to spu the economy forward. Until 1980, economic development meant everything: the ex-president Chian Kai-Shek stated in *China's Fate* that *'the economy is not only the main point of development but th premise for all development'* (Lee et al. 1994, p.109). From 1953 onward, a series of four-year econom development programmes were set in motion to advance Taiwan's infrastructure in terms of its railway

motorways, airports, harbours, transportation facilities, telecommunications and postal service networks.

During his term as Premier of the Executive Yuan, Chiang Ching-Kuo announced 10 important construction projects. All had obvious environmental implications; six of them addressed traffic facilities[4], three, heavy chemical industries, and the tenth was the construction of a nuclear power plant. The last to be completed was the north line railway in 1979. All the others were finished before 1978 despite the fact that they were constructed during the mid-'70s when the global economy was in recession as a result of the energy crises and private investment funds were consequently in quite thin supply.

While the 10 projects were under construction, the government judged that Taiwan's economic development was better than expected and so, in 1977, announced a second wave of 12 major projects, worth more than £8 billion. With the exception of three agricultural programmes, all were set to have significant impacts on the environment.[5] The government hoped that these additional 12 projects would stimulate economic development and turn Taiwan into a modern nation.

As we have seen, the main goal throughout this great effort was national economic development. And, indeed, the stategy worked: the development of the industrial areas, the simplification of procedures to establish factories, and the major infrastructural construction projects stimulated growth to over 8% p. a. As Taiwan transformed itself from an agricultural to an industrial economy, its foreign trade between 1952 and 1980 grew by 131% and the value of its foreign exports by 170%. This rapid growth in trade further

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[4] The 10 projects included Chun-shan motorway, the electrification of the west line and north line railways, Taichung and Su-Ao harbours, C.K.S. international airport, and a steel mill, shipyard and petrochemical factory.

[5] These projects included expanding a steel mill; building the second and third nuclear power stations; constructing a circum-coastal railway network; building three cross-island motorways; starting a new town project; and the second and third stages of building Taichung harbour.

stimulated national economic growth.

The early strategy for Taiwan's industrial development was to use imports as an alternative to indigenou industry until the 1960's when export trade expanded swiftly, production scales were raised and th number of sources and parts hugely increased. By the 1970's, the government had decided to develop th heavy chemical industries. Consequently, the construction of petrochemical factories and steel mills wer amongst the first and second waves of major developments announced by the government. Though th heavy chemical industries consume a great deal of energy and produce significant levels of pollution, the were still favored by government and public alike because, at that time, economic development was th over-riding goal.

6.2.2 The Gradual Acknowledgement of Environmental Problems

As a consequence of the pursuit of rapid economic growth, environmental problems gradually began t become apparent. In the 1950's, a particular clause of the land law was invoked to reform land use an protect farmland. Clause 30 stipulated that the ownership of private land could only be conferred if th owner guaranteed that the land would be cultivated, i.e., farmers were the only people who had the right t obtain farmland. Yet, as industrial development and the export trade boomed, thousands of mainly smal and medium-sized factories opened in Taiwan; by 1980, there were 60,277 of them. Acquiring land fo industrial use was extremely difficult because of Clause 30, so many investors built factories witho having permits. These illegal factories were scattered on the outskirts of big cities and along main road For example, Taichung (Taiwan's third largest city) had 4,320 of them in 1980.[6] (Actually, their belt-lik scattering subsequently shaped how new road constructions and infrastructural developments we decided on.) Both agriculture and the environment were affected by the growth of this kind of factory: o the one hand, fertile land was being illegally occupied and, on the other, the uncontrolled spread

[6]Taichung City Government, 1992, pp.1-5.

factories without operation permits degraded living conditions and blighted the natural environment.

In 1960, due to the over-crowded cities and limited land space, the average domestic floor area per capita was only 7.6m^2. However, by 1975 this had increased to 13.5 m^2 and by 1980 to 16.8 m^2. Although living space did improve, many homes are still located in illegal buildings and some even occupy land designated for public use. For example, Taichung City Stadium (the country's second stadium) is home to 752 households.[7] Illegal buildings on public land have reduced the usability of parkland in Taichung from 0.7 m^2 per capita in 1940 to 0.2 m^2 in 1980 (Hsiao 1991, p.102). On this evidence, we can easily picture the increased urban population, illegal residences, insufficient parkland and confined domestic space of the time. Although national income was rising rapidly every year, it was at the price of environmental quality.

Pollution was becoming a serious hazard what with the concentrated population, the thousands of factories and the millions of cars. The levels of TSP in the air (measured as ug/m^3) massively exceeded air quality standards; in 1970 the level was as high as 250.3 ug/m^3 and in 1980 216.1 ug/m^3[8]. Compared to the US and Japan, Taiwan's situation was indeed bad. In 1980, dust fall reached 11.5 tons/km^2/month and the haze coefficient (COHS/1,000 ft.) was 1.5 (Lee et al. 1994, p.104).

6.2.3 The Gradual Emergence of an Environmental Policy

The pollution generated from industrial output had by now exceeded the environment's ability to purify itself. Instances of pollution-related disease, damage and death occurred routinely. In 1978, hydrogen cyanide escaped from the Chinese Petroleum Corporation's propylene factory in Kaohsiung, killing one

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[7] This stadium is the Taiwan Provincial Stadium located in Taichung and is sited on land that used to be water-source parkland in earlier times. Its east side is occupied by people living in illegal buildings.

[8] The national standard for TSPs is 140 ug/m^3. Japan's standard is 100 ug/m^3 and the USA's 75 ug/m^3.

person and injuring over 200 others. The Taipei Water Pollution Prevention Institute collected samples from Houchin River and found its cyanide content to be alarmingly high (the sample with the most cyanide was 250 times higher than standard). At that time, many livestock farms were based downstream of Houchin River and the contamination was serious enough to threaten food safety. In 1980, a chlorine leak from the Jenwu factory of the Formosa Plastics Corporation hurt over 400 people in Kaohsiung.[9] These accidents were all caused by the inadequacy of anti-pollution facilities, the improper disposal of waste, and the fact that factories sat on the very doorstep of people's homes.

By now it was becoming apparent that public health and well-being was under threat from the several cases of industrial pollution which were starting to surface. By April 1979, the Taiwanese Environmental Protection Programme was instigated. This programme aimed to prevent pollution and to promote environmental hygiene using the slogan 'Everyone is responsible for protecting the environment'.

6.2.4 Environmental Legislation Aimed at Hygiene and Health Care

The quality of drinking water was sometimes at issue and the pollution of underground water threatened public health.[10] According to the Taiwan Water Corporation, 77% of its water came from ground water sources (EPA 1997a, p.122); with the rate of river pollution running at 38.9%, public health was at risk. As we saw, the Executive Yuan announced drinking water control regulations at the end of 1972, but these only addressed the safety of drinking water rather than the whole issue of waterborne pollution for the notion of environmental protection had been yet been conceived.

6.2.5 The Introduction of the EIA

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[9] EPA, 1997a, pp. 414 - 443.

[10] In 1980, 71% of the population used tap water but the remaining 30% still used underground water or other water sources.

By 1969, the US had passed a National Environmental Policy Act (NEPA) which initiated its EIA system whose terms gradually changed from post-hoc remedial action on pollution to a concern with early prevention. As mentioned earlier, the EIA concept was first aired in Taiwan in December 1975 by the EPC (the predecessor of the CEPD). By that time, the US's EIA system had been operating for more than five years and experience in its use was starting to accumulate. However, even then Taiwanese engineers were interested in it primarily as a set of engineering techniques rather than as a method for managing the environment. Nevertheless, by 1978, as Taiwan gradually became more familiar with the concept and evidence of its results began to filter in from other nations using it, the Environmental Pollution Team in the Executive Yuan suggested that Taiwan should start implementing the system as soon as possible. A pilot scheme was announced in 1979 and this was an important milestone for by then the EIA had been a subject of discussion amongst Taiwanese scientists for several years and the US had been implementing it for nearly a decade.

After this, the Executive Yuan required the Taiwan Power Corporation to submit an EIA report on each nuclear power plant in the country. However, as the EIA was still seen primarily as an engineering tool, these EIA reports did not have to be examined or commented on by the Environmental Protection Department, unlike the operation of the system in the US. In the States, the EIA report was submitted to their EPA in the first instance and only later sent to CEQ or the President in disputed cases.

So although Taiwan had come to a common agreement on the EIA concept, the actual implementation of the system did not yet express the core function of the EIA. By 1980, the Executive Yuan had decided to start implementing the system and the process of its evolution moved to another stage, i.e., the preparation of EIA legislation.

In conclusion, the 5-year period leading up to 1980 represents the gestation of the EIA concept in Taiwan.

When the EIA system under NEPA was implemented in the US in 1970, each department neglected it or was reluctant to implement it. Only after the CEQ declared a series of instructions and after judicial review by the courts, did each department start to take the system seriously. Asian nations like Hong Kong, Japan and Singapore established an EIA system in 1972. By the time Taiwan introduced it in 1980, 10 other nations were already implementing it.[11] Although every nation adopted its own procedural details, the bones of the EIA system were now of global interest.

6.3 THE SECOND PHASE (1980-1990): THE PREPARATION OF EIA LEGISLATION

The period from 1980 to 1990 was the preparatory stage towards legalising the EIA system. An EI demonstration project - Industrial Zones on The Northern Coast of Taiwan - was chosen in 1980 t demonstrate the feasibility of the system. The Environmental Protection Bureau of the Public Healt Administration was established in 1982 and was made responsible for environmental protection issues. draft version of the EIA Act was rejected by the Executive Yuan in July 1983 because of circumstance an a dearth of relevant experts, and an administrative order - the Programme to Strengthen the EIA - wa chosen instead as the basis for progressing the EIA system in the country. An EIA was now to b conducted on 14 important development proposals and, by the end of that process, Taiwan ha accumulated expertise in using the system and the public were gaining a better understanding of it as well.

Durng this period, the Environmental Protection Bureau of the Public Health Administration of th Executive Yuan was upgraded to the Environmental Protection Administration (EPA) of the Executiv Yuan, making it the first institute of its kind directly accountable to the Executive Yuan. Between 1987 an

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[11]Gilpin has noted when the EIA system became effective in different countries: USA (1969), Hon Kong, Japan and Singapore (1972), Canada(1973), Australia (1974), Germany (1975), France (1976), th Philippines (1977) and China (1979). See Gilpin, 1995, p.3.

1988, various local governments set up their own EPBs. The EPA began the task of issuing technical manuals and guidelines on how to implement the EIA on different kinds of development project. The EPA was also nurturing its own expertise base by reviewing EIA reports on important projects.

Because there was still no law governing the EIA system, the process was conducted on important developments as demonstration projects and so the EIA process lacked teeth. For example, approval for given to the 5th and 6th light oil refinery projects before their EIA reviews were even conducted. Though experience was gained in its use through the auspices of the Strengthening Programme, the EIA was seen quite narrowly at the time as a system for inspecting anticipated pollution levels. In 1989, the EPA drafted a new version of the EIA Act which drew on its own direct experience and on the evidence of the EIA system's operation in other countries. This draft was accepted by the Executive Yuan and submitted to parliament for review in 1990, ending the second phase.

The most important change during this period was political in nature. Having been subject to martial law where political parties and periodicals were banned, Taiwan's political structure changed from 1987 onward. The change was gradual and amidst the slow upheaval, several local environmental protection groups sprang up. The general public's slogan became 'let's have a beautiful environment'.

6.3.1 An Era of Social and Economic Change

Economic growth continued to be a prime objective during this phase too. However, Taiwan's economic development policies were adjusted to cope with international competition, to extend private investment and to rejuvenate the economy. As opposed to the stress placed on manufacturing industry which had characterised the previous few decades, Taiwan now looked to develop strategic high-tech industries such as computers, visual communications and automation products.

A science-based industrial area was established in Hsin Chu in 1981 for this purpose, for Taiwan was nov keen to transform itself from a labour-intensive industrial nation to a "brains-intensive" one. Upgradin regulations aimed at promoting new kinds of high-tech industry were announced in 1982 in a contex where Taiwan's service-based industries were going from strength to strength as a result c industrialisation, urbanisation and a general rise in the standard of living. Looking at FIG. 6-2 above, w can see that agriculture as a proportion of Taiwan's total productivity continued to fall in this decade; b 1990, it represented only 3.5% of GDP. After peaking in 1986 at 47% of GDP, the industrial sector als started to fall, accounting for 41.1% by 1990. Meanwhile, the service industries were on the up: 47.2% c GDP in 1980, rising to 50% in 1989 and 55.1% in 1990.

As the industrial structure evolved, the trend towards urbanisation increased even further. By 1990, 76% o the population were city-dwellers who occupied only 12.1% of Taiwan's total land area at a density o 3,549 people per square kilometres. The increasing density of the urban populations led to a tremendou spurt of development on suburban hillside sites. Between 1980 and 1990, 416 hillside developme projects went ahead over an area of 5,544.03 hectares[12], and all had impacts on the urban and countrysi environment.

This decade saw a huge level of change in the political arena. In 1986, martial law was lifted by the la President, Chiang Ching-Kuo, and the establishment of political parties, movements and media was no permitted. With the repeal of the national security laws in 1986, Taiwan had reverted to constitution control. Opponents of the Kuomingtang (KMT) pushed to form a new political party - the DP

[12] The Construction Management of Hillside Developments was announced in 1983. Of the decade's 41 projects, residential buildings accounted for 1,604.5 hectares; schools 129 hectares; golf courses 2,941.1 hectares; and other constructions 662.0 hectares.

(Democratic Progress Party) - which was established in September 1986 and which[13], by the end of that same year, had won 22% of the vote for the Legislative Yuan. Thus, competitive party politics asserted itself in Taiwan.[14] The opposition party frequently participated in environmental protection movements which increased the frequency of anti-pollution demonstrations.

As the political and economic structure changed and the standard of living rose, the environmental movement began to really find its voice. Whereas there had been only five environmental protection demonstrations pre-1980, the '80s saw 311 occur (see FIG. 6-4). The lifting of martial law was what opened the floodgates. From 1980 to 1987, there were 101 but this rose dramatically by a further 210 in the next three years (1988-1990). This decade was the period when the environmental protection movement went from "bubbling to boiling" (Hsiao 1993, p.554).

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[13] Till the lifting of martial law, opposition parties were officially banned. However, the DPP had been forging alliances with anti-KMT factions since the late 1970's and had emerged as an important political force prior to its legal establishment. Indeed, in 1986, when it declared itself as a party it was done without formal permission.

[14]Taiwan has two elected Yuans: the Legislative Yuan and the National Assembly, the former being more important in the political arena. The Legislative Yuan legislates for and supervises the Executive Yuan, i.e., central administrative government. The Legislative Yuan was not completely reelected till 1992. In 1986, a supplementary election for the Legislative Yuan was held.

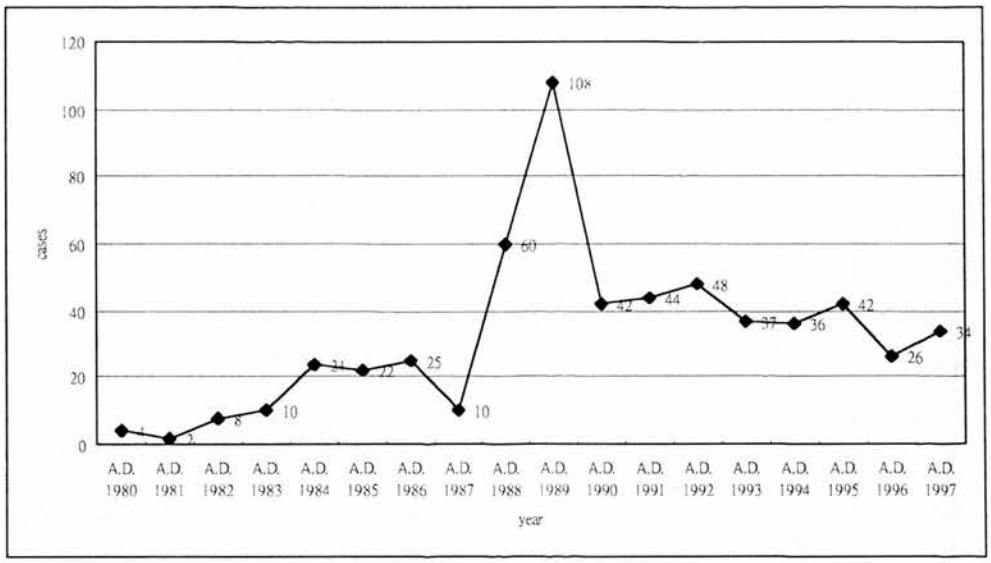

FIG. 6-4: Environmental Protection Demonstrations in Taiwan

6.3.2 Growth in Environmental Awareness

Throughout the '80s, general awareness of the environmental crisis rose rapidly, aided by the formation o several environmental protection groups and spurred by several alarming discoveries. For example, i April 1980, an investigation revealed that the average pH value of rainfall in Taiwan was 4.2 (a sign o acidity). It was confirmed that Taiwan was the fourth country to be threatened by acid rain.[15] Thi finding shocked both the government and the general public alike, and grass-roots anti-pollution protest began to flourish.

In 1985, a resident of Taichung County established " Love My Village: Public Nuisance Defenc Groups" which was a pioneering undertaking for private organisations to co-operate in halting publi

[15] This investigation was conducted by the Taiwan University's Graduate School for Plant Diseases and Insect Pests. This report indicated that Taiwan was the fourth country to be threatened by acid rain. See Chang, 1991, p.45. However, according to Jacobs, 1996, p.16, 22% of European forests have been damaged by acid rain in the last decade, giving us grounds to doubt that Taiwan was the fourth nation to face the threat of acid rain.

hazards. The locals of Hsin Fong village in Hsin Chu County demonstrated outside Baker Chemicals Co. against its poisonous water and air emissions, forcing the factory to stop production and move to another place. In 1986, about 600 people from Kaohsiung and Ping Tung Counties assembled at the Da Fa Waste Hardware Disposal Centre, Kaohsiung, to protest against the 'Dioxin Event', which occurred from burning waste cables and wires. In 1987, the US Du Pont Co. was due to set up a titanium dioxide factory in the town of Lu Kang, Zhang Hwa County, but was forced to cancel because of local opposition.

6.3.3 Environment Policy: Control of Pollution as the Main Goal

The scope of environmental protection issues are extensive and their nature is complex. This decade saw a transition in understanding from a concern with hygiene to a much more trenchantly expressed concern with pollution control. As anti-pollution protests escalated, the government directed its environmental protection policies towards controlling pollution and managing public hazards.

The Executive Yuan convened an economic conference in 1975. The consensus view on the second main issue was the statement that "because of rapid industrialisation and growth of the metropolitan population, air pollution, water pollution and waste treatment will become our most serious problems in the future. In order to maintain the environment, public hazards prevention and control need an integral plan which should be put into practice as soon as possible" (EPA 1989, p.4). Even then, the government had already sensed the importance of pollution control as a policy theme. In 1979, the Executive Yuan passed the Environmental Protection Programme in Taiwan; its purpose was to solidify the kind of organisation that could tackle the pollution issue. Based on this programme, the Environmental Protection Bureau of the Hygiene Administration of the Executive Yuan was established in January 1982. It was responsible for water and air pollution prevention/control, environmental hygiene, traffic noise control, environmental impact assessment and control of poisons.

Meanwhile, the Environmental Protection Group was set up in 1986 with the Deputy Minister as its convener. Its goal was to draw up integrated environmental policies and to coordinate the work of different departments. It was this group which drafted the Essential Points of Current Environment Policies in Taiwan in 1987. In August 1987, the government established the Environmental Protection Administration (EPA) under the Executive Yuan to develop national policies for the prevention and control of pollution, increasing its manpower to 284 from the original 124 (EPA 1989, p.3).

6.3.4 Environmental Legislation: The Legislative Process Lags Behind Social Change

Legislation is also a product of public opinion, with congress acting as its collective voice. Therefore, legislative procedures in democratic countries need to be reviewed and examined by congress before they are passed and put into practice. Yet, in Taiwan, a general election for the Legislative Yuan was not held until 1992.[16] In this context, we find that the chronic disassociation between the people and the Legislative Yuan of the previous decades meant that public opinion was often betrayed or ignored, and very little was to be expected of environmental legislation at this point in Taiwan's political history.

The EPB was set up in 1982, to be replaced by the EPA in 1987. At the EPB stage of the evolution of the administration of environmental protection affairs, no specific plans for legislation were laid down though the efficiency and integrity of legislation was badly needed. The EPA era heralded aggressive attempts to draft appropriate legislation but, for the reasons mentioned at the opening of this section, their effectiveness was limited.

What these aims reveal is that the Executive Yuan wished the EPA to comprehensively review the administrative structure for preventing, controlling and redressing environmental damage with a view to

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[16] Before 1992, it was called the Legislative Yuan of the first term. Most of the legislators were re-elected but only some regularly faced the re-election process, called a supplementary election.

establishing organised and systematic environmental laws. The EPA duly mounted a large-scale environmental legislation plan which aimed to finalise the establishment and/or amendment of legal codes within three years (1987 to 1990).

There were 59 kinds of legal regulation relevant to the environment. The status quo was clearly inadequate since 43 new laws would need to be passed and 16 existing laws would need to be amended. Unsurprisingly, the EPA did not manage to meet its own deadline; it only managed to achieve 22% of its legislative plans by the end of 1990. Table 6-1 shows that 13 new or amended legal codes were in place by that time. Apart from the legislation governing the organisation of the system's administration, most of these 13 referred to the control of pollution. Preventative or remedial legislation was nowhere in sight as yet.

Table 6-1: Environmental Legislation Achievement Rates

Expected Complete	Legislation Volume (case)	Actual Completion (case)	Achievement rate(%)
Dec. 31, 1988	24	4	17
Dec. 31, 1989	24	5	20
Dec. 31, 1990	11	4	36
Total	59	13	22

Note: The large-scale environmental plan was started in 1987

6.3.5 The EPA's Role as Environmental Goalkeeper

As we saw, the EPA first emerged in 1987 from the ashes of the old EPB. With its new title and expanded remit, it consisted of eight divisions which were responsible for national environmental protection policy-making. Unlike the older EPB which had been located as a second-level division within the Health Ministry, the EPA was constituted as first-level department reporting directly to the Executive Yuan. The establishment of the EPA was a milestone in the promotion of environmental protection measures.

See Figs. 6-5 and 6-6 for an outline of the structure of government in Taiwan and for the organisational structure of the Executive Yuan relating to environmental protection administration.

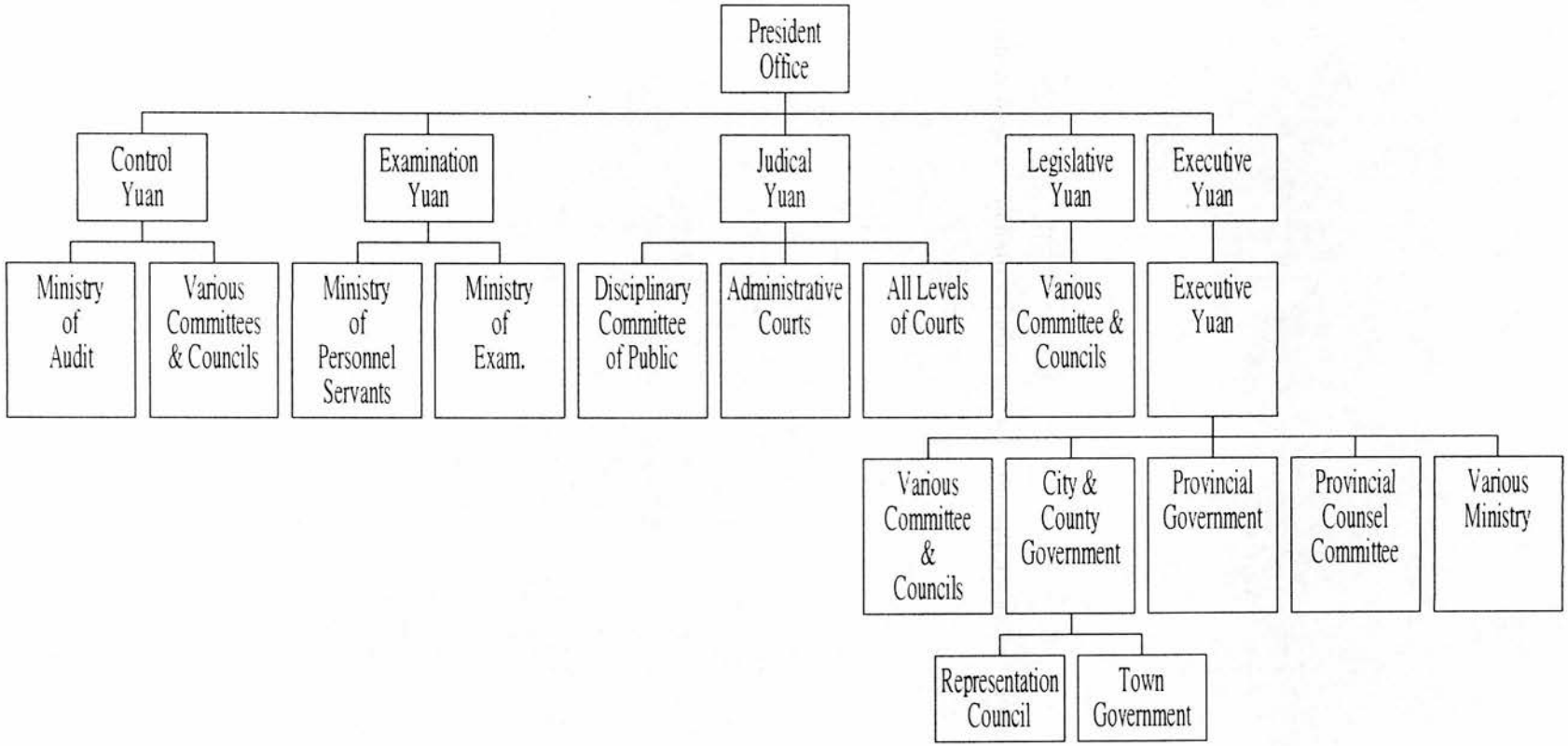

FIG. 6-5: The Structure of Government in Taiwan

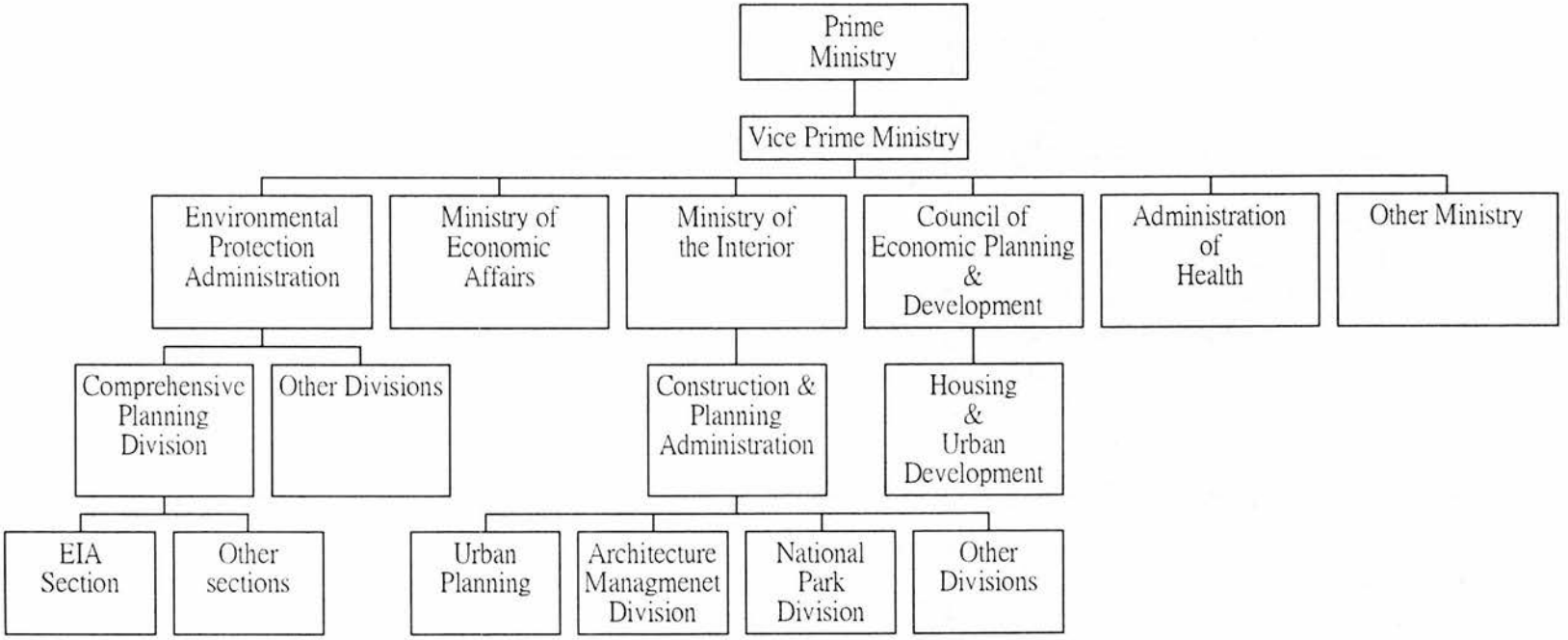

FIG. 6-6: Organisational Structure of the Executive Yuan Relating to Environmental Protection Administration

Table 6-2 shows how environmental protection staffing levels continued to rise. However, they still remained relatively low compared with other countries' manpower. As Table 6-3 shows, there were only 0.7 to 0.8 of these staff per 10,000 people in Taiwan, as compared to 2.0 to 2.14 in the US and 1.16 to 1.25 in Japan. Table 6-4 shows that Taiwan's expenditure on environmental protection was also lower than other countries' relative to GNP.

Table 6-2: Environmental Protection Staffing Levels in Taiwan (1985 to 1990)

Manpower	1985	1986	1987	1988	1989	1990
Central	110	110	116	284	284	414
Local	853	867	881	1115	1346	2004
Total	963	977	997	1399	1630	2419

Note: Local governments began to establish environmental protection units in 1985

Table 6-3: Environmental Protection Personnel Per 10,000 Pop. (Government Staff)

Nation	Central Agency (duration)	Central & Local Agency (duration)
Taiwan	0.06 - 0.04 (1985 - 1989)	0.7 - 0.8 (1985 - 1989)
U.S.A.	0.46 - 0.60 (1980 - 1986)	2.0 - 2.14 (1981 - 1986)
Japan	0.07 - 0.08 (1980 - 1986)	1.16 - 1.25 (1980 - 1986)

Data Source: Yau, 1989, p. 93

Table 6-4: Environmental Protection Expenditure as a Proportion of GNP (%)

Year	Taiwan	USA	Japan	W. Germany
1988	1.10	1.69	1.76	1.58
1989	1.12	1.67	1.73	1.58
1990	1.09	1.70	1.70	1.56

Data Source: EPA,1996a, p. 118

6.3.6 The Preparation of EIA Legislation

The series of EIA pilot studies which were conducted in the '80s served to build a base of professional experience in the system's use. As discussed earlier, the Health Administration had drafted an early version of the EIA Act in 1983 which was rejected but which had the effect of focusing minds on the Programme to Strengthen the EIA. When the EPA was set up in 1987, it vigorously renewed the task of preparing a draft version of the Act which was duly presented to the Executive Yuan for review in 1989 and to the Legislative Yuan for approval in 1990. By that time, 123 development projects had submitted to EIA trials.

The spirit of the EIA system was an advance on the policies based on ex-post clean-up of environmental damage: it was anticipatory and interventionist, aiming to prevent or minimise damage being caused in the first place. The system was therefore well placed to make up for the deficiencies of previous environmental policies. However, this was not entirely an unmixed blessing during the '80s when the EIA system was undergoing a series of pilots with a view to establishing how best it could be modified to suit Taiwan's purposes. For example, its use on the decade's major construction projects was feared to have the effect of slowing their completion schedules. Thus, it was in this context of complicating factors that the EIA was piloted, that draft legislation was prepared and that a series of demonstration projects were selected for EIA trials.

As the implementation of EIA trials clearly had implications for important public and private sector developments, and for the public's rights, the pilot studies in themselves served as an additional impetus for providing the system with a legal basis. The EPB (as it then was) invited relevant institutions, experts and scholars to form an Interim Research Group on EIA Legislation, and it was this group which drafted a version of the Act six months later.

This draft was a milestone in the development of Taiwan's EIA system. However, it was rejected at the time as the Council for Economic Planning and Development (CEPD) regarded Taiwan's existing base of experience, professional staff and technical skill to be insufficient to the task and it feared that the EIA system as proposed in that version would impact too greatly on Taiwan's economic well-being.[17] As we have already seen, the Health Administration in 1985 then instigated an interim measure - the Programme

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[17]Draft versions of the EIA draft were rejected several times by the Executive Yuan which decided to postpone legislation until more professional training was provided and more experience from other countries' usage of the system could be called upon as a reference. See Liu, 1995, p. 47.

to Strengthen the EIA - and selected 14 representative development proposals to test the EIA's procedures. These projects, which included power generation stations, reservoir engineering, sewer system projects and industrial park projects, were important development proposals of that time. Should they be delayed as a result of the EIA process, there would be critical consequences for the economy. Hence, the trials were more flexible in their application of the EIA process than would otherwise have been the case; their primary purpose was not to conduct a full and binding EIA but to gain experience in the system's use. In addition to these 14 projects, the EPA and CEPD required other test cases; by 1988, 52 development projects had undergone some version of the EIA review process. Of the 123 EIA test cases implemented by 1990, 37 were on places of entertainment, 22 on environmental protection projects (mostly landfill dumps and incinerators), and 20 on industrial parks and factories.

With this growing body of experience at its back, the EPA renewed the task of drafting the EIA Act. It was submitted to the Executive Yuan for review in March 1989, passed in July 1990, and then submitted to parliament for review. This closed the phase of preparation of EIA legislation.

6.4 THE THIRD PHASE (1990-1995): THE FORMAL ESTABLISHMENT OF THE EIA SYSTEM

After the draft EIA Act was formally submitted to the Legislative Yuan for discussion in July 1990, the stage of formal legislation began (1990-1995). At the end of 1991, three committees of the Legislative Yuan (the Interior, Economic Affairs and Judiciary Committees) jointly reviewed and amended the draft. They altered the review body of the EIA system from the Competent Authority to the EPA itself and made some adjustments to the level and type of public participation. After the amendment process, the role of the EIA review in merely informing the policy-making process was upgraded to having a decisive status in the approval or withholding of approval for a project. The version of the Act which was finally

announced as law in late 1994 was based substantially on the amendments made by this group of committees.

During this stage, the economy continued to grow at an average rate of 6.4%, per capita income rose to $10,000, and the nation's standard of living rose. From the volume of anti-pollution cases which were under appeal in this period, we can see that the environmental complaints also thrived: in 1990, there were 58,778 cases rising to 117,788 in 1995.

Change also occurred in this period in the policial arena, for in 1992 a full general election was held for parliament (the Legislative Yuan). The outcome was that the KMT's seats were greatly reduced and the DPP (with 51 seats) gained about one-third of the chamber. Thus, genuine oppositional parliamentary politics were now in play. In 1994, elections for provincial and city governorships were held and, in 1995 a (general) election for the third term of the Legislative Yuan was held. Policy-making during this period was characterised by attempts to be sensitive to public opinion, to nurture a hospitable investment climate and to foster national wealth and stability.

The Taiwanese branches of global environmental protection groups had been lobbying for some time for more to be done to protect wildlife and were now also proposing that trade sanctions be applied against Taiwan. The activities of the global environmental groups contributed to Taiwan's growing sense that had an international reputation to manage, and that moral credit could be gained by swimming with the tide of the international environmental movement. For example, in March 1990, Taiwan sent a delegation (the first of its kind) to the Montreal Protocol Conference in Geneva, Switzerland (EPA 1997a, p.348).

This stage was a highly productive one in terms of legislation passed on environmental issues: 106 laws were stipulated or amended and seven others were revoked. On average, a new law was passed every

three weeks, a substantial achievement indeed.

The establishment of the EIA system was the big event for environmental management in this period as was a constitutional change made. In May 1992, the constitution was amended to include a clause on the environment (the first such clause in Taiwan's constitutional history) which endorsed the protection of the environment and its ecosystems. The symbolic significance of this amendment was enormous, as was the constitutional weight it gave to the environmental protection laws which are currently in place in Taiwan.

6.4.1 Dramatic Socio-Economic Change

From 1990 to 1995, Taiwan underwent enormous societal, political and economic change. In the political arena, Lee Teng-hui became the 8th President of Taiwan in May 1990. In his inaugural speech, he declared the end of the Mobilisation Against Communist Rebellion, repealed the Temporary Provisions which had been put in place to quell it, and named General Hao Po-tsun as Premier of the Executive Yuan.[18] There was popular up-roar at the appointment. Once in post, Hao Po-tsun adopted an unyielding working style (Liu 1995, p.103), responding in a high-handed manner to all kinds of popular demonstration. He aimed to stabilise the country for, with the environment going from bad to worse, he considered this measure was necessary if Taiwan was to create an attractive climate for investment.

As mentioned earlier, in December 1992 a full general election for the Legislative Yuan was held, which returned a resounding 51 seats to the opposition party, the DPP. Its greatly enhanced oppositional power in parliament played an important role in moving environmental legislation forward since at least some of these new DPP members had credentials as anti-pollution campaigners (e.g., Huang Tien-sheng, who played a central role in opposing the establishment of the 5th light oil decomposition factory in

[18] Hao, Po-tsun was a powerful military figure. A most senior general in the military ranks, he had been Chief of General Staff in the Defence Ministry as well as holding the post of Minister of that Department.

Kaohsiung). In the mayoral and local government magistrate elections of November 1993, the KMT had another gain in Changhua County, winning the seat from the DPP. In 1994, at the elections for Provincial Governor and City Mayor in Taipei and Kaohsiung, the DPP won the Taipei City Mayor seat and the KMT the seats of Taiwan Provincial Governor and Kaohsiung City Mayor. In 1995, the 3rd term election for the Legislative Yuan was held.

Thus, during this short period, there was almost one big election each year, making Taiwan's political landscape unstable and interrupting the smooth flow of some important policies. Frequent elections also made Taiwan's Legislative Yuan focus almost exclusively on political, financial and economic affairs: of the eight laws of highest priority proposed by the KMT members of the chamber, only two concerned environmental protection, and of the eight of similar ranking proposed by the DPP, only one did.[19] Clearly, amidst this turbulent political upheaval, environmental issues were not the government's (or the people's) top priority.

During this period, the structure of industry also changed: the ratio of manufacturing business to GDP fel from 32% to 28.5%, while tertiary service industries rose from 56% to 60.2%. Within the manufacturing sector, the capital- and technology-intensive industries were still growing though labour-intensive ligh industries seemed to decline significantly. Although the economy was still growing steadily, other factor such as the appreciation of the Taiwanese dollar, soaring wages, shortage of land for industrial use and labour shortages[20], meant that there was a bottleneck in upgrading industrial techniques. One of the

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[19] Because there were hundreds of bills, emanating from one party or another, waiting to be reviewed and approved by the Legislative Yuan, each party was asked to rank the bills they most wanted dealt with in order of priority so that the most urgent topics could be placed on the parliament's agenda. See Yeh, 1993 p.110.

[20]Because of these labour shortages, the government adopted a policy of buying in some foreign labour. In 1995, a total quota of 270,000 foreign workers was approved of whom more than 200,000 came from Thailand and the Philippines. See Yeh, 1997b, p.35.

consequences of this bottleneck was that public investment in Taiwan's economy fell and the "immigration of industry" discussed earlier grew to more than a trickle. In response, the government announced a Six-Year Programme of National Construction in January 1991.

This programme had an enormous impact on Taiwan's landscape, water sources and raw material resources. It included the development of 28,600 hectares of farmland, 800 hectares of land for a large shopping centre and an industrial and commercial centre, the building of nine reservoirs and the completion of seven fossil-fuelled power plants.

In addition to the spurs of the Upgrading of Industry Programme and the National Construction Programme, Taiwan's economy was now increasingly shaped by international economic and societal forces. After the General Agreement on Tariffs and Trade (GATT) was reorganised as the World Trade Organisation (WTO) in 1995, issues such as intellectual property rights, environmental protection and labour conditions became increasingly important topics (EPA 1997a, p.348), bringing new challenges for Taiwanese industry.

Socially, this period was also a time of turmoil in Taiwan. The old order had just collapsed and it was not yet clear what would take its place. Street demonstrations were on the increase and it appeared as if social order was under threat. Hao Po-tsun, the strong-arm General who had been appointed to the post of Premier of the Executive Yuan, claimed his legitimacy to govern in terms of his concern with re-asserting social order (Liu 1995,p.103). His tactics were overbearing: demonstrative social activity declined during his tenure as did the number of anti-pollution protests (from 42 in 1990 to 11 in 1995) (EPA 1997a, p.724).

6.4.2 The Shift from Local to Global Environmentalism

While local pollution problems continued to assert themselves, issues to do with pollution at the national level were what most occupied the government agencies, e.g., the management of nuclear waste and the protection of wildlife. Yet to this mix was added Taiwan's growing involvement with global environmentalism as we saw in the last section (Yeh 1997b, p.49). In particular, the Montreal Protocol and CITES mattered to Taiwan for these conventions threatened trade sanctions against those infracting their terms. In the WTO, a Trade and Environment Committee was set up to coordinate the management of problems which resulted from specific conflicts of interest between trade and environmental protection. All of these layers of environmental problem meant that the work of environmental protection became hugely more complex: environmental policy-making not only had to respond to local and national problems but also had to follow the precepts set by international conventions and standards.

At the next level up from national environmental problems, international environmental concerns revolve around the issue of sustainable development (Yeh 1997b, p.140). In 1992, the United Nations established Agenda 21 - the principle of sustainable development - at the Earth Summit held in Rio de Janeiro Agenda 21 attempted to sketch out how global development should be approached in the 21st century. By May 1992, the Executive Yuan had set up a Global Change Task Force, which was followed in August by the establishment of a Global Environmental Change Research Centre in National Taiwan University. In 1994, the Global Change Task Force was expanded and renamed as the Policy Guidance Task Force fo Global Change. At the same time, six discrete work teams were formed to deal with Taiwanese topic relevant to the Montreal Protocol, the Basel Convention, Climate Change, CITES and CBD, Agenda 2 and Trading and Environmental Protection. In December 1995, another team began work on ISO 14000 the environmental management system which aims to audit the environment (EPA 1997b, p.335).

At the end of 1993, when agreement on the Uruguay Negotiation was reached, each member state though

it necessary to discuss trade and environmental protection in order to unite both issues as an indivisible topic under a multilateral trading system. At this stage, there were about 180 international environmental protection agreements, of which about 20 had trade sanction clauses (EPA 1997b, p.335), e.g., CITES, the Montreal Protocol, the Basel Convention and CBD. All these agreements have had a great impact on Taiwan for although it has never signed any regional or international environmental treaty it has been subject to their provisions.[21] In 1994 CITES condemned Taiwan for its failure to curb the smuggling of rhino and tiger parts and imposed the Pelly sanction against the country.

6.4.3 Environmental Policies: From Pollution Control to Environment Management

At the national level of environmental policy-making, conservation of the natural landscape assumed importance. By the end of 1995, six national parks were established covering 322,207 hectares in an attempt to protect areas of special beauty or historical significance and certain wildlife habitats. The management of forests also received attention, but came too late to alter the fact that originally wooded hillside land near the cities had already been stripped for residential or industrial use. As matters stand, Taiwan's ancient forests grow smaller daily and several species of forest plant and animal are close to extinction. In addition to the six national parks, the Ministry of the Interior also designated 12 coastal areas as conservation zones. The Ministry of Economic Affairs and the Council for Agricultural Planning and Development announced 18 conservation districts; the Ministry of Transport and Communications organised a north-east scenic area, an east coast scenic area and a Penghu scenic area; and the Forestry Administration of Taiwan Province Government founded six forestry conservation districts. From this list we can see that the authorities responsible for aspects of conservation policy were diverse. Yet, although no single agency carried responsibility for the task, it is clear that even at this stage the notion of

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[21] Because of Taiwan's ambiguous diplomatic status and lack "national" standing, it has never had international environmental treaty membership. However, it is subject to international environmental laws which it has not participated in drafting, nor has signed. See Yeh, 1997b, p.50.

environmental protection had expanded to include ecological conservation.

At the level of policy-making addressing global environmental concerns, some advances were also made in this period. The criticism Taiwan had received from the international environmental community over its failure to protect rhinos, tigers and elephants from the ivory, tiger meat and rhino horn trade not only embarrassed Taiwan but resulted in the Pelly sanction been applied in 1994. This further galvanised efforts to address the environment at the global level. In addition to positively enrolling in organisations like CBD, CITES, the Convention on Internationally Important Wetlands (RAMSAR) and the Forest Principle, the Taiwan government participated in the Geneva conference of March 1990 on the Montrea Protocol. It was willing to comply not only with the terms of the Montreal Protocol but also with those passed at the Rio Declaration and the Agenda 21 that emerged from the Earth Summit of 1992. In May 1995, it organised a Policy Guidance Task Force for Global Change Policies to enable Taiwan to meet the terms of these various treaties.

6.4.4 A Spate of Environmental Legislation

By the end of the previous stage (1980-1990), only 13 environmental laws had been passed - 46 laws were still waiting in the pipe-line. As the context of environmental concerns had expanded from local to national and international levels, the pressure to push through more legislation mounted. "Think Global Act Local" had become a clarion call as much in Taiwan as in the other countries of the developed world.

Between 1990 and 1995, the government exerted itself to complete the enactment of 119 environmental laws - a nine-fold increase on the legislation of the previous stage, representing a 910% growth overall. This was a truly remarkable achievement for it required that an average of 20 new laws be revised or laid down each year of this stage. Table 6-5 shows that there were 29 kinds of legislation on air pollution followed by legislation on the EIA system (26 in one year alone following the passing of the EIA Act a

the end of 1994).

Table 6-5: Environmental Legislation

Characteristic	Type	Volume(Bills)
Ex-ante Prevention	EIA Act	26
Prevention & Control	Air quality control	29
	Noise nuisance control	9
	Water pollution prevention	12
	Waste disposal	18
	Hazardous waste management	5
Remedy & Appeal	Environmental Dispute resolution	6
Organisation	Administration organisation	8
Other	Environmental business management	6
Total		119

Legislation and policies mirror each other's precepts and contents. Looking at the environmental legislation passed in this period, we can see that two principles became incorporated into legislative and policy-making processes: the Polluters Pay Principle and the Precautionary Principle. The former is premised on the idea that since the polluters profit from the activity which caused the pollution in the first place, they should also be the ones to pay for it in the form of government tax. Following the theory of internalisation of external cost, polluters only have a true incentive to reduce their emissions if it affects their financial bottom line (Yeh 1993, p.92).

Evidence of the operation of this principle is found in legislation dating from this period. For example, the amended Waste Disposal law included a deposit system whereby producers of PVC containers were required to pay a sum for each container produced or sold, though the sum would be refunded if the producer recycled it within a specified time. As a consequence, recycling of PVC containers reached 66.36% by 1995. Another example is found in the amendment to the Air Pollution law of March 23rd

1995, which generated £56 million in tax in its first year of operation.[22] The second concept - the prevention principle - is also found in the legislation of this period - most notably, the EIA Act itself.

Laws on the control of pollution enacted at this stage tended to use several instruments (including economic incentives) to achieve their ends. For example, the amended Waste Disposal law imposed a rubbish fee which applied to the producer but which also meant that the consumer usually paid a higher price for goods contained in certain kinds of packaging and this in itself was hoped to persuade consumers to reduce their usage of such packaging. The Air Pollution Prevention law incorporated the idea of a "Pollution bubble" to entice enterprises to improve their equipment and so restrict their emission levels.

6.4.6 The Formal Establishment of the EIA System

The Programme to Strengthen the EIA, which we examined in the previous section, was run as a series o trials and had no powers of enforcement. As this was unsatisfactory over the long term, we have seen how it came about that the Executive Yuan submitted a draft of the EIA Act to the Legislative Yuan in 1990 and that this marked the beginning of the EIA legislative process. In the interim, a Sequential Programme to Strengthen the EIA was announced in 1992 as the original programme was due to expire leaving nothing in its place. This sequential programme was not confined to coverage of nominated developmen projects, but was to act as a general test of the implementation of the system. It still did not posses powers to enforce its findings nor were its exact review procedures or coverage made explicit which caused some inconsistencies in its use by the local agencies. Despite these inconsistencies, most EIA administrators took the line that the main responsible authority was the Competent Authority and that th EPA was that Authority's professional assistant.

When the draft EIA Act was examined by the joint commission of the Legislative Yuan, it underwent

[22]The sum came to NT$218,740,000 (equal to £56 million) between July 1995 and June 1996.

number of significant changes, some of which we have discussed already. The EPA was now named as the competent authority; penalties for infractions were greatly increased; and government policies which were likely to have significant impacts on the environment became subject to EIA review. These amendments greatly strengthened the power of the EIA system for it now had the power of veto over approval decisions.

By the close of this stage, both central and local authorities had made strenuous efforts to enforce the system. The kinds of project which came under its remit were expanded to include private ventures such as shopping centres or department stores. As soon as the EIA Act came into law, the EPA set about making the system's procedures and contents explicit and, therefore, consistent.

6.4.6.1 Main Issues to Arise from the Legislative Process

The legislative process threw up three major adjustments to the EIA system. First, the responsible authority was shifted from the Competent Authority to the EPA itself. Second, the review procedures were adjusted time and again. Third, the EIA Report changed from two types (EIS and EIR) to three types (EIS, draft EIR and final EIR), which caused a great deal of controversy during the process of legislation.

In the draft Act, the Competent Authority was held responsible for conducting reviews but, after debate, the Legislative Yuan decided that the EPA was better equipped for the task given Taiwan's unsatisfactory administrative apparatus for environmental protection. This view was supported by the various environmental NGOs. In addition, the Legislative Yuan set great store by the contribution which relevant experts could make to the effective execution of the system. For this reason, it was decided that scholars or experts should constitute two-thirds of the membership of EIA committees, so as to ensure that the quality of EIA review reports was appropriately high.

Generally speaking, other EIA systems submit their EIR conclusions to the Competent Authority which then makes the final decision. However, the Legislative Yuan revised the draft so that the body conducting the EIR retained the right of veto over decisions made on particular proposals. This was done both to strengthen the EIA system and to ensure that environmental concerns could never be side-lined in cases where the project's environmental impacts were likely to be significant.

During this period, the EIA system was applied to 377 cases. As its administrators came through the learning curve, they inevitably encountered controversies such as how to handle public participation in terms of its type or frequency; how to handle natural or cultural conservation cases; and how to locate the EIA system relative to national policies on energy and water resource management. The outcome was that the EIA system was somewhat unevenly executed during this trial phase and other organisations questioned the fairness both of the system itself and of the EPA's role in administering it.

During this trial period, it was quite often the case that a decision on a project was taken prior to the completion of the EIR review. This happened in the controversial cases of the 4th nuclear plant project. construction had already begun before the EIA was conducted, and the Prime Minister of the Executive Yuan had already decided that the plant's value outweighed the environmental impacts it might have as they were likely to remain within acceptable levels. The Minister of Economic Affairs also stated that there was no alternative to the plant.[23]

What these cases reveal is that the administrative authorities did not, at the time, understand the EIA's proper upstream location in the decision-making process. As a result, the public came to understand the EIA as being another bureaucratic manifestation of the tail wagging the dog. This was very bad news for the credibility of the system and in order to redress that problem the Legislative Yuan added a notabl

[23] Chinatime News, May 22nd, 1994, p.11, Taipei, Taiwan.

article to the draft EIA Act: *"if the conclusions of the EIR review suggest that a project should not get the go-ahead, the Competent Authority should not then approve it"* (EPA, 1996c). This article provided the system with teeth, for it now possessed the power of veto. Later, the Legislative Yuan nominated the EPA as the Competent Authority for EIR reviews, enhancing the EPA's expert status. Thus, despite the controversies surrounding the EIA trails, the actual outcomes for the system were extremely fruitful by the conclusion of this stage.

6.5 THE FOURTH PHASE (1995 -): THE EIA SYSTEM IN ACTION

This current era has proved the most challenging for the EIA system. In July 1997 the Asian economic crisis began and Taiwan did not escape unscathed: the New Taiwan dollar depreciated by 20% and the economic growth rate dropped to 5.3%. To offset some of the worst of the buffeting, a series of improvement policies were proposed, most notably the Plan to Increase Domestic Demand. The government has spent £4 billion on urban renewal, infrastructure, privately-owned power plants, etc., and all are closely linked with the question of environmental quality.[24] On 21st of September 1999, an earthquake at 7.3 on the Richter Scale shook Taiwan, causing 20,815 buildings to collapse and estimated costing £6 billion in recovery. The growth rate of the economy then dropped to 5.2%.[25]

Despite these reverses, Taiwan continues to thrive. According to the World Bank's 1998 figures, Taiwan enjoys the 4th highest economic growth rate in the world, averaging 8.6% annually over the last 30 years.[26] The average GNP per person has jumped to 23rd highest globally. Throughout this stage, the

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[24]Central Daily News, 17 August 1998, p.3, Taipei, Taiwan.

[25]Central Daily News, 29 September 1999, p.1, Taipei, Taiwan.

[26] According to the World Bank's statistics, Taiwan's economic growth rate over the last 30 years has only been topped by Po-Jar-Nah (13%) in Africa, Oman (9.5%) and South Korea (8.9%). See the Central Daily News, 26th, November, 1998, p. 4, Taipei, Taiwan.

government has been aiming to accelerate the upgrading of industry and to transform Taiwan into a "technical island" to attract foreign investment. The mid-range goal is to develop Taiwan as the Asian centre for high value-added manufacturing, sea and air transport, telecommunications, finance, media and other services. At the moment, Taiwan is actively gearing up to face a challenging future. This is bringing both a certain dynamism and a certain uncertainty to the country.

In the political arena, the first national presidential election was held in 1996. This took place at the same time as Mainland China carried out military and missile exercises in the seas to the north and south of Taiwan. In 1997, the KMT sustained serious losses in the mayoral/magistrate election, winning only eight of 21 county and city seats. As a result, the central and local governments are now controlled by two opposing parties, making it difficult for central government policies to find acceptance at local government level. In 1998, the central government set out to continue reforms by expanding the administrative structures and devolved powers of central, county and city governments. As part of this catalogue of reform, the establishment of the Ministry of Environment was finally declared and the local EPBs were enlarged such that each now have two additional divisions.

Environmental policy in this current era has become more international in scope. In December 1997, the Climate Change caucus established a consensus to cut back CO_2 emissions. This led to a dispute within the country about several important national investments such as the 7th petrochemical factory. The government finally announced that from 1998 CO_2 emissions would be one of the items assessed by the EIA, as per the European SEA system. Apart from that, the EIA system has aimed to strengthen its preventative function by focusing its attention on how important government policies are formulated: if those policies remain cognisant of environmental implications then they should be advanced. This new focus is assisting the EIA system's evolution from a project assessment system to a "3 Ps" (Policy, Plan and Programme) assessment system.

Overall, this current period has been a social, political and economic roller-coaster. Though the environmental question was the public's greatest concern in 1996[27], and the establishment of the Ministry of the Environment is evidence of the government's serious response to the issue, the Asian economic crisis and the recent earthquake disaster (21st Sep. 1999) have renewed the public's concern with economic development. Most recently, national policy-making reflects the conviction that neither issue should be prioritised at the expense of the other.

6.5.1 Social, Political and Economic Crisis and Opportunity

Over the past five decades, Taiwan has undergone dramatic social, political and economic change which, in turn, has had a huge effect on the environment. For example, Taiwan's population in 1946 (just after the Japanese colonial period came to an end) was just 6.09 million; by 1998 this had jumped to 21.83 million. Within 50 years, the population has increased 2.5 times. With its rich human resources, Taiwan has been able to satisfy the demands of the labour-intensive industries which characterised the pre-1980s era which, in turn, gave the country its stable economic foundations and its continuing ability to infuse its business ventures with a vitalising energy. The average net GNP per person reached US$13,872 (c. £8,700) in 1998, and this is growing annually at a rate of about 14.6%. This achievement makes Taiwan the world leader in this regard.[28]

6.5.1.1 Taiwan's shift from an Asia-Pacific Regional Operations Centre (APROC) to a Technical Island

In the face of international economic turmoil, the Executive Yuan has actively planned to make the best

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[27]A public opinion survey conducted by Taichung City Government indicated that the environment and traffic are the topics the public most care about. See Taichung City Government , 1996d ,p.21.

[28] See the Central Daily News, 26th November 1998. p.4, Taipei, Taiwan.

possible use of Taiwan's advantaged APROC position in the global marketplace. It is hoped that by using Taiwan's strong manufacturing foundations, excellent geographical location, huge marketing potential, proven managerial ability and extensive industrial networks, the country may continue to advance its economic liberalisation and internationalisation programme. The aim is to persuade international or national enterprises that Taiwan is the best investment springboard into the East Asian markets.

The APROC includes centres for manufacturing, shipping and air transits, finance, telecommunications and medical care. Among these centres, the first three relate to the use made of land resources. For example, the manufacturing centre is to be developed into a comprehensive series of high value-added industrial estates all of which will affect how land is used. Or again, the plan for the air transit centre is premised on converting the area around Jiang-Kieh-Shyr international airport into an air city, which will affect the region's land resources.

Using APROC as a staging post, the aim is then to consolidate improvements in Taiwan's level of sustainable economic development, to generate wealth which can be returned to the public purse, and to foster the kinds of talent-based industry which will enable the country to become a technical island by 2010.[29] However, the establishment of science parks has often been disputed by environmental groups. For example, the Bin-Narn industrial estate requires 300,000 tonnes of water daily and the Tainan science park 160,000 tonnes - such a great quantity, in fact, that the Mei-Nurng dam needed to be built. Thus we can see that the decision to build these parks was not decisively influenced by their environmental impacts, for, in the case of the Bin-Narn development, there was an additional environmental problem raised, i.e., that it would destroy the natural habitat of the threatened Black-Faced Spoonbill. Clearly, even science-based industry is not environmentally cost-free.

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[29] At present, Taiwan possesses 17 science parks, which occupy 3,300 hectares of land.

6.5.1.2 Changes in how Policy is Formulated

In 1996, the Taiwanese enjoyed their first opportunity to directly elect a president. Mainland China - fearing that this prefigured the declaration of an independent Taiwan - initiated military exercises in the seas off Taiwan in an attempt to influence the election's outcome. The post was won by Deng-Huei Lee (a KMT candidate) with 54% of the vote. It appeared as if the status quo of policy-making would remain undisturbed for a while longer. However, as we have already seen, the mayoral/magistrate election of 1997 effectively ousted the KMT from local government for they only won eight out of 21 county and city seats.

The DPP, who were now the majority party at the local government level, lobbied the central government for further decentralisation of administrative powers. They also opposed certain central government decisions - most notably, the approval it had given to the German company, Bayer, to invest £1bn in a TDI factory in Taichung.

With the central and local government administrations opposing each other, important topics were hotly contested prior to agreement being struck on the precise formulation of policy. In the 4th legislative election of 1998 the KMT only barely retained a majority (51%) forcing it to engage with the opposition to an unprecedented level. As a result, the formulation and implementation of environmental policy has become immensely more complicated.

6.5.1.3 The Enlargement of Domestic Demand

The Asian economic crisis of 1997/8 did profound damage to many Asian countries' financial systems. Taiwan was not the worst affected; though its currency was devalued by 20%, it still fared better than Indonesia's (at 61.2%) and Korea's (at 53.88%).[30] Nevertheless, Taiwan's economic growth rate dropped

[30]Central Daily News, 5th January 1998, p.3, Taipei, Taiwan.

from 6.5% to 5.3%. The Executive Yuan's response to the crisis was to attempt to enlarge domestic demand and to stimulate the economy by means of several large-scale public investment projects. Between 1998 and 1999, the government invested £4 billion in a motorway, a large shopping mall, water resource engineering, power station, etc. As this activity was primarily geared to re-energise domestic demand, the programme of change lacked an integrated approach to the management of environmental resources.

6.5.2 The Increasing Load Being Placed on the Environment

6.5.2.1 Mounting Waste and the On-going "Rubbish Wars"

Taiwan's volume of rubbish has risen from 4.8 million tonnes in 1985 (0.74kg per person per day) to 9.45 million tonnes in 1998 (1.18kg per person per day). The operational life of landfill sites is becoming shorter as they fill up at an ever speedier rate. According to 1998 EPA landfill data, of 316 county and village landfill sites in Taiwan, 82 are already full (17.7% of Taiwan's total), and sites which have more than two years of capacity left account for 47.2% of the total, i.e. more than half will be full by the turn of the century.[31] New sites are very difficult to come by because nobody wants one located in their immediate vicinity, ensuring that policy decisions on solid waste disposal are exceptionally fraught. So called "rubbish wars" are now quite commonplace.[32]

6.5.2.2 The Impacts of Global Environmental Protection

At present, there are about 180 international environment protection agreements, 20 of which include trade regulations. Agreements such as CITES, the Montreal Protocol, the Basel Convention, etc. have had an impact on how Taiwan proceeds with global environmental protection; several members of parliament and

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[31] EPA, 1998f, p.1.

[32] In March 1997, rubbish remained uncollected for 45 days in Tao-Yang city because a new landfill site had not yet been completed and local residents near the old (full) site prevented the city council from continuing to use it in the interim.

lobbyist NGOs push the government to achieve the goals set by these agreements, while other members of parliament and lobbyists for industrial and commercial interest groups query these treaties' power to impose trade sanctions. That latter group consider trade sanctions as trade protection in another guise (Industry and Commerce News, 11 Dec 1998, p.2).

Despite the opposite views held on these treaties, Taiwan cannot ignore global environmental protection issues partly because its environmental problems have been neglected for such a long time and more especially because it is a country oriented towards international trade. We have already discussed the embarrassment and trade sanctions it suffered as a result of its role in the trade of rare wild animals. Swimming with the international tide, the government has begun to promote the slogan 'think global, act local', most especially in relation to the terms of the Montreal Protocol which is an international agreement to phase out the production and consumption of ozone depleting substances such as CFC11. By now, Taiwan has complied with this provision (EPA 1997b, p.335).

Another issue which is receiving positive attention in Taiwan is emissions of greenhouse gases - most notably, CO_2 which accounts for 57% of the sources causing climate change (Houghton 1990, p.10). However, CO_2 is mainly produced by burning fossil fuels and Taiwan has especially well-developed petrochemical industries, e.g. petrochemicals, steel-making, etc. Therefore, the Climate Change Convention is certain to have a marked effect on the future fate of constructions such as Bin-Narn industrial estate and Hai-Do and Peng-Hu fossil-fuelled power plants.

In 1995, five of Taiwan's major products were boycotted by CITES because of the country's careless regard for wild fauna and flora.[33] The Basel Treaty, which controls the cross-border movement of hazardous waste, has prohibited the Organisation for Economic Co-operation and Development (OECD)

[33] See EPA, 1997b, p.175-182; p.334-338.

from exporting hazardous waste (including any recyclable kinds) to non-OECD countries since 31st December 1997. This is having a huge influence on Taiwan's export of industrial waste and its import of waste as a secondary material, e.g., in 1999, the Taiwan Chemical Corporation exported hazardous waste to Cambodia, which was heavily criticised by environmental NGOs.

6.5.3 The Emergence of Environmental Policy Premised on Sustainable Development

With the end of the Cold War, international trade has become much more important to each country's economic development yet in chasing niche markets within that global economy it has too often happened that local resources are abused, contributing to the havoc that is being wreaked on the global ecosystem. For this reason, sustainable development has become the keynote of current environmental policy world-wide and it is seen as the best way of laying the foundations for economic development in the next century (Chen 1997, p.11).

As discussed earlier, in 1992 the Earth Summit passed Agenda 21 which sketched out how sustainable development must be the way forward for the future. In signing up to Agenda 21, countries attempt to put that notion into practice. Towards that end, the Executive Yuan established the Policy Guidance Task Force for Global Change in 1994 and, in 1997, this task force was re-named as the National Committee for Sustainable Development. Its sub-divisions include teams working on CITES, the Montreal Protocol, the Basel Convention, climate change, CBD, Agenda 21, ISO 14000 and trade and environmental protection.

In 1998, the EPA published its mission statement on national environmental protection, declaring its purpose to be the prevention and control of pollution, the conservation of environmental resources, active participation in both local and global environmental affairs, and the pursuit of sustainable development (EPA 1998d, p.5). In addition to statements made by the EPA and the Executive Yuan, the Legislative Yuan has also declared that Taiwan actively promotes and attempts to improve sustainable developmen

Clearly the notion of sustainable development is emerging as the consensual basis to environmental protection, and is attracting the attention of several different economic sectors in Taiwan (Yeh 1997a, p.32).

6.5.4 Parliamentary Inefficiency Delays Environmental Legislation

6.5.4.1 The Legislative Yuan Undervalues Environmental Issues

Given Taiwan's social, political and economic upheavals of recent years, it is not surprising that the newsworthiness of environmental issues has drifted from peak position both for the general public and for the Legislative Yuan. In 1997/98 only 6.4% of parliamentary questions concerned the environment, i.e., on average, only one question posed per 17 members. Questions raised on domestic affairs, social welfare and education were much more prominent in this session: on average, every fifth or sixth question related to one of these topics.

Of the 555 questions on environmental policy listed in Table 6-6 shows that 42% of them referred to local issues rather than broader environmental concerns. This level is not surprising since members must respond to their electorate; issues of concern within their constituencies will, of course, find expression in parliament. Differentiating between types of environmental issue, we find that conservation of ecosystems accounted for the greatest proportion at 18%. This is because two mountain-side catastrophes occurred in 1996 and 1998[34], which led to a high level of public discussion at the time about ecological conservation. Table 6-6 also shows that the disposal of rubbish was another prominent topic. Though waste disposal is, in fact, a local government issue which should not reach the national assembly level, the

[34] In August 1996, a typhoon caused a rock and mud slide in Narn-Tour county which drowned a whole village. In July 1998, a flood in the south caused a serious landslide at A-Li Mountain and again additional mudslides in the Narn-Tour area

series of "rubbish wars" in Taiwan in recent years has ensured that the topic is now a national concern.[35]

Table 6-6: A Breakdown of Types of Parliamentary Question Raised on Environmental Issues

Sectors	Issues	Times	% of total questioning times-550 times(%)	Ranking	total(%
Local	Air pollution	34	6.2	8	
	Disposal of Rubbish	66	12.0	2	
	Landscape	57	10.4	3	
	Noise	22	4.0	10	
	Soil contamination	6	1.2	16	
	Water contamination	45	8.2	5	
	Ecosystem conservation	102	18.5	1	
National	Fallen geological strata	14	2.5	11	
	River pollution	17	3.1	12	
	Processing nuclear waste	4	0.7	18	
	Environmental education	6	1.1	16	
	Resources recycling	38	6.9	7	
	Usage and management of water resources	44	8.0	6	
International	cosystem of ocean	11	2.0	14	
	xtinction of some species in he world	11	2.0	14	
	eforestation and depletion of atural resources	48	8.7	4	
	lobal warming	25	4.5	9	
	epletion of ozone layer	2	0.4	19	
	cid rain	12	2.1	13	

Notes: The percentage of total questioning time on each issue is obtained by dividing the total or environmental issues by 550. Some questions cover more than two topics. This table is based on the statistical database of the Legislative Yuan's questions (1997/98)(http://www.ly.gov.tw).

[35] In 1997, a landfill site was barricaded by the pubic in Taur-Yuarn City, preventing the disposal of rubbish there. It was later found in the hillside surrounding Kaohsiung and Taichung, prompting another round of the on-going rubbish war.

6.5.4.2 Parliamentary Delays on Environmental Legislation

Because of inefficiencies in the Legislative Yuan, hundreds of proposals have piled up in the proposal bottleneck and environmental bills - amongst others - remain trapped in the in-tray. Table 6-7 shows that the Environmental Protection Bill has been languishing for over 10 years (4,225 days); the Vibration Control Bill has been delayed for nine years (3,577 days); and the amendment to the Drinking Water Management Regulation for 3,220 days.

Table 6-7: Duration of Legislative Progress on Environmental Laws

Laws	Date reporting to Executive Yuan	Date of handing in to Legislative Yuan	Date of promulgation	Total duration of examination by Legislative Yuan (day)
Environmental protection law	13/2/1988	31/5/1988	Unannounced	4225+
Vibration control law	21/6/1989	31/3/1990	Unannounced	3577+
Prevention of soil contamination law	22/4/1991	6/5/1992	Unannounced	2789+
regulation on drinking water control law	3/3/1990	5/3/1991	Unannounced	3220+
Environmental medicine control law	20/11/1989	4/10/1990	Unannounced	3371+
EIA Act	21/3/1989	21/8/1990	30/12/1994	1,672
toxic chemical materials control law	7/12/1987	2/3/1988	16/11/1988	259
clearing waste materials law	2/11/1987	20/5/1988	11/11/1988	174
water pollution prevention law	22/5/1989	23/10/1989	6/5/1991	559
resolution of pollution disputes	12/12/1988	18/5/1989	1/2/1992	986
air pollution prevention law	25/5/1989	14/11/1989	1/2/1992	807
noise control law	8/6/1988	9/12/1988	1/2/1992	1147
organisation of EPA environmental inspection	24/11/1987	8/2/1988	24/5/1989	471
training of EPA environmental protection staff	26/1/1989	22/8/1989	7/12/1990	470

Notes: The total examination days of those still unannounced are counted till 1st January 2000. Where there is an announcement date, the total examination days are counted up to that point (the announcement date differs from the date on which the Legislative Yuan passed the proposal by less then 10 days).

Data Source: EPA, 1997a, p.648-654 and Yeh, 1993, p.114, Table 5

These environmental laws are closely related to the quality of everyday life, e.g., the drinking water management regulation, or the vibration control bill (especially in light of the boom in the construction industry). As for the law of environmental protection - the so-called "constitution of the environment" - it concerns the overall structure of environmental protection. Generally speaking, the more important the law, the longer it takes to be examined, e.g., the EIA Act took 1,672 days. On the whole, environmental legislation is not the highest priority for the Legislative Yuan, being superseded by a more pressing concern with passing laws on economic affairs.

6.5.5 The EIA in Action

Since the passing of the EIA Act in 1995, local government has set about regulating how EIA committees should be organised for reviewing proposed projects, while the EPA has established the 21 types of project which come under the scope of the Act. The appointment of the EIA Committee Chair is the responsibility of the head of the county or city administration. As a result, review findings are critically shaped by the political affiliation and/or personal environmental stance of those executives. Some tend to be environmentalists first and last, suggesting that reviews conducted under their authority will come to strict conclusions; others are more mindful of industrial and commercial interests, suggesting that in these jurisdictions review procedures will be simplified and shortened so as to ensure that the region's investment environment is not threatened. However, regardless of the possible biases in the system at the detailed level, the EIA Act has undoubtedly aided the progress of the EIA system in Taiwan.

Between 1995 and the end of 1998, an average of about 89 cases a year submitted to an EIA. Of these, about 30% referred to high-rise buildings, new town developments and urban renewal projects, followed by factories at c. 13 cases per year. The current average annual caseload indicates that a great many more

cases are coming under the viewfinder of the EIA system since the passing of the Act.

Table 6-8: The Development of the EIA System in Taiwan

December	1975	EPC translate American EIA system. EIA concept introduced to Taiwan for the first time
June	1978	Administrative Yuan convene first technical committee and suggest that the EIA system should be implemented as soon as possible
March	1980	Administrative Yuan ask Tai Power Company to submit an EIR on planned nuclear power plant
July	1980	The 1,692nd committee of the Administrative Yuan decide on some EIA trials and ask the Sanitation Agency to gradually establish an EIA system.
August	1980	Implementation of 'EIA pilot plan at Da-Yuarn industrial park'
July	1983	Draft EIA Act finished and reported to the Executive Yuan.
October	1983	The 1,854th committee of the Executive Yuan reject the draft
October	1985	Announcement of the Programme to Strengthen the EIA
January	1986	Regulation on conservation and use of hillside amended and announced. Article 30 regulates that mountainside developments need an EIA review - the first law passed by the Legislative Yuan on EIA execution.
July	1990	Executive Yuan finish EIA Act and hand to Legislative Yuan for examination
April	1992	Executive Yuan announce Subsequent Programme to Strengthen the EIA
November	1992	Joint Interior/Judicial/Economic parliamentary committee review EIA Act
December	1994	Parliament pass EIA Act on Third Reading
30th December	1994	President announces the EIA Act as law
November	1995	EIA standards on high-rises announced
December	1995	Main points for establishing an EIA review committee in Taichung City announced. The EIA system officially becomes law in local government
20th September	1997	Implementation of Operational Regulations of Government Policy EIA
27th May	1998	National Energy Committee decide CO_2 emissions need examination in important cases

6.5.6.1 The Emergence of a Consensus about the System

We can see that various internecine disputes about the system necessarily characterise how it is implemented, though they are no longer anything near as frequent as they were in the early EIA days. The reason for this is that the system has already proved its value though it took some natural disasters to truly bring the message home. In 1997 Taiwan suffered from two strong typhoons, which caused serious flooding, landslides and mud and rock slides. Part of Shihn-Yih village in Nan-Tou county was buried and 35 buildings destroyed. Lin-Ken Grant Residency - a hillside community in Taipei county - also fell over in a landslide and 105 houses were completely destroyed. On examination, it became evident that in both cases the choice of site was potentially dangerous and the development plans were insufficient, and that both had been built prior to the establishment of the EIA system. The toll wreaked by these typhoons shocked the public into a recognition that the EIA system was necessary. In addition, US experience demonstrates that the cost of an EIA review increases construction costs by only 3% whereas the cost of post-disaster recovery represents 40% of the original cost of construction (Liu 1995,p.20).

6.5.6.2 Enlarging the EIA System; Introducing the SEA System

In 1994, when the draft EIA Act was entering its Second Reading in the 24th conference of the Legislative Yuan, Bai-Xian Perng - a member of parliament - noted that some of the government's important policies (e.g., vehicle exhaust emission standards, industrial effluent standards, urban renewal plans, formation of national parks, etc.) deal with issues which may have greater environmental implications that the development projects which the EIA systems targets. He argued that these kinds of issue should also be subject to some kind of EIA. His argument found favour and the 4th Article of the EIA Act states that

'governmental policies' come within the range of the EIA system.

6.6 SUMMARY

Over the last fifty years, as a result of the Taiwanese government's economic development and the nation's hardworking attitudes, an "economic miracle" was achieved. Since the 1980s environmental protection has become an issue throughout Taiwanese society with many of the public taking environmental pollution seriously and joining environmental organisations.

In the meantime the EIA system was being set up world-wide becoming a powerful environmental safeguard for the project planning process. The Economic Planning Council (EPC) introduced the American EIA system into Taiwan in 1975. The government ran a series of EIA demonstration projects to amass operational experience before establishing the EIA Act. From a historic perspective, the origin of environmental problems and the development of a corresponding EIA system in Taiwan have undergone four distinct phases since 1969 when the EIA was first established in the US. The evolution of the Taiwanese EIA system highlighting the interrelationship between EIA establishment and national development.

Before 1980	Development of concept of EIA system
1980-1990	Preparatory period of EIA legislation
1990-1995	Establishment of formal EIA system
1995-presenet	EIA action period

The first phase - the concept germination stage - is pre-1980. It was during this phase, as mentioned above, that the EPC introduced the US version of the EIA system into Taiwanese government and

industrial circles, and the first pilot study of the system was conducted at the prompting of the specialist environmental group within the Executive Yuan.

The second phase - laying the legal groundwork - lasted from 1980 to 1990. During this period, the government set up an EIA research team who initiated the task of establishing the EIA's parameters and who selected several projects for testing them out. As valuable experience was gained, the Executive Yuan was ready by 1985 to announce a programme for strengthening the EIA system, using 14 major projects as test cases. As a result of this endeavour, the Environmental Protection Administration (EPA) was established in 1987; by 1988 the first draft of the proposed EIA Act was deliberated on; and by 1989 the EPA had submitted a draft of the Act to the Executive Yuan for approval.

The third phase (1990 to 1995) was the period when a formal EIA system was established. In 1990, the Executive Yuan examined the draft EIA Act and passed it on to the Legislative Yuan who, in turn, submitted it to the Committee of the Interior, the Economy and the Judiciary in the 86th session. Meantime, the EPA continued to strengthen the EPA system by initiating a follow-up programme. Throughout this period, migration into the cities continued apace and the demand for urban dwellings and workplaces continued to boom. High-rises increasingly represented a way of balancing high urban population densities with expensive land prices. In an effort to forestall some of the worst environmental damage caused by high-rise buildings, some of the bigger cities began to insist on them submitting to an EIA examination. Thus, during this phase, both central and local governments were actively seeking ways to legalise the EIA system. By the end of 1994, the EIA Act came into law and the legal groundwork was almost complete. Indeed, this Act was selected by Taiwan's environmental protection groups as one of its top ten news items.

Once the Act became law, the Executive Yuan announced at the end of '95 how its terms should be implemented so that the EIA system could operate smoothly. Its coverage was also extended from the original three development types to 16 categories. The central EPA and local environmental agencies all set up EIA committees to conduct reviews, borrowing some of the procedural practices used in Europe and the US. In 1997, review guidelines were issued by the SEA, and the "3 Ps" (Policy, Plan and Programme) were incorporated into the EIA system's targets. In December 1997, a conference on global climate change was held in Kyoto, Japan which reached several agreements to reduce CO_2 emissions. In 1998, Taiwan responded by calling a National Energy Meeting which resolved that assessing the CO_2 emissions of all major development proposals would be included in the EIA's scope.

CHAPTER SEVEN: THE OVERVIEW OF THE TAIWANESE EIA MODEL

When the EIA Act came into effect on December 30 1994 it was widely held to be an important milestone, carrying high expectations of its expected efficacy. By now, the EIA has been operational for five years and its execution guidelines have also been completed. This chapter analyses the contents of each stage of the EIA's procedures so as to illuminate how it operates in Taiwan.

Taiwan's EIA requirements are divided, in the first instance, into two parts: the first stage demands an Environmental Impact Statement (EIS) and the second an Environmental Impact Report (EIR). However, not all developments are subject to the second stage. It is only when the EIS report concludes that the environment might be significantly affected does a subsequent EIR report - in an early and then a final draft form - become mandatory. The entire EIA process includes an inspection assessment, public hearings, a review (i.e., an examination by the EIA Commission), a conclusion, an announcement and post-development supervision and monitoring requirements.

During the process of establishing the EIA system, the relevant Taiwanese authorities not only consulted with their counterparts in Europe and America but they also gradually instigated some local agencies, such as setting up a Review Authority to oversee the work of the environmental protection agencies. Thus, the EIA process enables a veto over proposed developments: if a proposal fails to pass the Environmental Impact Assessment (EIA), the Review Authority will not permit the development to proceed in that form though it may allow the developer to formulate alternative approaches which can then be resubmitted for examination. Thus, the EIA system guarantees that the environmental protection agencies have teeth, for they have the power not only to examine but also to adjudicate on proposals submitted to them.

The EIA's procedures also include the monitoring of the environment both when the development is in construction and after its completion. The environmental protection agencies supervise the implementation of the detailed plans laid out in the EIS and the EIR. If necessary, they can also require the developer to present additional environmental impact survey reports and to conduct environmental difference investigations and analyses at pre- and post-development stages. This supervisory power constrains developers from departing from their environmental promises.

7.1 THE STRUCTURAL FEATURES OF THE EIA ACT

The EIA Act became law on December 30 1994 and has been implemented since January 1 1995. The Act contains four chapters and 32 clauses. The first chapter - General Principles - includes clauses 1 to 5; the second - Assessment, Examination and Supervision - clauses 6 to 19; the third - Responses to Infractions - clauses 20 to 24; and the fourth - the Appendix - clauses 25 to 32 (see Figure 7-1).

The first clause of the EIA Act declares that the aim of implementing the EIA system is to prevent or reduce any adverse effects caused by development, thus protecting the environment. The EIA Act contains four goals which contribute to this overarching aim[1]:

a) to provide reference for government policy. In the process of policy-making, economic benefit cannot be the only consideration. For major developments, decision-makers must take the natural environment, resources depletion and socio-economic impacts into consideration. The EIA's report can act as a repository of scientifically objective information to aid decision-making.

[1] Although the first clause limits itself to defining the purpose of the EIA Act as being to anticipate, and so prevent, public pollution it is generally understood that this aim contains four purposes within it. See Huang, 1995, pp. 30-31.

b) to effectively manage national resources. The EIA system focuses on resource management and environmental planning. Through impact assessment, mitigation measures can be utilised effectively.

c) to prevent adverse impacts on the environment by means of advance planning. The main thrust of the EIA system is to anticipate pollution problems and to ensure that mitigation measures are implemented which prevent or reduce adverse effects.

d) to facilitate public participation in decision-making. Effective public participation is best achieved by the developer co-operating with the public prior to the project's submission, so that each party can acquire a clear understanding of each other's concerns. This can lead to development proposals which are more acceptable to all concerned and which can reduce costs in the EIA studies and in the construction/operation of the project.

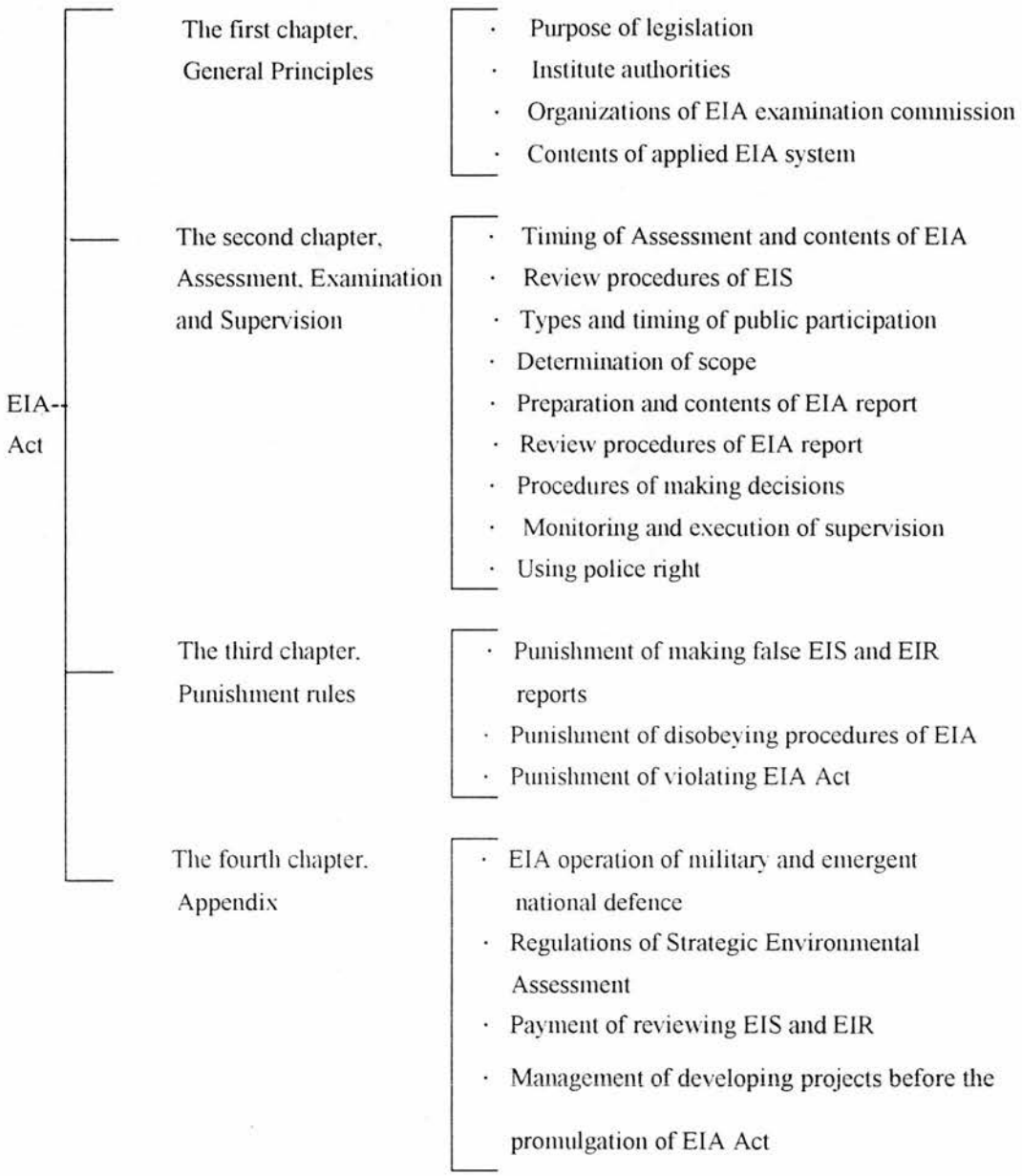

FIG. 7-1: The structure and main contents of the EIA Act

7.1.1 Features of the EIA System

As we saw, the operation of the EIA system is divided into two stages. The Environmental Impac Statement (EIS) is submitted by all proposers. Developments that are not likely to have a severe impact o

the environment may commence once the EIS is approved. Some, however, then require the submission of a further report, the Environmental Impact Report (EIR).

Furthermore, the EIA's review system depends on matching the project to its appropriate administrative decision-making domain. That is, each project must be approved at its own local government level and reviewed by its own local environmental protection agency. If the project is approved by central government, it must also be reviewed by central environmental protection organisations. The principle is to set the EIA's review remit according to the level the project approval belongs to.

Reviews are conducted by EIA Committees. Each committee is largely made up (more than two-thirds) of experts and scholars. The EIS review period is 50 days (though, occasionally, this can be extended for a further 50 days) while the EIR review period is set at 60 days. The review time for major developments can be extended, but only once and not indefinitely. The committee's review findings carry force. If the review stage is still in process, the authorities cannot permit the development to commence in the interim. If the committee's conclusion is that the project will have severe negative impacts on the environment and should not be allowed to proceed, developers must abide by this though they are free to present alternatives options to the reviewing institutes.

7.1.2 EIA Procedures

Taiwan's EIA procedures resemble those of other nations, i.e., screening, scoping, EIS (or EIR) preparation, review, decision-making and monitoring (see Figure 7-2).

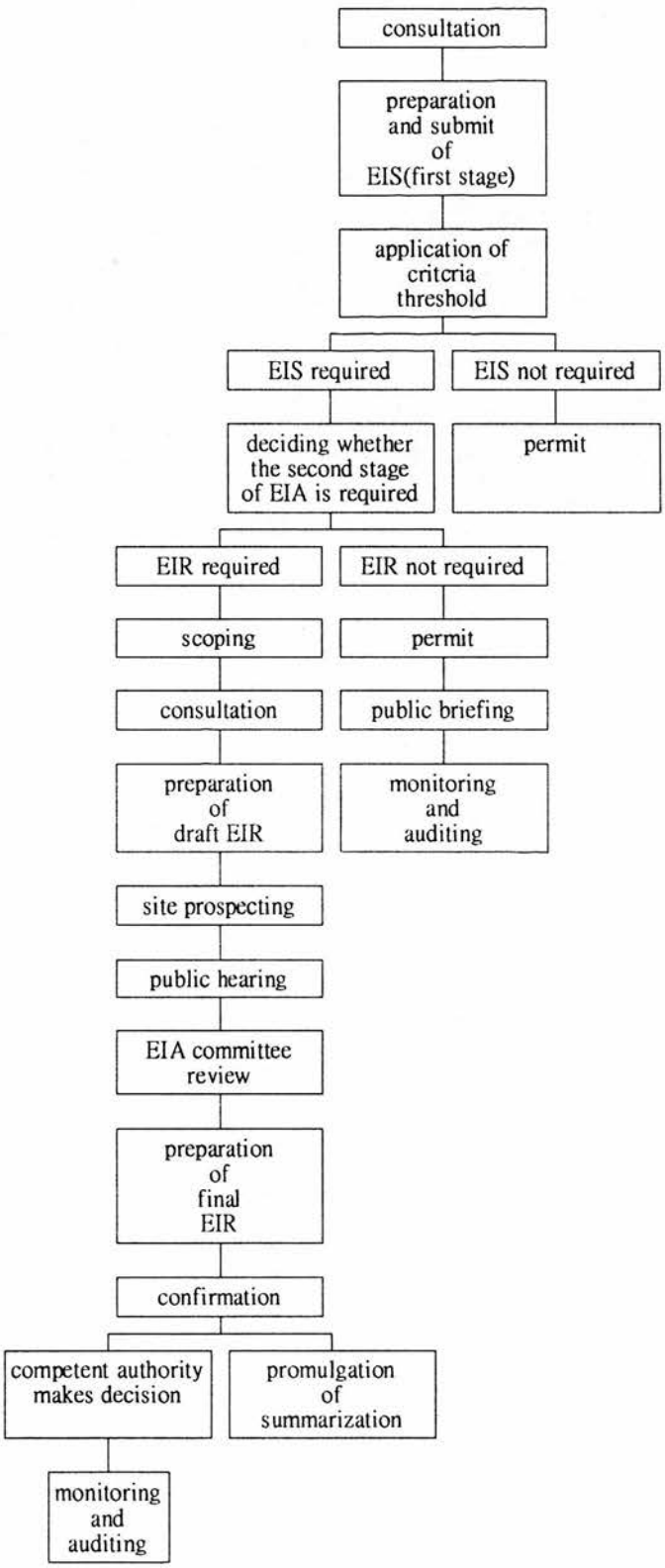

FIG. 7-2: Flow chart of EIA process

Screening involves two types of development activity. The first is exempt from EIA review procedures while the second must review the EIS and determine whether their further second stage involvement is required. Screening is judged according to particular criteria and particular thresholds. If the proposed activity exceeds a set threshold, the EIS report then becomes mandatory. And, as we saw, a further EIR report may then also be judged to be necessary.

Following screening, there are two main scoping procedures. The first step is to hold public hearings and the second is to seek the public's opinion within 15 days. After the hearing, the environmental protection agency convenes a competent authority comprised of relevant institutes and groups, citizens' representatives, experts and scholars to determine the scope of the project being assessed. Doing this involves the convened group in assessing feasible alternative projects and in determining which investigative, predictive and assessment methods should be deployed.

After determining the scope, assessors address the project's impact on the environment and prepare a draft EIR. When this is completed, the review work commences. This is done in two parts: the public review and the EIA committee's review. The competent authority convenes the relevant institutes and experts together with local citizens to conduct field prospecting and hearings. Afterwards, the records of field prospecting, minutes of hearings and the draft EIR are reviewed by the environmental protection institutes and the committee.

After this, the project's proposer revises the draft EIR in accordance with the review body's findings and sends the final EIR to the environmental protection agency for confirmation. Finally, the competent authority is responsible for monitoring the construction while it is underway and also when it is operated. The environmental protection agencies are responsible for overseeing that the conditions set out in the EIS and EIR review findings are implemented.

7.1.3 Area of Application

The application scope of the EIA Act covers 11 kinds of activity. Whether these become subject to EIA procedures depends on whether they cause negative impacts on the environment. The implementation details of the Act define "negative impacts" and, as we saw earlier, the EIS report defines whether a subsequent EIR report becomes necessary.

In the EIA Act, significant negative impacts on environment include the following:

a) Water pollution, air pollution, soil pollution, noise, vibration, foul smells, toxic material pollution, sunken land or radiation pollution;

b) Natural resources are jeopardised;

c) Natural landscapes or ecological environments are destroyed;

d) Social, cultural and economic environments are destroyed; and

e) Other behaviours deemed to be of concern by the government.

There are 11 types of construction activity that fall under the scrutiny of the EIA Act and for which an EIS report must usually be prepared. These are:

a) Establishment of factories and construction of industrial parks;

b) Construction of roads, railroads, mass rapid transit systems, ports and airports;

c) Stone quarries, prospecting and mining;

d) Construction of water reservoirs, water supply, flood control engineering;

e) Development of land for farming, forestry, fisheries or pastures;

f) Development of land for entertainment, scenic spots, golf courses and sports ground;

g) Cultural, educational and medical buildings;

h) Construction of new towns and high-rise buildings or urban renewal;

i) Construction of environmental protection engineering plants;

j) Development of nuclear energy and other energy plants, storing other radioactive nuclear wastes or constructing disposal ground; and

k) Other constructions like commercial and shopping centres, exhibitions, abattoirs, animal-holding sites, underground streets, electricity wires and cement storehouses in ports.

Whether these types of project become subject to EIA scrutiny depends on the thresholds and criteria set at the screening stage (See Table 7-1). These thresholds and criteria are usually based on the following variables:

a) the location of the project, e.g. national parks, urban areas and hillsides;

b) the scale of the project, e.g. the length of roads, floor areas and height of buildings, etc.; and

c) the project's special features, e.g. the complex usage of buildings, or factories powered by gas.

Table 7-1: Thresholds and criteria for high-rise buildings, new town construction, urban renewal, medical institutes and commercial and industrial complexes

Items	Thresholds
High-rise buildings	• Residential buildings with more than 30 floors or higher than 100m. • Official, commercial or complex buildings with more than 20 floors or higher than 70m.
New town construction	• Located at national park. • Located at wild protection areas or important habitats. • Located at tidal land. • Located at water resources, quality and amount preservation areas. • Located at hillside; the developing areas proposed are above 1hectare. • Located at suburban areas; the developing areas proposed are above 10 hectares or the expanded areas are accumulated for more than 5 hectares. • New towns constructions. • The accumulated expanded areas of new towns are 10% the original areas.
Urban renew	• Located at national park. • Located at wild fauna protection areas or important habitats. • Located at water resources, quality and amount preservation areas. • The renewal areas proposed for are above 20 hectares.
Medical institutes	• Located at national park with the construction area above 1hectare or the expansion area above 1hectare. • Located at wild fauna protection areas or their important habitats. • Located at water source, quality and amount preservation areas. • Located at hillside; the developing areas applied for are above 1hectare. • The developing areas proposed are above 5 hectares or expansion areas are above 5 hectares.
Commercial and industrial complex areas including exhibition and sopping mall)	• Located at national park. • Located at wild fauna protection areas or important habitats. • Located at tidal land. • Located at urban lands and developing areas applied for are above 5 hectares. • Located at non-urban lands and developing areas applied for are above 10 hectares.

7.1.4 The EIA's Legal Basis

The 28 laws relevant to the EIA can be divided into four categories: administrative operations; assessment guidelines; organisational issues; and specific regulations (see Table 7-2 and Figure 7-3). The first category of laws - administrative operations - cover the regulations and procedures which must be followed by environmental protection agencies when executing the terms of the EIA Act. These regulations also include action items, e.g. charging tariffs for EIA reviews. Taken together, they aim to standardise how government officials execute the EIA Act as well as to formalise developers' legal obligations prior to commencing their projects.

Table 7-2: Legislation relating to the EIA system in Taiwan

No.	Date	Title
1.	1994.12.30.	EIA Act
2.	1995.08.23.	Organizational structure of the commission for EIA
3.	1995.8.23.	Guideline of development of industrial estate for EIA
4.	1995.8.23.	Guideline of development of seaport for EIA
5.	1995.9.6.	Guideline of development of recreation area and tourist facility for EIA
6.	1995.9.6.	Guideline of department of golf course for EIA
7.	1995.9.13.	Guideline of development of quarrying for EIA
8.	1995.9.20.	Guideline of development of rapid mass transit for EIA
9.	1995.9.20.	Charge for EIA report review
10	1995.10.18.	Coverage of development project subject to EIA
11	1995.10.25.	Regulation of EIA
12	1995.10.25.	Guideline of development of airport for EIA
13	1995.10.29.	Guideline of development of high-rise building for EIA
14	1995.11.01.	Guideline of development of road and railway for EIA
15	1995.11.08.	Guideline of development of incinerator for EIA
16	1995.11.08.	Charging standards of EIA report review of nine development types of industrial and commercial complex areas
17	1995.11.15.	Guideline of development of sewage system engineering for EIA
18	1995.11.22.	Guideline of development of hospital and education facility for EIA
19	1995.11.29.	Guideline of development of waste landfill for EIA
20	1995.11.29.	Guideline of development of industrial factory for EIA
21	1995.12.13.	Guideline of development of agriculture utilization for EIA
22	1995.12.20.	Guideline of development of hydraulic electric power station for EIA
23	1995.12.20.	Guideline of development of thermo-electric power station for EIA
24	1995.12.27.	Guideline of development of radioactive wastes disposal and storage area for EIA
25	1995.12.27.	Guideline of development of nuclear power station for EIA
26	1997.9.20.	Regulation of SEA
27	1998.3.11.	Guideline of statement of SEA
28	1998.8.3.	Policy details of executing SEA

The laws governing assessment guidelines set out standards for all kinds of development, providing assessors with measures of environmental impact. They also formalise the items that must be covered in EIS and EIR documents. The laws on organisational issues regulate the composition of EIA committees (e.g., that there must be a particular quota of experts on the Board), their duties and their examination methods. Specific regulations cover items such as the Strategic Environmental Assessment (SEA), including details of the SEA's operational remit. The SEA regulations are the most recent to come into law

(1997 and 1998) and the SEA system is regarded as being the best way to address the defects of the EIA system.

EIA Act and Execution Regulation of EIA Act

- **Administrative operation (3):** details of executing EIA and standards of scope recognition, charging methods of EIA Report review, charging standard of review
- **Standards of development assessment (19):** industrial park, ports, recreation areas and scenery spots, golf courts and sports ground, pebble excavation, mass rapid transit, airports, high-rise buildings, roads, incinerators, sewage system, cultural and educated facilities, construction, landfill, factories, agricultural/forestry/fishery/pasture land development, hydraulic electric power station, thermo-electric power station, radioactive wastes disposal and storage area and nuclear power plants.
- **Organization (1):** EIA committee
- **Particular regulations (3):** SEA operation order, SEA statement operation guideline, policy details of executing SEA

Remarks: ( ) refers to numbers of laws.

FIG. 7-3: Areas of Law relevant to the EIA system

7.2 THE OPERATIONS OF THE EIA

7.2.1 Preparing the EIS Document

7.2.1.1 The EIS's Assessment Body

In Taiwan, the designated assessment body is the developer. That is, developers bear the cost of conducting the assessment in line with the 'Polluters Pay Principle'. In practice, most assessment work is sub contracted out by the developer to specialist consultancy firms. Since the EIA Act was enacted in 1995, the assessment workload of the EIA has increased significantly. Some consultancy companies conduct as many as 12 assessment cases annually.[2]

[2] The EPA evaluates these companies on an annual basis. Their report of 1997 noted that one such company, employing nine people, was handling 12 cases a year. See EPA, 1997d, p.20.

7.2.1.2 Timing and Coverage of the Assessment

The earlier the assessment is done the better. The Act stipulates that developers implement the first stage of the EIA process in the project's planning stage. The EIA Act's execution regulation defines the planning stage as the feasibility study which is undertaken prior to the operational study and the application for a permit. The EIA assessment is undertaken as an intrinsic part of the feasibility study, since the assessment's outcome will shape the decision-making on whether and how to proceed. The coverage of the assessment includes items like the living, natural and social environments and the economic, cultural and ecological environments.

7.2.2 Contents and Review of the EIS Report

As we would expect, the EIS's contents are simpler than the EIR's. The EIS report covers the purpose of the development; any related plans; the current environmental status of the proposed site and the expected impact on it of the development; the environmental protection policies of the developer together with suggested alternative measures; the anticipated costs of meeting the requirements of environmental protection; a summary of mitigation measures; and how the developer's proposed preventative measures will alleviate any negative impacts etc. (See Table 7-3 for details). Apart from the EIS's contents as laid down in the EIA Act, other EIA regulations stipulate that the EIS document must not exceed 150 pages and that the competent authority must send the EIS to the environmental protection authority for review.

The EIA review covers issues both of procedure and of substance. The procedure review assesses whether the submitted EIS meets the prescribed regulations on contents and form. The substance review examines whether the environmental impact of the proposed development warrants further review. According to operational regulations, the procedure review must include the following items:

a) whether the EIS emanated from the competent authority;

b) whether the contents of the EIS match the requirements of the EIA Act and the related operational guidelines;

c) whether the views of related institutes concerning the proposed development have been compromised; and

d) whether the proposed project is limited by other laws and so cannot be passed for development.

Table 7-3: Contents of environmental impact statement (EIS) and review points

Recorded items	Examination points
1.Titles of developer and its business location or office.	Fill in according to forms
2.Names, residents and ID numbers of person in charge.	Ditto
3.Titles and locations of proposed development.	Ditto
4.signatures of assessors of environmental impact assessment statement and	Ditto
5.purposes and contents of development	Ditto
6.related plans existing situation in the affected area	(1) related plans in the affected area . (2) Existing situation 1. According to guideline specific location environment and case feature can be exempt from partial investigation items. 2. Except regulated by the content, the previous cases should fill out details list.
7.predicted impacts of environment by proposed development	If employing other methods to predict each environmental items, environmental factors and prediction method, academic theory and application conditions should be stated clearly.
8.environmental protection strategy and alternative projects	(1) environmental protection strategy: environmental protection strategy of construction stage and operation stage should be stated specifically. (Including environmental supervision plan) (2) alternative projects:
9.expenses needed to execute environmental protection work	Including expenses of construction and equipment and maintenance cost
10.summarization of preventing and reducing negative influence of environment caused by development	

Data source: EPA, 1995, P.9

7.2.2.1 Review Duration

According to the EIA Act, the time spent reviewing the EIS cannot exceed 50 days, including distributior of the committee's findings, though in special cases the committee can receive one extension of a further 5(days. This regulation ensures that possible projects will not be indefinitely stalled and that the EIS review

process remains efficient. The definition of "special cases" is regulated in the EIA Act execution details and covers projects where:

a) the scale of the development is huge and the impacted level and area is extensive and so cannot be effectively analysed within 50 days; and

b) the development is highly controversial and so places greater demands on the committee while they make their inquiries.

7.2.3 The Move from an EIS Requirement to an EIR Requirement

If it is found, after the EIS review, that the development could cause severe damage to the environment, the proposed project must then be the subject of a second report - the EIR - whose scope and contents exceed the EIS. According to the Act, "severity of environmental impact" refers to the following features of the proposed project:

a) where it comes into conflict with other plans for the area;

b) where it would cause obvious harm to environmental resources and features;

c) where it would cause obvious harm to preserved or precious fauna and flora;

d) where it would force the local environment to exceed its environmental quality or carrying capacity;

e) where it would cause obvious harm to local residents' rights of immigration or to the traditional lifestyle of minority races;

f) where it would cause obvious harm to national health or security;

g) where it would cause obvious harm to other nations' environments; and

h) where the supervisory agency possesses other relevant facts about the project.

7.2.3.1 The pre-EIR Assessment Process

The EIR, or second stage, assessment follows a different procedure to the EIS method. While there is only a requirement for consultation in the EIS, the EIR stage also requires public participation. Methods used

include opinion gathering, public briefings, scoping meetings and public hearings. The public participate both during and after the assessment.

At the outset of the second stage, the EIS is sent to all relevant institutes for a public airing and the findings of that review are also posted in public reading places and in news bulletins. The period for dissemination of the EIS material to the public cannot be shorter than 30 days. Following this, public briefings are held where relevant institutes, local district offices, local councils and village heads are invited to attend. Thereafter scoping meetings may be held with the participation of the competent authority, relevant institutes, key experts, and interested groups and individuals. The purpose of scoping is to ensure that the assessment items and methods have been adhered to and to confirm whether feasible alternatives to the proposal exist. Until the draft EIR is completed, assessors conduct the second stage assessment according to the scoping contents.

Once a draft EIR exists, key scholars, experts, groups and local residents are invited to conduct site prospecting. At that point, public hearings should also be held inviting these people to comment according to the characteristics of the proposed development, the assessment items and any related specialisms. The main purpose of encouraging public participation at this stage is to elicit opinion about the draft EIR and also to provide the EIA committee with a sense of the public's view.

7.2.4 The Preparation and Review of the Draft EIR

Both the contents and the assessment scope of the draft EIR are more complex than the EIS (see Table 7-4) Its main contents are as follows:

a) a description of the development;

b) a consideration of the current environmental status and related plans;

c) predictions, analyses and assessments of environmental impact;

d) mitigation measures;

e) alternatives;

f) how opinion gathering has been managed and how relevant institutes and local residents have responded.

Investigation items to measure the current environmental state differ according to the development's characteristics but they typically include the following:

a) the physical and chemical environment, e.g. climate, air quality, noise and vibration, water and water quality, soil, terrain and geology and solid waste;

b) the ecological environment, e.g. the terrestrial or aquatic ecology or special ecosystems;

c) the landscape and recreational environment, e.g. geography, terrain and the natural or human landscapes;

d) the social and economic environment, e.g., population composition and structure, land use, public facilities, living standards, urban planning, land prices and public hygiene;

e) the traffic situation, e.g., transport systems, vehicle types and numbers and road service levels;

f) the cultural environment, e.g., monuments and memorial buildings, special buildings and social customs; and

g) safety issues, e.g., risk analyses of the local neighbourhood.

Which of these items requires coverage depends on the particular features of the proposed development. For example, chemical factories or nuclear power plants focus on safety issues, while developments of recreational areas focus on ecological and landscape issues. In every case, however, the Environmental Protection Administration (EPA) specify the development guidelines, including those governing the investigation of the current environmental quality, in order to provide a detailed reference point for assessors.

Table 7-4: Contents of draft Environmental Impact Report (EIR) and review points

Items to be recorded	Review points
1.Titles of developer and its business location or office.	Fill in according to forms
2. Names, residents and ID numbers of person in charge.	Ditto
3. titles and locations of proposed development.	Ditto
4. signatures of assessors of environmental impact	Ditto
5.purposes and contents of proposed development	Ditto
6.related plans and existing situation in the affected area	Existing environmental situation: items of investigati contents and methods of assessment according to scopi meeting.
7.prediction, analysis and assessment of environmental impact	Items are decided according to scoping meeting. Prediction a assessment methods are regulated by guidelines. If employi other methods, state clearly theory basis and conditions.
8. mitigation measures or avoiding negative environmental impact strategies.	Concrete mitigation measures during construction a operation stage should be made; state clearly mitigati management, procedures and efficiency; test and verify w the results of environmental impact prediction, analysis a assessment.
9.Alternatives	
10.Comprehensive environmental management plan	Including environmental management plan of construction a operation stages. (Including environmental supervision pl emergency plan, environmental hygiene management plan a drinking water management plan)
11.opinion handled of related institutes	Enclosed with related official letters or meeting minutes. St clearly management process and result.
12.opinion handled of local residents	Enclosed with public reading and briefing procedures, writt opinions and Q&A records in the meeting of NGOs and lo residents.
13.conclusion and suggestion	(1) Raised on the stance of development sector. Conclusion should include comprehensive assessment result environmental impact, feasibility of strategies and promi items.
14. expenses needed to execute environmental protection work	Include equipment expenses , operation and maintenan personnel, supervision and handling expenses dur construction and operation period.
15.Summarization of preventing and reducing environmental impact caused by proposed development	

Data source: EPA,1995,pp.10-11

7.2.4.1 Review of the EIR

The EIR is transferred from the competent authority to the environmental protection agencies. The review, like the EIS's, includes both procedural and substantive review sections. The procedural review is conducted by an environmental institute and the substantive review by the EIA committee. The procedural review includes the following items:

a) whether the EIR has been issued by the competent authority;

b) whether the assessment items and contents meet with the EIA Act's regulations and operational standards;

c) whether the EIS was sent to relevant institutes;

d) whether the duration of the EIS's public dissemination and display exceeded 30 days;

e) whether the EIS was published in public reading places or news bulletins for more than three days;

f) whether an EIS public briefing was held;

g) whether the site prospecting record issued by the planning approval institute and hearings records are enclosed;

h) whether the views of other relevant institutes have been canvassed appropriately; and

i) whether opinion gathering has been handled according to the resolutions of the scoping meeting.

Table 7-5 below offers a comparison of the EIS and EIR assessment processes.

Table 7-5 : Comparison of first stage (EIS) and second stage (EIR) assessment reports

Stage	The first stage	The second stage
Items	EIS	EIR
Area of application	likely cause negative impacts on the environment	Severe impact to environment
Applicable conditions	(a) causes pollution or nuisance (b) hinders reasonable utiiity of natural source (c) damages natural landscape or ecological environment (d) ruins social, cultural or economical environment (e) others	(a) conflict with other plans (b) obvious harmful to environmental sources or features (c) obvious harmful to inhabitants of preserved or precious animals (d) makes local environment exceed quality standards or carrying capacity (e) Obvious harmful to local residents' right of migration or traditional life of minor races (f) Obvious harmful to national's health or security (g) Obvious harmful to other nation's environment
Length	150 pages	300 pages
Procedure	Those who exceeds thresholds should raise EIS	After the first stage of review
Public participation	(a) opinion consultation (b) announcement and public briefings after decision	(a) opinion consultation (b) public briefing (c) scoping meeting (d) public hearing (e) announcement after decision
Examination period	50 days (may extend another 50 days)	60 days (may extend another 60 days)
Scoping	Non	Yes
Content	(a) information of developers (b) information of assessors (c)description of development (d) abstract list of mitigation (e) expenses for executing environmental protection	
	(f) related plans and existing situation in the affected area (g) prediction of possible environmental impact (h) environmental protection strategies and alternatives.	(f) Related plans and existing situation in the major and minor affected area (g) environmental impact, prediction, analysis and assessment (h) mitigation measures (i) alternatives (j) comprehensive environmental management plan (k) opinion handled of related institutes (l) opinion handled of local residents (m) conclusion and suggestion (n) reference

If the proposed development passes the procedure review screening, it is handed on to the EIA committee for a contents review. As we saw earlier, this committee is composed of representatives of environmenta

protection agencies and other relevant institutes and of key experts and scholars. These individual specialists must account for not less than two-thirds of the committee's membership, thus assuring its professionalism and independence. In addition, bodies and individuals with a vested interest in the outcome of a particular case are debarred from membership of the committee investigating that case. The EIA committee's conclusions should include composite comments and its decision should be labelled as belonging to one of the following categories:

a) the development is acceptable;

b) the development is acceptable with certain conditions attached;

c) the development should be returned to a second stage assessment (referring to the EIS review); or

d) the development is rejected.

7.2.5 Public Participation

The purpose of public participation is to raise the effectiveness of the EIA system in a process of on-going intercommunication. Through this process, developers, assessors and related institutes may control and solve environmental problems, helping the public understand their decision-making on development vis-a-vis environmental protection.

The basic requirements for public participation in the EIA process are that related institutes (or developers) must provide appropriate and timely information so that public opinion can be effectively sought (a feedforward mechanism) and that the concerned public subsequently relay information back to government to shape decision-making (a feedback mechanism).[3]

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[3] Canter treats public participation environmental policy as having both feedforward and feedback elements. Canter, 1977, pp. 257-269.

7.2.5.1 Categories of Public Participation

In the implementation of the EIA system in Taiwan, public participants can belong to the following categories:

a) the general public, e.g., local residents in the affected area;

b) minority races, e.g., aborigines and those whose traditional lifestyles are affected by the proposal;

c) non-governmental organisations (NGOs), e.g., environmental groups and public profit institutes such as the Environmental Protection League;

d) experts and scholars drawn from colleges and occupational groups, e.g., ecological scholars or architectural associations;

e) other institutes, e.g., relevant government authorities;

f) commercial and industrial groups, e.g., interested companies other than the NGOs mentioned above;

g) the media, e.g., newspaper reporters or media specialists covering controversial developments such as nuclear power plants.

7.2.5.2 Timing and Methods of Public Participation

There are many types of public participation within the EIA system, the most common being announcements, public briefings and review meetings. Each serve different purposes and have their own features and participants, as shown in Table 7-6. In the first stage of assessment, public participation takes the three most typical forms mentioned above. Announcements are used to disseminate the conclusions of an EIS review, while public briefings are held with residents and groups after the decision has been made to explain what the development consists of. In controversial cases, this medium helps to resolve conflicts. Experts and scholars are the targeted participants of review meetings. If necessary, preliminary examination meetings may be held which include groups and residents' representatives.

Table 7-6: A comparison of public participation mechanisms in the EIA system

Stage	Methods	Time	Purpose	Features (communication)	Participants
EIS (first stage)	Opinion consultation	Assessment stage	Scoping/ solving questions	Two-way	Related institutes
	Announcement	After making review conclusion	Providing information	Single way	All
	Public briefing	After making decisions	Providing information / solving collision	Two-way	Residents, groups
	Review meeting	EIS review	Scoping / solving question/setting up common agreement	Two-way	Experts, scholars (groups, resident representatives)
EIR (second stage)	Public reading	In the beginning of assessment	Providing information / feedback	Single way	All
	Public briefing	After public reading	Providing information/ feedback/ scoping /solving questions	Two-way	Residents, groups
	Opinion consultation	In the EIR assessment and prepare period	Feedback /scoping	Two way	All
	Site prospecting	After draft EIR is sent to competent authority	Scoping/ feedback /solving questions	Two-way	EIA committee, experts, scholars, groups, residents and related institutes
	Public hearing	Before EIR review	Scoping/ feedback/ solving questions/ setting up common agreement	Two-way	EIA committee, experts, scholars, groups, residents and related institutes
	Review meeting	After public hearing and before decision	Scoping/ solving questions/ setting up common agreement	Two-way	Experts, scholars (groups and resident representatives)
	Announcement	After review conclusion	Providing information	Single way	All

Note: Members inside ( ) can be invited when necessary.

In the second assessment stage, public participation takes seven forms. Public readings and briefings are held after the EIS review. Public opinion is sounded out during the preparation of the EIR to provide feedback. After the draft EIR is completed and sent to the competent authority, site prospecting and public

hearings are held. These participants are experts, scholars and EIA commissioners, relevant institutes, local residents and groups. Review meetings are constituted in the same way as for the EIS and, again, preliminary review meetings may be held should they prove necessary. Announcements are used to publish EIR review conclusions.

7.2.6 Decisions and Monitoring

7.2.6.1 Limitations on decision-making

So as to prevent decision-makers from ignoring the precepts of the EIA system, the EIA Act places certain constraints on the decision-making process. The Act regulates that the competent authority cannot approve projects prior to an EIS or EIR review. In addition, environmental protection agencies can exercise a veto over a proposed development if they are still not satisfied following the review's findings though, in these cases, the developer may still re-present an alternative case for examination.

7.2.6.2 Monitoring

According to the Act, planning approval authorities must monitor or track the project both during and after construction, and environmental protection agencies must supervise the work to ensure that the conditions of the EIS and EIR review findings are being adhered to. In practice, there is little difference between the tracking function of the former and the supervisory function of the latter, so the bodies charged with these responsibilities often negotiate amongst themselves as to who will carry the burden of work on any particular case.

7.2.6.3 Handling Proposed Modifications to the Project

Once a development gets the go-ahead, it cannot be later altered without the permission of the environmental protection agency it is dealing with. Where the project's design is requiring alteration, the

proposed change may be either substantial or partial and so the Act places different requirements on how the developer gains permission to modify the work. In the former case, the developer must re-submit the project and undergo the full EIA review process; in the latter, it is sufficient to present a report outlining how the modification will impact on the environment.

"substantial" modification is defined as meaning the following situations:

a) where proposed expansion of the scheme or route or alterations to the plan exceed 10% of the scope of the original;

b) where proposed alterations to the use of land involve preservation areas, green buffer zones or other environmentally sensitive areas;

c) where the efficacy of environmental protection facilities are reduced;

d) where the alteration would have negative consequences on the natural or social environments or on protected targets; and

e) where the change would result in the project as a whole falling below the designated threshold of environmental quality.

"Partial" modification covers the following scenarios:

a) where there are minor changes to the contents of the development or to its environmental protection strategies;

b) where it can be shown that the difference to the environment will be slight; and

c) where the change involves a review and modification of the project's environmental protection strategies or of its comprehensive environmental management plan.

7.3 THE APPLICATION OF THE STRATEGIC ENVIRONMENT ASSESSMENT.

Though the EIA system has been in existence since 1980 (becoming law in 1994) and has had a positive influence on environmental management and sustainable development, it does have some blind spots which require systematic redressing. In common with the US and the European nations, Taiwan is looking to adopt ways of improving its tiering assessment criteria. To this end, the government announced its Strategic Environmental Assessment (SEA) methodology in 1998.

7.3.1 The SEA's Legal Basis

Given the constraints of the EIA system, a more strategic view is beginning to be valued. In 1994, when the 24th meeting of the second session of the second term of the Legislative Yuan was examining the draft EIA Act, the legislator - Peng, Pai-hsien - pointed out that[4]:

The EIA only examines development projects, but according to evidence and examples from many countries, some major governmental policies also impact the environment tremendously: for example, changes to the standards regulating exhaust discharge from vehicles/motorbikes; alterations of the standards governing waste water discharge from factories; changes in urban planning; alterations to the scope of national parks; bans on fishing using drift and gill nets, etc. These government policies don't belong to development projects. However, some of them cause larger impacts on the environment than do development projects. Therefore, we should widen the scope of the EIA to include those government policies that are likely to affect the environment. (Legislative Yuan 1994, p.72)

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[4] Taiwan's Legislative Yuan is its law-making assembly, similar to the UK's parliament. When the EIA Act was in its second reading there, Peng, Pai-hsien proposed that the SEA regulations should be added on and this was agreed to by the other legislators. Refer to the Official Report of the Legislative Yuan, p. 72, Vol. 2, 74th session meeting records, 1994.

Peng's proposal was endorsed by the majority and the SEA system was officially incorporated into the EIA Act, ensuring that government policies that are most likely to affect the environment must be examined by the EPA.[5] The EIA operational regulation of government policies was promulgated in 1997 and the guidelines for writing government policy assessment statements in 1998 . Though it is too soon to say for sure, it seems likely that the implementation of the SEA will be another milestone for the EIA.

Table 7-7: The legal basis to the SEA system

Title	Date of promulgation	Basic contents
EIA Act	1994.12.30	The 26th clause regulates the government policy should implement EIA procedures and is the law source of SEA system.
Operation Regulation of Government Policy EIA	1997.9.20.	It regulates the applicable range, procedures of SEA system and contents of assessment statement.
Guideline of Government Policy Assessment Statement	1998.3.11.	It regulates the assessment items, coverage, contents and methods of SEA.
Policy items required SEA process	1998.8.3.	It regulates the policy items to be required SEA.

Table 7-7 above summarises the laws relating to the SEA system. The 26th clause of the EIA Act is the mother law. The others stipulate more detailed formulations of its basic premises, e.g., the Operational Regulation of Government Policy EIA outlines the necessary execution procedures, applicable ranges and contents of assessment statements, while the remaining two are supplementary clarifications of the required assessment issues and implementation details.

7.3.2 The Application Range of the SEA System

The EIA Act does not define "government policy" nor how it "might impact the environment", for these definitions remain the preserve of the Executive Yuan. The Operational Regulation of Government Policy EIA states that "government policy" refers to "policies directly related to applicable EIA projects which

[5] The terms concerning the SEA is outlined in the 26th clause of the EIA Act.

need to be approved by the Executive Yuan". "Government policy" in the SEA is similarly defined. Therefore, government policies which do not need the approval of the Executive Yuan - for example, those emanating from local government or from the lower-level decisions of central government departments - need not be subject to the SEA process.[b]

There are nine policy areas that may come to be examined by the SEA system (see table 7-8):

a) industrial policies;

b) mining development policies;

c) water utility development policies;

d) land use policies;

e) energy policies;

f) livestock-raising policies;

g) traffic policies;

h) solid waste disposal policies;

i) radioactive nuclear waste disposal policies; and

Any of the above policy areas that might have environmental implications must implement an SEA and they need to be approved by the Executive Yuan. The Operational Regulation defines "Environmental impact" to include the following seven items:

a) where the environment is being asked to exceed its carrying capacity;

b) where natural ecological systems are being destroyed;

c) where national health or security is threatened;

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[b] There are 28 central government departments and commissions under the Executive Yuan, as well as the local government strata of province, county and city. In May 1997, provincial government was brought under the control of the Executive Yuan and provincial-level institutions are no longer autonomous nor do they have the right to make policy.

d) where natural resources are being substantially damaged;

e) where water source systems, water quality and water utility are being severely degraded;

f) where the harmony of the natural landscape is being damaged; and

g) where international conventions are being violated or the sustainable development of ecological systems is being impeded.

Table 7-8: Policy details related to the SEA requirement

Policy title	Policy details
1. industrial policies	establishment of industrial parks
2. mining development policies	gravel quarry and supply
3. water utility development policies	water resource development
4. land utility policies	golf court establishment, large-scale alternation of farmland and preserved lands
5. energy policies	energy ratio policy
6. livestock-raising policies	pig-raising policy
7. traffic policies	major railroad plan
8. waste matter disposal policies	garbage disposal plan
9. radioactive nuclear waste disposal policies	nuclear waste disposal plan of nuclear power plant

7.3.3 Assessment Targets and Range of the SEA

The SEA system aims at assessing policies, programmes and plans. Compared with individual development projects, its focus is more extensive and more highly alternative. For this reason, SEA assessment items are not required to be as detailed and concrete as is those presented in projects undergoing the EIA system; their more extensive characteristics are on a larger scale and range and affect a greater number of people.

The assessment range required of Taiwan's SEA is as follows:

a) regional, i.e., influencing regional areas of Taiwan;

b) national, i.e., affecting the nation's environmental carrying capacity beyond the boundaries of particular provinces; and

c) global, i.e., affecting international environmental protection treaties and involving cross-border issues such as transportation.

7.3.3.1 The Assessment Items of the SEA

The assessment items of the SEA are wider ranging than those of the EIA. They include the following eight items:

the carrying capacity of the environment

a) Air: to assess whether each containment pollutant meets air quality standards or carrying capacity (TSP, PM_{10}, SO_2, NO_2, O_3, Pb);

b) Rivers, dams, lakes, oceans, underground water: to assess whether each water quality item meets with water quality standards, carrying capacity or eutrophication. (PH, DO, BOD, SS, NH_3, NO_3, T-P);

c) Soil: to assess whether the imposition of heavy metals, toxins, pesticides or chemical fertilisers are polluting the soil or making it barren;

d) Solid Waste Disposal: to assess whether the increasing rate and amount of general solid waste and industrial waste exceed handling capacity; and

e) Noise: to assess whether noise levels remain within the environmental sound volume standard or degrade the aural environment.

natural ecological systems

a) Terrestrial ecological systems (including fauna and flora): to assess changes to the degrees of types and amounts of fauna and flora, changes in diversity of types and dominant communities;

b) Aquatic ecological systems: to assess changes to the degrees of types and amounts of fauna, flora and benthos; and

c) Inhabited ecological environments: to assess their decrease/increase.

the health and security of citizens

a) Toxic or hazardous substances transmitted through air, water or soil: to assess the risks associated with toxic chemical substances, hazardous industrial waste and harmful health substances transmitted through air, water and soil; and

b) Radioactive or chemical disaster scenarios: to assess the risks associated with the leakage of radiation or chemical substances.

the depletion of natural resources

a) Forestry resources: to assess the environmental impact of deforestation;

b) Mining and gravel quarrying: to assess the direct and indirect effects of mining or gravel quarrying;

c) Water resources: to assess utility methods, amounts, ratios of water sources and their effects (surface water, underground water and desalination of seawater); and

d) Species: to assess the reproduction and regeneration of particular species and the changes and influences thereby brought about.

the consumption of water source systems

a) Water utility goals and allocation: to assess the adjustment of water utility goals or changes to the amount of water allocation and rations and their environmental impact; and

b) Water squeezing effects: to assess regional water squeezing effects and their impact.

the harmony of the natural landscape (including cultural assets)

a) Geographical landscape: to assess the impact caused by large-scale changing of terrain, landforms or particular landscapes;

b) Ecological landscape: to assess the effect on environmentally sensitive regions and on the increase/decrease of areas; and

c) Cultural assets: to assess the influence of preserving cultural assets.

international environmental treaties

a) Montreal Protocol on Substances that Deplete the Ozone Layer: to assess the impact of using CFCs, HCFCs and Halon;

b) Climate change: to assess the amount of discharge of CO2, CH4, N2O, CFC-11 and CFC-12;

c) Basel Convention: to assess the cross-national transportation of toxic substances;

d) Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): to assess the influence of preservation of precious or endangered species of wild fauna and flora; and

e) The Convention on Biological Diversity (CBD): to assess changes in biological diversity.

other matters

a) The SEA should pay regard to opinion response, economic efficiency issues or assess other environmental items.

7.3.3.2 The Contents of SEAs

The contents of a Strategic Environmental Assessment Statement (SEA) are as follows:

a) the organisational title of the body proposing the policy;

b) the title and purpose of the policy;

c) the background and content of the policy;

d) an assessment of policies that might have an environmental impact;

e) the mitigation measures being proposed to avoid environmental damage; and

f) conclusions and suggestions.

7.4 THE IMPLEMENTATION OF THE EIA IN TAIWAN

Taiwan has been implementing the EIA for almost 20 years from the early pilot EIS studies to the legislation of the EIA Act. Although the detailed methods of delivering the EIA have been subject to different regulations over different periods, this is less relevant than Taiwan's accumulated expertise over a generation. In this section, I will take a micro perspective to analyse the prevailing status of EIA implementation in order to understand how it currently operates.

7.4.1 The Current Operation of the EIA System

7.4.1.1 The Number of EIA Cases

Since 1994, the number of EIA cases has increased annually. Figure 7-4 reveals that the numbers prior to the Act remained below 70 per year. Pre-1990, the annual numbers were even lower, at 15 or less. The EIA Act's range and enforcement power has clearly contributed to a sharp rise in numbers since then.

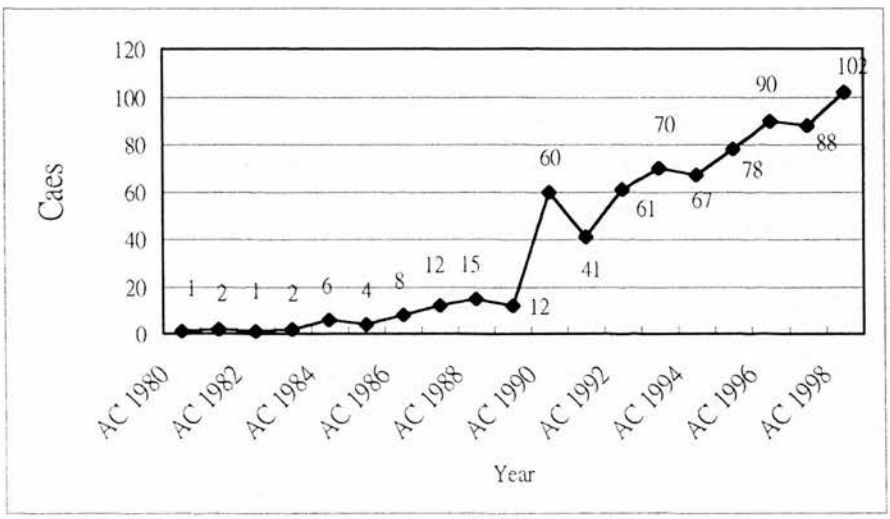

FIG. 7-4: Annual increases in numbers of EIA cases

Table 7-9 shows an increase from 78 cases in 1995 to 102 cases in 1998, an annual average growth of 15% or so.[7] If divided by category over the last four years, 108 of the total number (i.e., one-third) refer to high-rise buildings, the construction of new towns and urban renewal projects. The second largest category (63 cases, or 18% of the total) are factory projects. Fifty-two cases (15%) concern environmental protection engineering projects (e.g. incinerators and landfills) while cultural, educational and medical constructions account for 12% of the total with 44 cases.

[7] We find an increase every year since 1995 except for 1997, whose negative growth of 2.2% can be attributed to the Asian economic turmoil and the attendant decrease in development projects.

Table 7-9: Statistics on EIA cases in Taiwan from 1995 to 1998

Year	1995	1996	1997	1998	Total	Ratio %
Factories, industrial parks	12	16	15	20	63	18
Traffic engineering	5	6	8	17	36	10
Gravel mining	0	2	0	4	6	2
Water engineering	3	1	3	5	12	3
Agricultural development	0	2	0	2	4	1
Recreation area development	3	5	4	6	18	5
Cultural, educational and medical development	9	13	8	14	44	12
High-rise buildings, new town, old town renewal	29	28	29	22	108	30
Environmental protection engineering	12	14	16	10	52	15
Energy development engineering	3	2	3	1	9	3
Others	2	1	2	1		1
Total	78	90	88	102	358	100
Growth rate %		15.4	-2.2	16		

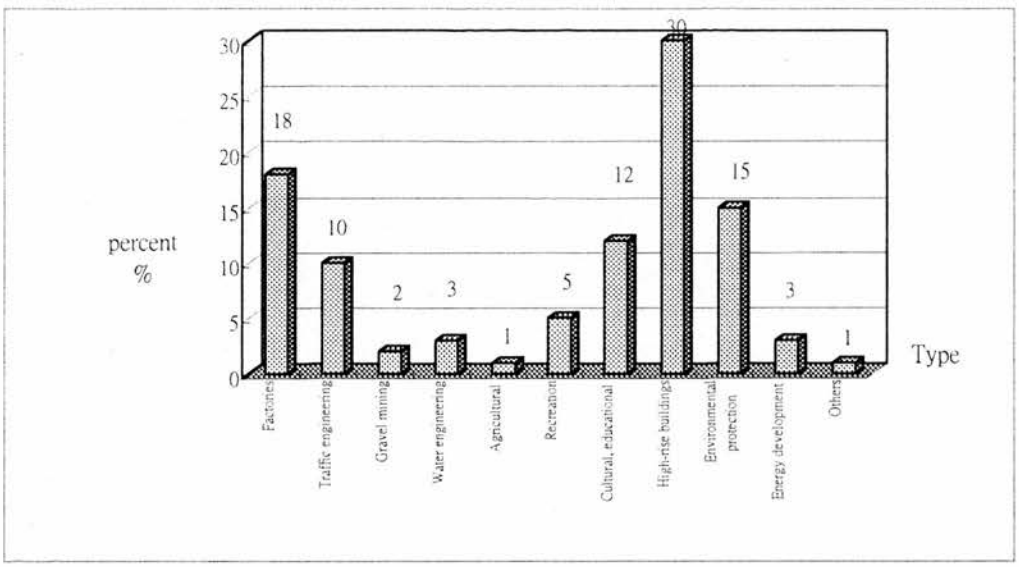

Figure 7-5 illustrates the EIA cases broken down by category.

FIG. 7-5: Statistics chart of EIA cases based on category

7.4.1.2 An Analysis of the Cost of EIA Cases

An investigation of the 581 EIA cases presented by 35 consultancy firms in the five years prior to 1998[8] show that the average cost of an EIA assessment over that time was £57,000.[9] This sum amounts to about 0.098% of the total project cost, a cost ratio which is significantly lower than the corresponding cost of 0.6% in the United Kingdom (Commission for EIA 1998a, p.249).

Broken down by category, as shown in Figure 7-6, water supply engineering enjoyed the lowest expense ratio, only 0.04%, while gravel quarrying took 0.05% and high-rise buildings 0.06%. The highest expense ratio was found in a nuclear waste disposal plant, with the ratio of 0.56%, followed by factory construction at 0.33% and 0.3% for a rubbish incinerator construction. The average ratio came to 0.098%.

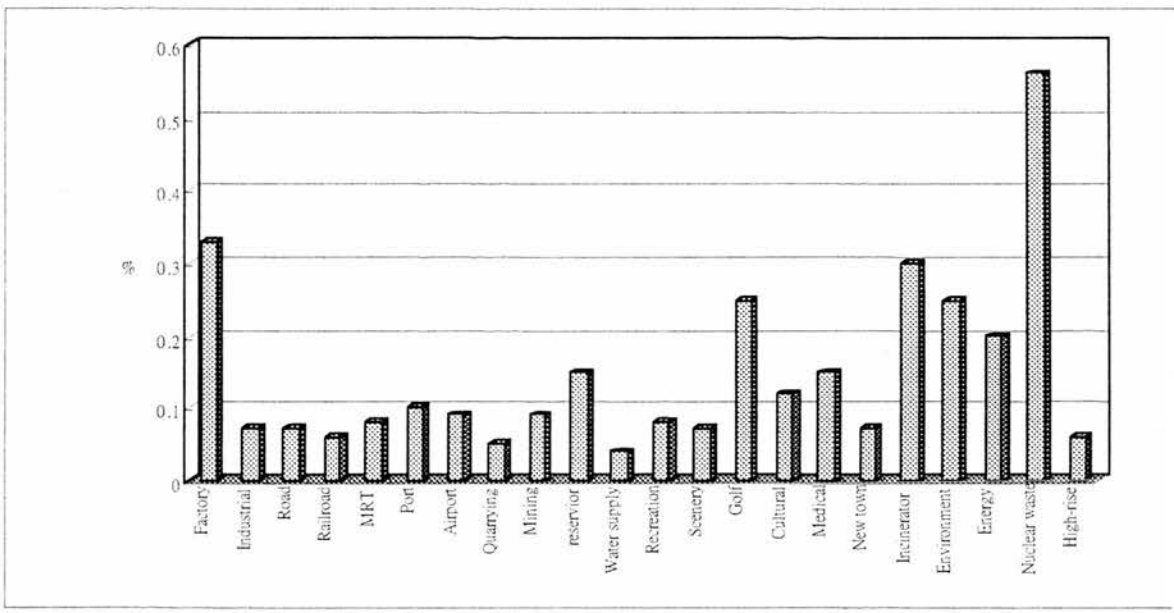

FIG. 7- 6: The cost of EIA cases

[8] In 1998, the EPA investigated 35 consultancy firms in order to evaluate them and obtained 581 pieces of data. The amount of money spent was based on original information, EIA reports and interviews.

[9] The average cost came to NTD 317,000,000. Using an exchange rate of 1:55, this equals £57,000.

Figure 7-6 illustrates that there is a 14-fold difference between the highest and lowest ratio cost. Nuclear waste disposal plants and incinerators are highly controversial developments. Since their construction invokes social and economic concerns, reviewing them requires that many more items be assessed and the issues raised are difficult and complex. Therefore, the cost of assessing them is higher. As for the EIA factory cases, most of them are petrochemical firms, invoking safety and risk issues, so they also cost more to assess.

In contrast, as Table 7-10 shows, the assessment expense of water supply engineering enjoys the lowest ratio because most of these projects are located in the suburbs and their environmental impact is quite simple and localised. For example, the EIS assessment of the Ping-ting water purification plant expansion took a mere three months and cost only £9,000. Gravel quarry assessment expenses are similarly low because they too are located in specific local rivers or suburbs. Their average assessment cost was only £7,000, while projects at scenic spots came to £12,000 per case. The highest assessment price-tag (£700,000) was attached to a high-speed railroad development, while the assessment of a mass rapid transit system cost £454,000. Overall, the average cost came to £57,000.

The overall range of expense of an EIA assessment accounts for 0.04% to 0.56% of a project's total cost, with the differential between £7,000 and £700,000 found in the statistics presented in Table 7-10 being accounted for by differences in the scale, characteristics and time taken to complete different projects, which is significantly lower than the corresponding cost of 0.1% to 5% of total project cost in the UK[10]

[10] In the UK, the cost of the majority is in the range of £10,000 to £ 100,000, the cost of preparing an EIS range from 0.1% to 5% of total project costs with an average of 0.6% , the average charge is £ 29,000 , see Commission for EIA, 1998a, p.249.

Table 7-10: EIA costs for each case

Category	Average expenses Pound/case	Ratio in total expenses (%)	Duration of assessment (month)
Factory	16,000	0.33	12.0
Industrial park	54,000	0.07	8.5
Road	69,000	0.07	5.5
Railroad	700,000	0.06	18.0
Mass rapid transit	454,000	0.08	15.1
Port	118,000	0.10	16.0
Airport	79,000	0.09	12.0
Gravel quarry	7,000	0.05	2.5
Mining	90,000	0.09	8.5
Water-reservior construction	72,000	0.15	11.5
Water supply construction	15,000	0.04	3.0
Recreation area	15,000	0.08	6.0
Scenery spots	12,000	0.07	11.2
Golf courts	82,000	0.25	14.0
Cultural, educational construction	38,000	0.12	6.0
Medical construction	25,000	0.15	6.0
New town construction	40,000	0.07	5.5
Garbage incinerator	139,000	0.30	10.4
Environmental protection engineering	64,000	0.25	13.5
Energy engineering	273,000	0.20	12.8
Nuclear waste disposal	174,000	0.56	16.0
High-rise buildings	16,000	0.06	4.5

Note:

a. The amount of pounds are calculated by the exchange rate of 1: 55. (pound: 55 NTD)

b The assessment time refers to the time of assessing EIA and writing reports, but not include review time.

7.4.1.3 Assessment Duration of EIA Cases

The time taken to assess the 581 cases is taken to mean the interval between the assessors beginning their work and the distribution of the completed EIS to the competent authority. Note that this interval does not include review time.

Figure 7-7 shows that the railroad took the longest time to assess, about 18 months.[11] The second longest, the mass rapid transit systems, took 15.1 months and the shortest, a gravel quarry, took 2.5 months.[12] Water supply construction took three months and high-rise buildings about 4.5 months on average. Overall, the assessment time differential within the 581 EIA cases was from 2.5 months to 18 months, while the average assessment time was 9.9 months, which is longer than the corresponding duration of 4.5 month (22 weeks) in the UK (Marr 1997, p.216).

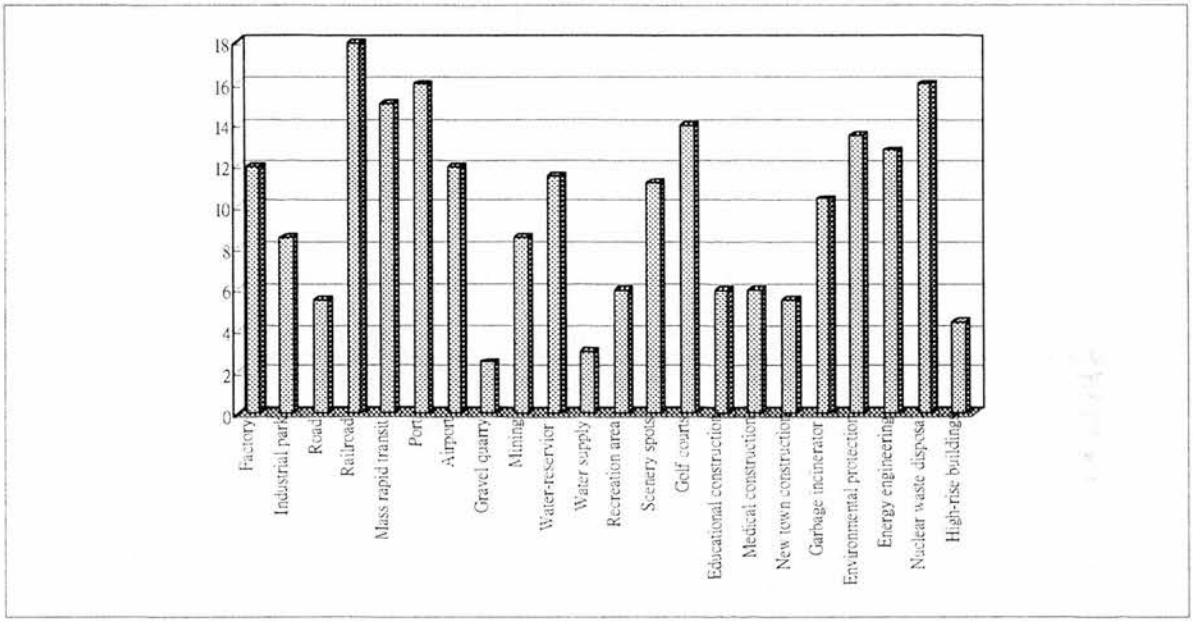

FIG. 7-7: Assessment duration of EIA cases

[11] The railroad project was the only one of its kind amongst the 581 cases. It was undertaken by the Chung Ting consultancy firm in 1992/93 (c. 18 months duration).

[12] The data set of 581 cases included four mass transit systems: Taichung rapid transit blue EIS; Taipei urban rapid transit Tanshui line EIS; CKS airport to Taipei rapid transit EIS; and Hsinchu city rapid transit EIS. These four cases were undertaken by three different consultancies.

7.4.2 A Profile of the Assessors

7.4.2.1 Staff in Assessment Consultancy Firms

The EPA report of 1998 on the 581 cases also contains information on assessor staffing levels[13]. The Chung Hsin consultancy firm is the largest, employing 69 people (with 25 EIA cases) while the Chung Ting employs 56 (with 50 EIA cases). Thirteen companies (one-third of the total investigated) employ less than 10 staff while 10 companies (29%) employ between 10 and 12. Table 7-11 illustrates that about two-thirds of the consultancy firms are small, employing less than 20. The average number of employees is 19.7.

Table 7-11 illustrates that more sufficient man power of companies have the more EIA cases contracted, the average EIA cases of company is in the range of 4.0 - 37.5 cases. In order to understand the relationship between the EIA consulting company's man power and the number of EIA cases contracted, Analysis of Regression Technique is adopted by this study. This technique is used to analyze the influential condition of how a variable can influence other variables as the variable changes. A positive correlation is shown in the relationship of the consulting company's man power and the number of EIA cases contracted (as Figure 7-8). However, $R^2 = 0.13$ shows that the degree of correlation is very low, which means that there is a positive influence between the relationship of the number of the EIA consulting company's man power and the number of EIA cases contracted, but the influence is very low.

[13] The manpower analysis of these consultancies was conducted according to the EPA's investigation list of assessor companies.

Table 7-11: Manpower analysis of EIA consultancy companies

Numbers (persons)	Numbers of consultation companies	Percentage %	Average EIA cases per company
More than 50	2	5.8	37.5
40~50	4	11.4	22.0
30~40	1	2.9	29.0
20~30	5	13.3	16.2
10~20	10	29.0	14.4
Less than 10	13	37.6	4.0
Total	35	100.0	
Average: 19.7 persons			16.6

Notes: (a) The date is analyzed according to EPA's enclosed investigation list of evaluation report about EIA assessing companies in 1998.

(b).The 35 consultation companies are those that have been evaluated by EPA among 147 companies.

(c). Average EIA cases per company do not include EIA cases on process.

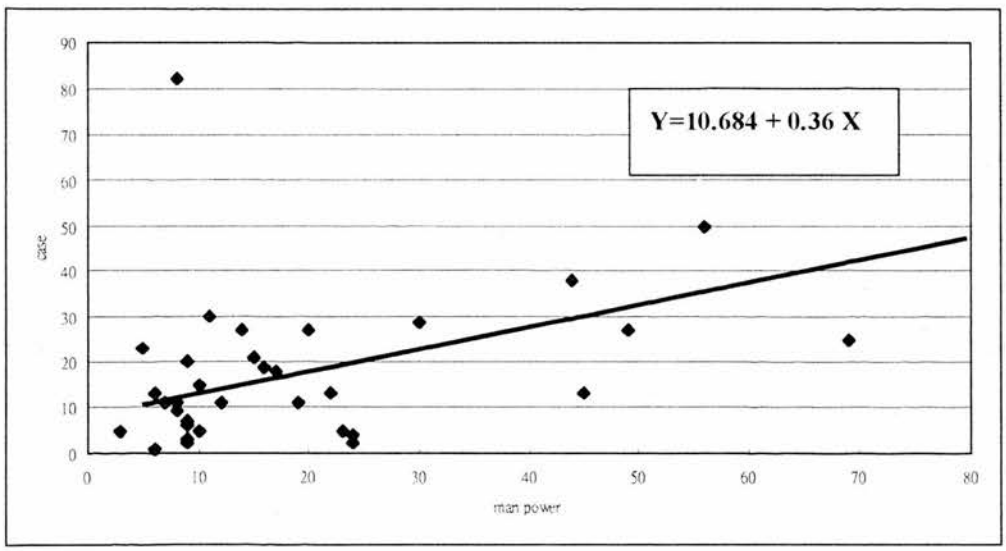

FIG. 7-8 : Relationship of Consulting Company's man power and number of EIA cases

Table 7-12 shows that five of these companies (13.3%) have been established in the last five years; 20 firms (58%) between 7-10 years ago; and only two (5.8%) more than 20 years ago. The average company age is 10.3 years.

Table 7-12 illustrated that seniority of consulting companies with fewer EIA cases contracted, In order to understand the relationship between the EIA consulting company's age of business and the number of EIA cases contracted, Analysis of Regression Technique is again adopted by this study to analyze the influential situation of how a variable can influence other variables as the variable changes. A positive correlation is shown like the above relationship (as figure 7-9). However, the positive correlation of R^2= 0.029 represents an extremely low relationship between the two variables. Therefore, it can be said that the EIA consulting company's business experience is not relevant to the number of EIA cases contracted. This correlation relationship of these two variables, which are far apart from the distribution diagram, can be seen from the diagram too.

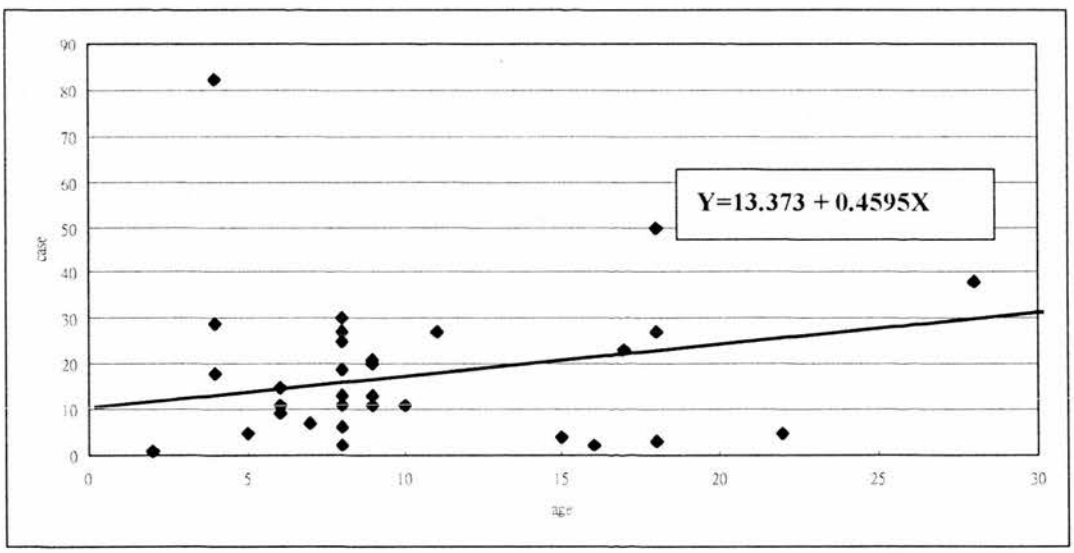

FIG. 7-9 : Relationship of Consulting Company's Age and Number of EIA case

Table 7-12: The age of consultancy companies

Seniority (year)	Numbers of consultation companies	Percentage %	Average EIA cases per company
More than 30	0	0.0	
25~30	1	2.9	38.0
20~25	1	2.9	5.0
15~20	6	17.1	18.2
10~15	2	5.8	19.0
5~10	20	58	13.0
Less than 5	5	13.3	26.0
Total	35	100.0	
Average: 10.3 years			16.6

Note: same as Table 7-11

The ratio between staffing levels and the number of cases a company handles tells us about the workload per employee. EIA assessment work is interdisciplinary and labour intensive and so the figures supplied in Table 7-13 indicate whether these firms are adequately staffed. Only one company's staff/cases ratio is higher than 15 (3%) while another's is between 12 and 15, suggesting that these two firms allocate more than 12 staff to each case. In contrast, eight companies have a ratio lower than one. This figure suggests that the average number of staff allocated to each case is less than one; in other words, each employee is responsible for more than one EIA case. Eleven companies have a ratio of between one and three (33%).

Table 7-13 indicates that 58% of firms have a ratio lower than three, and one-quarter allocate just one employee to more than one EIA case.

Table 7-13: Manpower analysis of EIA consultancy firms in relation to numbers of cases processed

Persons/processing cases	Numbers of consultation companies	Percentage %
More than 15.0	1	3.0
12~15	1	3.0
9~12	2	6.0
6~9	1	3.0
3~6	9	27.0
1~3	11	33.0
Less than 1	8	25.0
Total	33	100.0
Average: 3.84		

Notes: (a) same as Table 7-11

(b) Two companies don't have EIA cases on process.

7.4.2.2 Analysis of Consultancies' Assessment Cases

The number of assessment case contracts won by consultancy firms reveal their business ability and professional experience though it is equally possible that some firms seek to expand their business by winning as many contracts as possible by keeping their charges low. Looking at Table 7-14, we find two that undertake many cases at lower fees.

Table 7-14: Caseloads and average case fees of EIA consultancy firms (1992-1998)

Ten companies with most cases	Annual cases	Average case price (£)	Turnover (£)	EPA rating
×-Hua (1) consultation company	18.2	179,000	4,428,600	A
×-Ting(2) consultation company	12.6	68,000	3,257,800	B
×-Meng technician office	13.0	21,000	273,000	C
×-Ting(1) consultation company	12.2	363,000	4,428,600	A
×-Hsin(1) consultation company	12.2	165,000	2,013,000	A
×-Hsing(3) consultation company	11.0	189,000	2,079,000	A
×-Yeh consultation company	10.1	25,000	252,500	D
×-Ti consultation company	9.2	20,000	184,000	B
×-Chi(2) consultation company	8.2	17,000	139,400	C
×-Cheng technician office	6.8	6,000	40,800	C

Notes:

a. same as Table 7-11

b. The first character of consultation company's names are replaces by × to protect their business confidentiality.

c. The exchange between pound and NTD is 1: 55.

d. Consulting company with less than the age of five do not include.

e. When numbers of cases are the same, the company's rank will be decided by its amount of turnover.

For example, the x-Cheng technician office charges the lowest fees, only £6,000 on average (see Table 7 14), though it is ranked 10th, with 6.8 cases on its books. Similarly, the x-chi(2) consultancy company charges an average unit price of £17,000 yet runs 8.2 cases. The EPA also rated these two firms a belonging to Class C, i.e., as needing to improve staffing levels and assessment quality.

Table 7-14 reveals that the fee price for EIA assessment work varies enormously between firms, showing a differential as high as 61 times. This is because some firms charge high fees to undertake difficult and complex cases while others aim at lower fees and quicker turn-over. Tables 7-14 show that four companies charge high fees and conduct many cases. X-Ting (1) charges an average of £363,000 per case and yet is still ranked fourth in the number of cases it processes. X-Hua (1) charges an average of £179,000 and is ranked first in caseload, handling 18.2 cases. X-Hsing(3) charges an average of £ 189,000 per case and handles 11.0 cases. X-Hsing charges an average of £ 165,000 per case and handles 12.2 cases. The evidence suggests that these particular companies win contracts on the basis of their professional ability and reputation but that need not be true of all consultancy firms undertaking EIA work.

In order to understand the relationship between EIA case price charged by each consulting company and the number of EIA cases contracted, Analysis of Regression Technique is again applied to analyze if consultation fee charged by consulting companies has influence over the number of cases contracted. From the distribution diagram (figure. 7-10), it can be seen that points on the diagram shown a non-linear line. And the result derived from the Analysis of Regression shows that $Y= 20.74 - 0.138\ X + 0.000626\ X^2$. Results from the distribution diagram and the Analysis of Regression show that there are two trends exist in the correlation relationship of case consultation fee charged and the number of cases contracted by EIA consulting companies. One trend shows the higher the consultation fee charged the more the number of cases contracted by some consulting companies. This trend presents a positive correlation relationship(see figur 7-11). However, on the other hand, the other trend shows that lower the consultation fee charged more the cases contracted by some consulting companies. This trend presents a negative correlation relationship(see figure 7-12). The results of the trends says that clearly there are two groups of business among the EIA consulting companies in Taiwan. One group of business is quality orientated (see figure 7-11, EPA rating A and B class), the other group of business is price orientated. Quality of EIA consultation offered by the price orientated consulting companies tend to be lower than the quality oriented consulting

companies, and therefore, the type of consulting companies are evaluated as C or D class company as figure 7-12 shown. (A,B,C,D four classes are used to present all EIA consulting companies. A is the best, and D is the worst, EPA 1997d)

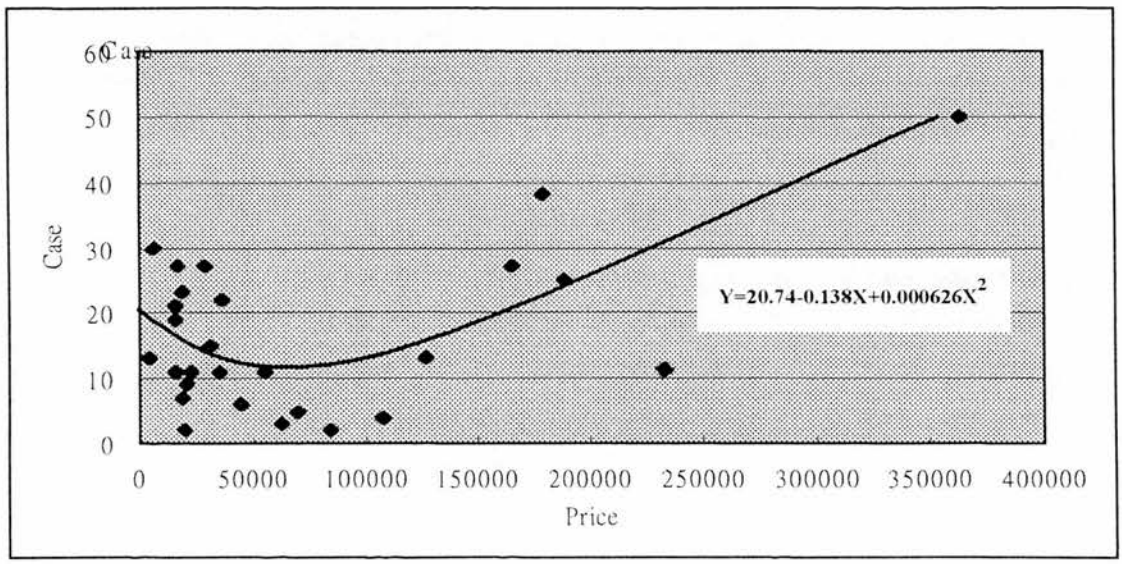

FIG. 7-10: Relationship of Consultation fee Charged by consulting Company and number of EIA cases

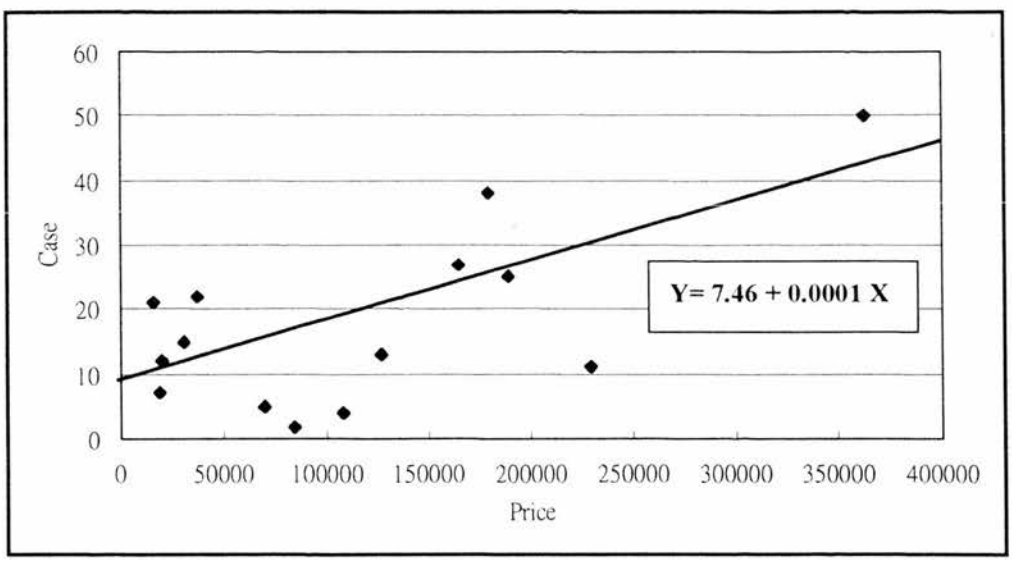

FIG. 7-11: Relationship of consultation fee charged by A and B class consulting company and number of EIA cases

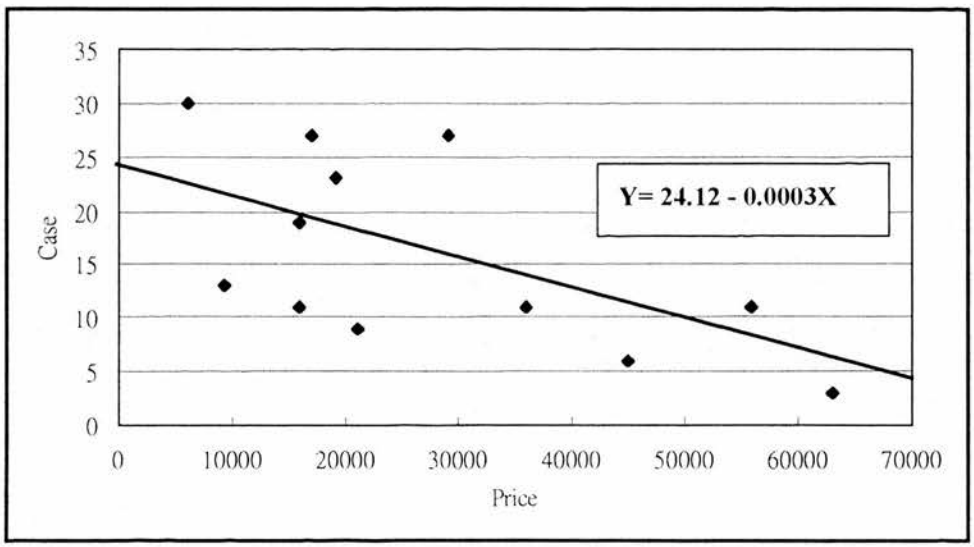

FIG. 7-12: Relationship of consultation fee charged by C and D class consulting company and number of EIA cases

7.4.3 Analysis of EIA Review Results

7.4.3.1 The Review Frequency and Duration of EIA Reports

The average number of times that EIS or EIR reports are reviewed is 2.42 times. This data is based on 77 reports examined by the EPA in 1997. Table 7-15 shows that seven cases (9.6%) were reviewed more than four times; 22 (30.1%) three times; 39 (53.4%) twice; and five (6.9%) were reviewed just once.

Table 7-15: EIS and EIR review frequency (1997)

Items	Cases	Percentage %
More than 4 times	7	9.6
3 times	22	30.1
2 times	39	53.4
1 time	5	6.9
Total	73	100.0
Average: 2.42 times		

Notes:.

a. This statistics is based on EIS and EIR passed by EPA in 1997, not including cases that are returned and overruled.

b. The meeting numbers refer to official committees, not preliminary examinations or group review.

c. This table does not include the reject cases (4 cases)

Turning to look at the duration of the review period[14], Table 7-16 shows that eight cases (11%) took longer than a year; 33 (45.2%) took 6-12 months; 24 (32.9%) took 3-6 months; and eight (10.9%) took less than three months. The average review time was 7.6 months(30weeks), which is longer than 23 weeks in the UK, but shorter than 60 weeks in Germany (Marr 1996, pp.223-33).

Table 7-16: Analysis of EIS and EIR review duration (1997)

Time (months)	Cases	Percentage %
More than 12 months	8	11.0
6~12 months	33	45.2
3~6 months	24	32.9
Less than 3 months	8	10.9
Total	73	100.0
Average: 7.6 months		

Notes:

a. same as Table 7-15

b. The calculation of review time starts from the EIA report being transferred from competent authority to environmental protection institute and ends at committee passing it.

7.4.3.2 Analysis of EIA Examination Results

In 1997, the EPA reviewed 77 EIA reports. Following the review, four cases (5% of the total) were deemed to have a very severe impact on the environment and were refused permission to go ahead. Three of these were residential community developments and one was a proposed hospital. Table 7-17 lists the eight reasons given by the EIA committee for vetoing developments, the most important being that the project would overload the local carrying capacity. (This was the verdict in three of the four rejected proposals). Specific instances given for why the environmental carrying capacity was being exceeded included: inferior geological conditions, over-intense development, steep base terrain, the hindering of local

[14] The time interval is calculated as starting from the transfer of the EIA report from the planning approval unit to the environmental protection agency and as finishing when the EIA committee announce their review decision.

ecological preservation, location at water source preservation areas, and water pollution created by the development exceeding the river's regenerative capacity.

Table 7-17 : Reasons for forbidding developments following EIA review

Reasons	Case
Exceeds local environmental carrying capacity	3
Soil conservation plan is not concrete	1
Water source is deficient	1
Traffic impact is too much	1
Potential risk is too high	1
Disaster prevention plan is not concrete	1
Mitigation measures is not concrete	1
Site allocation is improper	1
Suitability should be re-analyzed	1

Other reasons given for vetoing a proposal included: that soil conservation is not concrete; that the water source is deficient; that the impact on traffic is too great; that the potential risk (the risk coefficient) is too high; that the disaster prevention plan is not concrete; that mitigation measures are not concrete; that the site allocation is improper; and that suitability should be re-analysed. Each of these issues is cited once, accounting for 25% of the reasons for rejection.

Results of EIA reviews show that rejected EIA cases accounts 5 % of the total number, which is higher than 1 % in Netherland (Commission for EIA 1998a, p.198), but lower than 7 % of unsatisfactory and very unsatisfactory cases in the UK and Germany (Marr 1997, pp.223-31).

7.4.3.3 Analysis of EIA Cases Requiring Second Stage Assessment

In the 77 cases examined in 1997, 15 underwent an EIR review and the reminder (62) an EIS examination. After the review process, 19 cases (30% of the total EIS case) were deemed to have a severe impact on the environment and were obliged to submit to a second stage assessment. That is, one in every three of the EIS reviews were not passed at that first stage.

Looking at the second-stage cases itemised in Table 7-18, most were industrial park developments (9 cases or 47.3% of the total, two were technical industrial parks, one a professional industrial park and six were

general industrial parks). Three cases were residential community developments located on hillside; two were cultural or educational facilities also located on hillside; and two were energy development projects (a thermoelectric power station and a hydroelectric generation station). Six cases (32%) were to be located on hillside. However, the hillside environment is sensitive, so the impact caused by development is immense and complex. Another three cases were to be located in urban areas, extensively influencing the urban environment.

Table 7-18: Analysis of EIA case requiring a second-stage assessment[15] (1997)

Type	First stage EIA (cases)	Refuse	Second stage EIA cases	Main reason for needing a second-stage
Industrial park	15	0	9	• Mitigation measures should be further assessed:9 cases • Pollution prevention strategy is need:7 cases • Traffic impact should be further assessed : 6 cases
Cultural & educational facility & Hospital	12	1	2	• Suitability should be analysed: 2 cases • Traffic impact should be further assessed: 2 cases , • Landscape impact should be further assessed: 2 cases
Flood prevention, Water drainage and supply	5	0	1	• Mitigation measures should be further assessed: 1case • Hydrological impact should be further assessed: 1 case • Traffic impact should be further assessed: 1 case
New town construction	13	3	3	• Infrastructure capacity impact should be further assessed:3 cases • Suitability should be analysed: 3 cases • Development intensity should be lower: 2 cases
Mass rapid transit	2	0	1	• Mitigation measures should be further assessed: 1case • Landscape impact should be further assessed: 1case • Noise impact should be further assessed: 1case
Energy development	4	0	2	• Hydrological impact should be further assessed: 2 cases • Mitigation measures should be further assessed: 2 cases • Further alternatives is needed: 2 cases
Railway	1	0	1	• Disaster prevention plan is needed: 1case • Mitigation measures should be further assessed: 1 case • Hydrological impact should be further assessed: 1case
Road	1	0	0	
Airport, seaport	10	0	0	
Environmental Engineering	6	0	0	
Recreation facility	4	0	0	
Total	77	4	19	

[15] The data is analyzed according to nineteen cases required second stage assessment made by EPA review results in 1997.

Table 7-18 itemises reasons to conduct a second stage assessment and these include: that further alternative plans are needed; a pollution prevention strategy is needed; the environmental impact needs to be further assessed; a more detailed disaster prevention plan is needed; mitigation measures need more detailed assessment:; suitability should be analysed; and development intensity should be lowered. Most of these reasons were calling for further environmental impact assessment. Fourteen cases (73.7%) were about mitigation measures; and nine (47.4%) needed further hydrological impact assessment.

Ideally, alternatives play an important role in the EIA system. However, we find only two cases where a demand is made to assess alternatives further. It is obvious that the idea of alternative plans is not completely accommodated into the implementation of the EIA system. In contrast, mitigation measures to reduce pollution are valued. We can see how the main agenda for Taiwan's EIA is public pollution prevention.

7.4.3.4 The Contents of Additive Conditions of EIA Review Conclusions

Of the 77 EIA reports reviewed by the EPA in 1997, 73 permitted the development with certain conditions attached, and none were accepted unconditionally. Additional conditions can be divided into four categories: reminder items for developers (precaution condition); contents of EIA supplement reports (supplement condition); requirements for implementation development (compulsive condition); and procedural requirements (procedure condition).

The first category covers those items that need special treatment, though since they are already regulated by law the committee's additive resolutions are somewhat redundant except to remind developers of their legal obligations. Most typical of these 'reminders' are the necessary mitigation measures (appearing 70 cases, or in 96% of the conditional cases). For example, during construction and operational periods, air pollution

mitigation measures must be carefully applied in order to conform with air quality standards(see table 7-19).

Looking at the second category - the contents of supplementary conditions - the EIA committee views the project's EIA report as insufficient but not enough for it to fail the review. Cases such as this are passed on condition that the contents will be supplemented later in the final draft. However, the committee also demand to examine those contents before announcing the EIS and EIR verdict. This is a way of avoiding holding another review meeting in situations where the supplementary contents are not the key factor. Again, most of the conditions attached to this category are to do with mitigation measures (71 cases or 97.3% of the total), e.g., developers must supplement protection measures for precious fauna during construction. Environmental information supplements account for 43 cases (58.9%), e.g., insect investigation methods and results must be supplemented. Other supplementary contents include environmental impact (such as effects on underground water) and disaster prevention strategies (such as emergency reaction plans during an earthquake).

The third category refers to items cited in the EIA Act which, if left undone by the developer, would place the project in violation of the Act and would carry commensurate penalties. All these compulsory conditions refer to implementing environmental protection programmes. Fifty-six cases (76.7%) needed to augment particular parts of the supervision and inspection execution plan, e.g. requiring that polluting emissions should meet a stricter standard than that regulated by law. Other compulsive conditions included negotiating with the public and prohibiting partial development contents (See Table 7-19).

Finally, the fourth category refers to meeting certain procedural conditions. All of the conditional cases needed to provide an Environment Difference Analysis report should the construction be delayed for three years or more. Briefing meetings were also demanded of EIS or first-stage candidates, accounting for 5

cases (74% of the total). Other demands included permission procedures (e.g., that control areas should be agreed by the national Defence Department prior to construction) and that departmental plans should be sent to authorised institutes for examination (e.g., soil conservation plans should be sent for examination to water and soil preservation agencies prior to construction).

The highest number of additive conditions that were attached to passed EIA cases came to 15 items. The average number of additive conditions came to 11.3 items. As these have the function of supplementing the EIS and EIR reports they aid the implementation of the EIA system.

Table 7-19: Additional conditions attached to cases reviewed and passed by the EIA

Type	Contents	Cases	Percentage %
Precaution condition—to remind precaution items	Pollution prevention	66	90.4
	Development procedures	51	70.0
	Mitigation measures execution	70	96.0
	Safety measures during construction	58	79.5
	Safety measures during operation	22	30.1
Supplement condition—to supplement contents of EIA reports	Environmental information	43	58.9
	Assessment and prediction of impact	37	50.7
	Mitigation measures	71	97.3
	Disaster prevention plans	33	45.2
	Other contents	17	23.3
Compulsive condition—to require development conformity	Raising environmental protection standard	52	71.2
	Execution plan of environmental protection	73	100
	Negotiation with the public	26	35.6
	Adding supervision and execution plan	56	76.7
	Prohibition of partial development contents	25	34.2
	Demand of promise items	33	45.2
Procedure condition—to require procedures of implementation	Holding of briefings	54	74.0
	Requirement of permission procedure	30	41.1
	Department plans should be sent to authorized institutes for examination	23	31.5
	Developed after three years should present environmental difference analysis report	73	100.0
Total		73	100.0

7.5 IMPLEMENTING PUBLIC PARTICIPATION

Public participation is an essential part of the EIA system, having the purpose of garnering ideas and opinion. In this section, we will look at the features of public participation and then at the predicaments and shortfalls of Taiwan's attempts to make genuine participation a reality.

7.5.1 Features of Public Participation

7.5.1.1 Indifference and Fanaticism

One of the most notable characteristics of public participation in Taiwan's EIA process (though, presumably it is not confined either to Taiwan nor to the EIA's subject matter) is indifference. The public is simply not interested in attending development briefings and hearings. For the 15 development briefings held in Taichung city, on average only 4.5 members of the public attended and most of those were village heads or Community Directors. Others who do attend leave quickly. Therefore, briefings usually do not fulfil their expected purpose.

In contrast, another feature is the occasional frenzy of the public, demonstrated by their high and frequent attendance at meetings about specific developments. Generally speaking, these proposed developments are controversial or are related to local profits. For example, the German company, Bayer, intended to build a tolylene di-isocyanate (TDI) factory in Taichung. The 60 public briefings held on this one project were crowded with local residents and national environmental groups voicing their opposition. Though Bayer's EIA report passed its review, the company declared its withdrawal owing to the level of public opposition the proposal encountered.

Both indifference and fanaticism reveal the polar extremes of public participation in the EIA system and the absence of a happy medium suggests that the public do not have sufficient knowledge about the public participation system, nor are they impressed with the normal inclusion mechanisms of the normal political process.

7.5.1.2 The Public's NIMBY Attitude

A characteristic public attitude towards developments is often revealed as NIMBY (Not In My Back Yard), and this affects public participation and feeling. For example, in 1997 local residents enthusiastically participated in two cases about proposed waste incinerators (the Kaohsiung Kanshan and Tainan Yungkan projects). Their view in both cases was unanimous, i.e., that the incinerators should be built but not in their neighbourhoods. This kind of public opposition does influence the EIA's review conclusions. So, for example, though both of these projects were passed, the main clause attached to the EIA's conditions was that the developers continue to communicate with local residents and to set up feedback plans for the public benefit.

7.5.1.3 The Public's Dominant Concern with Self-interest

An analysis of public participation levels demonstrates that people are more concerned with their own profits than with the environment as a whole. This was clearly revealed in the briefing process attached to the Taichung Regional Shopping Mall projects. Here, the participants were mostly old employees of development companies or residents living on the proposed site.[16] The briefings were largely taken up with demands that residents should receive resettlement assistance while few people seemed concerned with how the 22.74 hectare project would affect traffic, noise levels, views or the microclimate.

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[16] The proposed site for this development was on the living quarters of Taiwan's sugar co-operative and so invoked the keen concern of retired employees of the Co-op who were housed there.

7.5.1.4 Public Briefings Becoming the Platform for Special Interest Groups

Public participation mechanisms are intended to provide people with opportunities to express their opinion of a development so that subsequent decisions made about it are more complete and acceptable. However, sometimes these participation fora are targeted by special interest or political groups who use them to educate the public about their particular message and to represent them in fighting for their special cause. A consequence of this hi-jacking of participation mechanisms is that non-aligned people lose the space needed for arriving at their own independent conclusions. In these cases, the public merely become the tool of groups who use them to expand their own campaigns. A common outcome in this kind of situation is that the special interest group threatens to protest and demonstrate if the EIA Committee's findings should go against their wishes, indicating a deep distrust of the EIA process.[17]

7.5.2 Shortcomings of Public Participation

7.5.2.1 Time and Cost Limitations

The more involved the public get and the closer they are to the policy's core, the longer the planning process takes. In addition, as the general public lack relevant professional expertise and citizens, by and large, are preoccupied with their own affairs, the public's statements tend to be impractical and/or ineffective, reducing the value of their input.

The costs of public participation can be measured as the cost of activities (e.g., the administration of briefings etc.) or the cost of opportunities lost (e.g., policy delays, loss of profit etc.). With these constraints in mind, government officials tend to simplify events and developers tend to reduce time spent

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[17] This seems to have happened in the case of Bayer's TDI factory proposal. See the Central Daily News, Taipei, Taiwan, December 18, 1997.

on public participation in order to cut costs. For example, the EIA Act regulates that the public's verdict must be available within 15 days of the public briefing - a period that is obviously too short.

7.5.2.2 First-Stage Public Participation is Deficient

As discussed earlier, only 30% of EIA cases entered into a second stage assessment and most public participation occurs in this latter phase. This situation generates two questions. First, by the time the public enter fully into the discussion, it is already too late. By this I mean that controversial projects will have already generated disquiet at the EIS stage, so by the time the public enter at the EIR stage the dice is already loaded and it is extremely difficult to gain the public's recognition and support for the development. Second, as the public does not have effective and direct opportunities to participate in EIS assessments (i.e. by and large, they are informed of the result of decisions after they have become fact), their participation is intrinsically weak.

7.5.2.3 Public Participants as a Self-Selected Elite

Generally speaking, the members of the public who do choose to participate are experts, scholars or special interest groups. The main reason why the general public excludes itself is that the EIA process is, itself, highly professional. It is difficult for the person on the street to understand - let alone critically assess and query - the EIA's procedures, methods and environmental prediction models. As things stand, it is only relevant experts and scholars who are invited to sit on EIA committees. The committee is not a public forum. It is the same elite groupings who participate in scopings, hearings and site inspections and though their findings are later publicly announced, the general public's role in the process is passive.

7.5.3 Current Controversies about Public Participation

7.5.3.1 The Dilemma of Democracy v. Efficiency

Taiwan's modern political system lays much emphasis on administrative efficiency and citizen-friendly policies. However, meeting the former goal involves controlling costs and deadlines - for example, by setting a short review period for new proposals - while meeting the latter (to continue with that example) necessarily involves a lengthening of the review period. As public participation is a dynamic process which seldom results in unanimous consensus, its inherent democratic intent does not aid efficiency. Facing the dilemmas posed by meeting these antithetical goals, it is difficult to see how much further the EIA process can accommodate public participation.

7.5.3.2 Public Opinion v. Public Profit

Public participation is usually inconsistent with public profit. The government's EIA policy is based on public profit, i.e., benefit to the majority of people. However, since the public's participation in EIA cases often exposes conflicts between the prevalent view of local residents and the project's more general societal benefits, decision-makers usually face the problem of disentangling the two issues.

The first problem lies in deciding who "the public" are in any given case for it may refer to local residents, the entire nation, or any gradation between those two extremes. The controversy attached to the Bayer's TDI factory project exposed the rifts within "the public", resulting in a declaration by the Taichung County Magistrate that a referendum would be necessary to establish some consistent view of "public opinion" on this case. Though a referendum on this topic has not, in fact, been held, the TDI case does reveal the nature and extent of the decision-maker's problem.

A second problem is who has the right to decide on the general good. Though public profit is for the public's benefit, it is usually the EIA's decision-makers who must quantify what that benefit consists in, in any particular case, and their findings will not please everyone. At other times, decisions on whether to proceed or not even exceed the brief of the EIA assessors. For example, the EIA assessment of Taiwan's 4th nuclear power station acknowledges that the project will have irrevocable impacts, yet the government insists that it should be built for the good of the nation as a whole.

7.5.3.3 Public Opinion v. Professional Knowledge

A highly industrialised society is characterised by its specialist divisions of labour and knowledge. To compensate for the fact that the general public is not equipped with the relevant expertise to critically assess EIA cases, the EIA process demands that a quota of experts be included in public discussion.

However, in practice, the experts and the general public rarely interact. The former generally avoid attending public meetings (though they are entitled to do so) while the latter are not invited to sit on the review committees; the former generally dismiss public opinion as irrational, while the latter generally do not trust that the experts are neutral or objective. For example, a central government EIA committee passed a proposal to build a 6th light oil refinery in Yilan County, though the local public there suspected that the committee was hiding something or, at least, was using its invited experts to justify a positive verdict that was questionable. As a result, Yilan's local government sent the EIA reports to other academics to be re-assessed. As the second group of expert reviewers returned with a different conclusion, it seems likely that this kind of public disquiet with the experts might well surface again.

7.6 SUMMARY

It has been 20 years ever since Taiwan pilot study the first EIA project in 1979. The EIA Act promulgated at the end of 1994 was considered a milestone for environmental legal regulations. The EIA system in Taiwan adopts two-stage assessment approach. The first stage, Environmental Impact Statement (EIS), aims at projects that impose adverse impacts upon the environment. The second stage, Environmental Impact Report (EIR), focuses on those projects with great environmental impacts which identified in the first stage of assessment. Procedures in the first stage assessment are quite simple because they only contain consultation and preparation of EIS prior to submitting EIS and public briefing after the review is passed. Whereas, the second stage of EIR assessment comprises plenty of procedures, including consultation, public briefing, scoping, public hearing, preparation of EIR, EIR review, confirmation, promulgation and publish and monitoring and surveillance, etc.

The environmental authority is responsible for administering EIA procedures of the EIA system in Taiwan, which is different from most of the countries (as Table 2-5). Nevertheless, the expert committee (EIA Committee) takes charge of EIA review. The EIA Committee in Taiwan is authorized with the rights of veto and decision-making, which means competent authority can't approve an EIA case unless it is reviewed and passed by the EIA Committee. Those EIA cases that the EIA Committee considers inappropriate for development are vetoed immediately. Thus, the EIA Committee is deemed to have "review right," "decision-making right" and "veto right." To pay attention to both review quality and administration efficiency, the longest durations of reviewing EIS and EIR are 50 days and 60 days respectively with extension once. Besides, members of the EIA Committee also prescribe that experts and scholars must account more than two thirds at least in order to maintain the independence of the committee and reduce the interference of other forces.

In addition to EIA with project level, the EIA Act in Taiwan also requires governmental policies, plans and programmes with significant impacts for EIA process. It implies that strategic environmental assessment (SEA) is established simultaneously and its main procedural details for implementation were promulgated in 1998.

The number of EIA cases is increasing year by year after 1979. By 1990, annual number of EIA cases was below 15; however, it grew rapidly after 1990. When the EIA Act was promulgated in 1994, it already reached to 67 because the applicable extent became wider and mandatory as the EIA Act took effect. There were 102 EIA cases in 1998. Among the development categories of EIA cases, high-rise buildings and new town development projects take the lion's share, which is 30% of the total number. The second highest rate is factory and industrial zone development projects. For the cost of EIA cases, the average cost per case is 57,000 pounds, which is higher than 29,000 pounds in the UK (Commission for EIA 1998a p.249); however, the EIA cost per case only takes 0.098% of the total project costs, which is lower than 0.6% in the UK (Commission for EIA 1998a, p.249). It indicates that the scale of EIA cases in Taiwan is greater, which leads to higher total project costs naturally. Among cost categories, water supply work has the lowest proportion of 0.04% and the highest is for nuclear waste disposal plant projects, which is 0.56%. As for the unit price of EIA cases, development projects of quarrying earth and stones cost the lowest price, only 7,000 pounds. It costs 16,000 pounds for high-rise buildings and the highest unit price cost goes to mass rapid transit projects for 454,000 pounds.

As for EIA duration (from first consultation to submission of EIS), railway projects take the longest time of 18 months and quarrying projects of earth and stones is the shortest for 2.5 months. On the average, it takes 8.5 months and that for high-rise building development projects is 4.5 months. Besides, the average number for human resource per assessment case is 3.81 people. Thus, the average manpower for each EIA case is 32 people-months, which is lower than 40 people-months in EU (trans-European rail network). For the

human resource of the EIA department in an EIA consulting company, the maximum number is 56 people and companies below 10 people account one third of the total number. History of most of the consulting companies is less than 10 years, which is 70% of the total number of EIA consulting companies. The correlation between the manpower of the consulting companies with analysis of regression technique and the number of EIA cases they reveals positive correlation; however, R^2=0.13, which reveals the correlation is quite low. That is to say that human resource does not necessarily increase for those consulting companies taking more EIA cases, which will definitely influence the quality of EIA reports. Furthermore, as we adopt the analysis of regression technique to compare the average unit price per EIA case charged by consulting companies with the number of EIA cases they accept, we can discover zero correlation from the scatter diagram. On the contrary, two groups appear. One of them shows the lower the unit price, the more acceptable EIA cases. The other is exactly opposite. It implies that consulting companies are becoming polarized. One group earns sales by low unit price; however, the other group is orientated by professionalism (or quality).

Results of EIA reviews show that rejected EIA cases (con development) account 5% of the total number, which is higher than 1% in Netherlands (Commission for EIA 1998a, p.198), but lower than 7% of unsatisfactory and very unsatisfactory cases in the UK and Germany (Marr 1997, pp223-31). The average review duration is 7.6 months (30 weeks), which is longer than 23 weeks in the UK, but shorter than 60 weeks in Germany (Marr 1996, pp.223-33). As for the average length of EIA reports (EIS & EIR), it has 162 pages in Taiwan, which is longer than 21-100 pages (80%) in the UK and 51-150 pages (65%) in Germany (Marr 1996, pp.218-27). Nevertheless, the average length of alternatives in EIA reports in Taiwan has only 1.8 pages, which accounts 1.1% of the total length and is insufficient obviously. Averaged 2.8 presented alternatives only deal with no-action and technical alternatives, but short of location, postpone action, equivalent value action and compensation action alternatives.

30% of EIA cases reviewed in 1997 were required to enter the second stage (EIR) and projects of developing industrial zones took the greatest proportion of 47.3%. Besides, 32% of those projects required to proceed the second stage is located on the hills, which shows that development of hills has become more concerned by the members of the EIA Committee. Insufficient mitigation measures are the main reason for 57.9% of cases that are asked to conduct the second stage of assessment. Each and every one of the passed EIA cases is attached with conditions. 29% of the attached conditions is mandatory and it either demands to raise the standard of environmental protection (more strict than the requirements in current legal ordinances) or prohibits part of the development activities.

For public participation, as public briefings are not held only after review on the first stage of assessment and no public participation occurs at earlier phase, 70% of EIA cases in Taiwan are approved during the first stage of assessment. Several characteristics of public participation in Taiwan are coldness and fanaticism, NIMBY (not in my backyard) attitude affecting participants, attention to his own gains and losses, few people concerned about environmental quality and interference of outer forces. Besides, the general public also takes time and costs into consideration. Thus, few people are capable or have the opportunity to participate.

This chapter mainly deals with the implementation condition of the EIA system in Taiwan. From the analysis mentioned above, we can realize the advantages and shortcomings of EIA in Taiwan, which also presents integrally the overall implementation circumstance after the EIA Act is promulgated in Taiwan.

CHAPTER EIGHT: THE EIA CONTEXT FOR HIGH-RISE BUILDINGS

High-rise buildings differ from ordinary buildings in their height, high energy consumption and complex functional uses. Their titanic size imposes huge impacts on the surrounding environment. For this reason, an exploration of the compatibility of a high-rise building with its environment is an indispensable part of the review process. A high-rise presents risks to the public in terms of wind hazard, insolation, the obstruction of signal waves, traffic, etc. and all these possible hazards are influenced by the location, style and height of the building. Mitigation measures are proposed to comply with the expected impact of the building on the environment based on the findings of a predictive analysis. The major topics tackled by an environmental impact assessment are waste management, energy saving issues, disaster prevention plans, pollution, etc. Due to the unique hazards they present to the environment, the approval system for high-rise buildings differs from that applied to ordinary buildings.

This chapter deals with Taiwan's approval system for high-rise buildings. As the urban zoning plan provides the first reference point for whether proposed developments are allowed to go ahead or not (i.e., it governs the over-all strategic management of urban building programmes), the relationship between it and the management of buildings will also be analysed, so as to throw light on the approval system regulating the construction of high-rises.

8.1 THE DEFINITION OF A HIGH-RISE BUILDING

Constructing ever more elaborate high-rises is premised on technological progress. The 21-storey Mesonic building was completed in the US in 1892, setting a new precedent for tall buildings[1]. High-rise

[1] William Le Baron Jenney designed the first iron-frame building, the Home Insurance Building, Chicago in 1883. The innovative use of structural steel provided the opportunity to separate exterior materials from supporting structure. The earliest electric elevator was installed in the Demarest Building in new York in 1889. See Yeang, 1996, pp.8-10.

construction techniques then developed apace in Europe. For example, the Eiffel Tower in Paris - built in 1989 and standing 300 metres tall - came to symbolise the sophisticated creativity of human civilization reaching ever upward towards the sky. Chicago took things a step further for it was in this city that high-rises were first built with human habitation in mind. This innovation was made possible by combining a steel frame structure with elevators.

Though the accomplishments of Chicago-style high-rises are properly acclaimed by modern architects, Americans generally prefer low-level living. In the States, the low-rise building represents the true, humane and ideal residence, while the high-rise represents wealth, power and corporate achievement. Both in America and elsewhere, this dichotomous view of a building's "meaning" has led to a marked concentration of high-rise buildings within small and bounded areas of land (e.g. urban centres), resulting in massive environmental impacts in these areas coupled with their attendant social costs (Wang 1998, p.25). Notwithstanding the lop-sided effects of this phenomenon, we find a global boom in high-rise construction in cities (see Table 8-1).

There is no standard definition of a high-rise building, either in terms of type or height. In Japan, the old architectural laws deemed that buildings should not exceed 31 metres; when those laws were later amended, "High-rise buildings" were simply taken to mean those which were taller than 31 metres. However, the first Japanese high-rise to be built after this amendment was the Kasumigaseki Building in Tokyo(1968). Standing at 147 metres, it makes a nonsense of such lowly 31-metre "high-rises". Thus, it may be sensible to take +60 metres as a working definition, though a more recent consensus emerging in Japan is that the cut-off point should be +100 metres (Yang 1988, p.1).

Table 8-1: A representative sample of world-famous high-rise buildings

Name of Building	Height of Building(m)	Finished Year	Representative Characteristics
Air City 1000 of Japan	1000.00	planned	Air City: The ultimate prospect for the future.
Peace Building in Tokyo, Japan	810.00	planned	Currently, the highest building whose planning is complete.
Miglin Beitler Skyneedle	610.00	planned & in design	Headquarters of skyscrapers: Chicago breaks the world record again.
Planning Centre in Melbourne, Australia	560.00	Planned & in design	A representative Australian work, challenging the highest building in the world.
International Finance Centre, Taipei	509.20	Construction (2001)	Expected to be the highest building in the world
Chon Chin Skyscraper, China	457.00	under construction	The highest building & symbol of development for inland China
Petronas Tower, Kuala Lumpur, Malaysia	450.00	1997	The highest building in Malaysia; the record for the highest building moved to Asia for the first time.
Sears Tower, Chicago, US	443.50	1974	The world's highest skyscraper pre-1997
Asia Enterprise Center, Kaohsiung	431.00	Construction (2004)	To be the 2nd highest in Taiwan.
World Trade Center in New York, USA	417.00	1972	The highest building in New York
Empire State Building in New York, USA	381.30	1931	The 1st high skyscraper & the highest building in the world for more than 4 decades
Central Plaza, Hong Kong	375.00	1992	The highest building in Hong Kong
Bank of China, Hong Kong	368.62	1988	Used to be the highest building in Asia
Tuntex Building, Kaohsiung	347.00	1997	The highest building in Taiwan at present
First Interstate World Center, L.A., USA	310.00	1989	The highest building in the west of the US
Landmark Tower, Japan	295.00	1993	The highest building in Japan at present
Overseas Union Bank, Singapore	280.00	1986	The highest building in Singapore
Messeturm Building, Frankfurt, Germany	259.00	1990	The highest building in Europe at present
Shin Kun Skyscraper, Taipei	244.15	1994	The highest building in Taipei at present
1 Canadk Square Building, London, UK	236.00	1991	The 2nd highest building in Europe at present
Rialto Center, Melbourne, Australia	242.00	1985	The highest building in Australia
Tokyo Metropolitan Government Hall (city Hall Complex), Tokyo, Japan	241.80	1991	The highest office building for governmental administration & the 2nd highest building in Japan at present
Long Valley United Building, Kaohsiung	221.60	1993	The 3rd highest building in Taiwan at present
Carldon Center, Johannesburg, South Africa	220.00	1973	The highest building in Africa

Data source: based on Wang , 1998, p.28 and Yeang, 1996, pp.250-255.

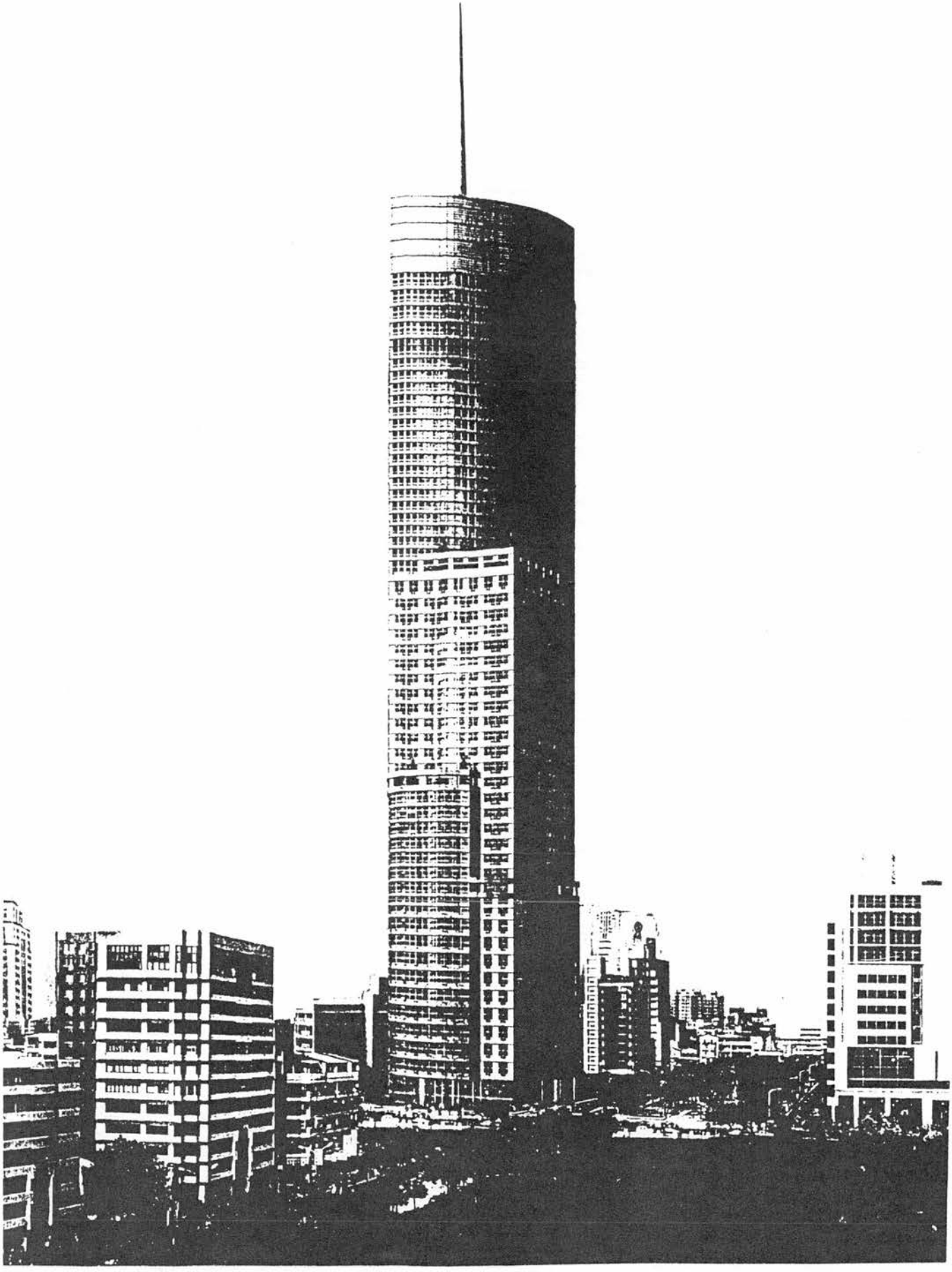

Plate 8-1 : Shining Park Tower : The Highest Building in Taichung City
(Courtesy : Shining Institution)

Lacking a standard definition, high-rises are usually understood in terms of the special architectural problems they present as the following list suggests:

Disaster Prevention and Evacuation: Buildings over 15 floors high must install a special safety stair, so we can take +15-storey buildings to be high-rises. The Building Code of Taiwan offers an example of this type of definition (Wang 1998, p.26)

Structural Safety: Based on the safety of the structure and vibration resistance, the building code of Japan requires construction projects of +60 metres to be approved by the Ministry of Construction. The building code of Taiwan prescribes that the structural design of +50 metre buildings must be reviewed by a specified agency. Thus, either +50 metres or +60 metres height is a working definition of a high-rise.

Fire Fighting Facilities: Generally, this issue is addressed in terms of the maximum height that a firefighter's tower ladder can reach. For instance, the National Fire Protection Association of Europe (EFPA) and the International Fire Protection Association take 100 feet (i.e., the fullest extension of the tower ladder) to be the cut-off point between high-rises and other buildings.

Relative Height: Absolute height is not a good definitional guide as it keeps rising in line with improvements in construction technologies. Relative height - meaning the height ratio (HR) of one building to the average height of those in its neighbourhood - provides a more appropriate measure. The Swiss United Land Programme Committee (SULPC) takes this approach and defines a high-rise as being either a building whose height exceeds the zoning requirement or one which remains within the requirement yet is taller than existing buildings in the vicinity (Tarn 1991, p.6).

Environmental Impacts: High-rises differ from ordinary buildings in their environmental impact. For example, Tokyo's EIA articles state that buildings over 100 metres, or having more than 28 floors, must be assessed; Taiwan's EIA Act demands that office blocks of 20 floors or 70 metres height, and residential buildings of 30 floors or 100 metres height, must submit to the EIA process. In addition, a single item having an environmental impact can also serve as a definitional reference, e.g., in Taichung, buildings

above 100 metres are required to conduct wind tunnel tests.

We can see from this discussion that a "high-rise" may be a building of 30 metres (100 feet), 70 metres (20 floors) or 100 metres (28/30 floors). Given this variation, we will take Taiwan's EIA Act as our definitional guide and assume that high-rise buildings are those which are +70 metres or are over 20 storeys high. In addition to height, a building's scale or size is also critical. For instance, some buildings with less than 20 floors (or lower than 70 metres) nevertheless occupy a large total floor area, and this in itself can impose a tremendous impact upon the environment. However, this issue is not part of our discussion here.

8.2 LAND PLANNING AND BUILDING MANAGEMENT IN TAIWAN

Building management is premised in the first instance on the controlled zoning of land. Thus, before exploring the construction permit system in detail, we need to place it in the context of Taiwan's land planning regulations.

8.2.1 Taiwan's Land Planning System

The land planning system is graded into types, i.e., urban, regional and national land use policies (Yang 1994, p.2). Ever since the Japanese first instigated urban planning for Taipei (in 1899) and Taichung (in 1900)[2], all Taiwanese cities have gradually introduced urban planning regulations. By the time Japan left Taiwan in 1945, 73 such regulations existed. By the end of 1996, this number had risen to 440 and 12.2% of Taiwan's total land area (accommodating 77.2% of the population) was subject to some level of planning regulation.

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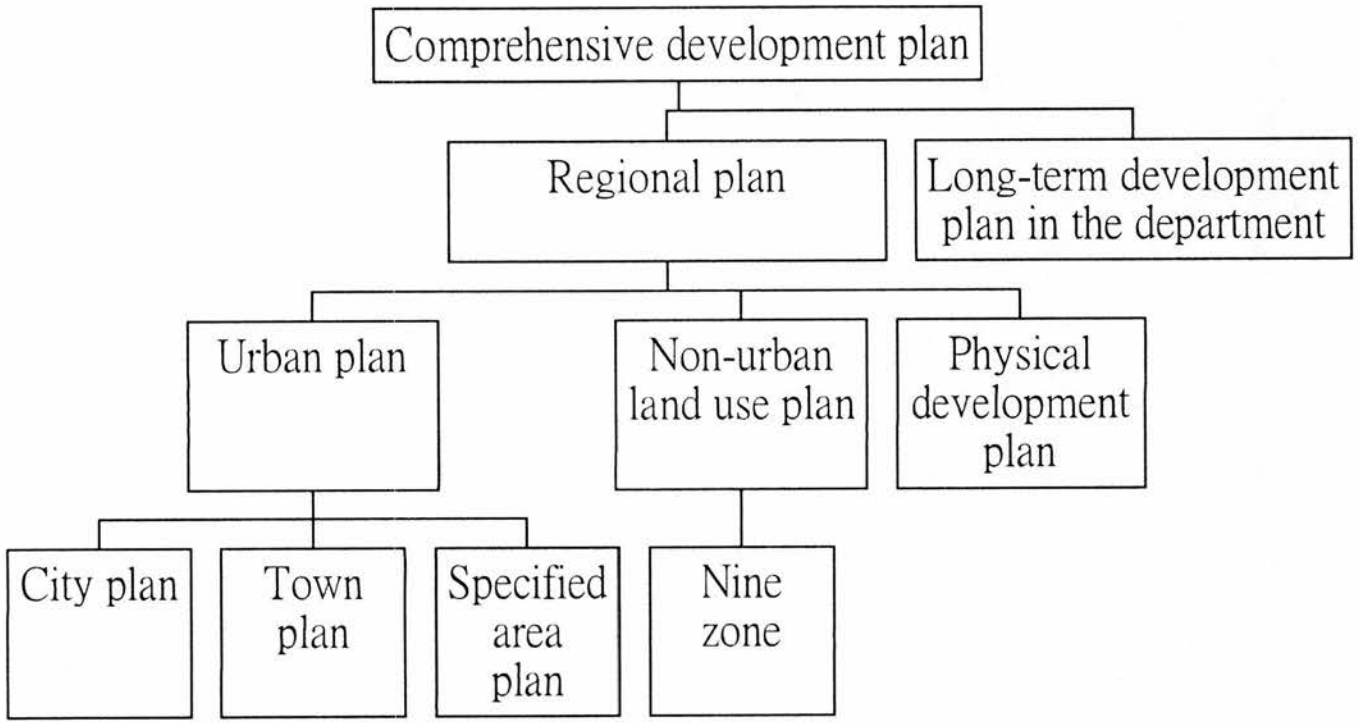
[2] Taiwan was a Japanese colony from 1895 to 1945 and all Taiwan's urban planning systems have been profoundly shaped by that colonial heritage. The Japanese were instrumental in introducing the idea of controlled expansion of cities, e.g., introducing the Downtown Correction Plan for Taichung as early as 1900. See Hsiao, 1991,p.54.

Prior to 1950, land planning took individual cities as its unit and regulatory contents focused on issues such as the zoning of land use and allocation of public facilities. The socio-economic development of cities - including the growth of satellite towns - was seldom taken into consideration (Yang 1994, p.3). This narrow focus shifted throughout the '50s as the economy expanded, trailing in its wake rapid industrialisation and urbanisation: urban populations increased dramatically, existing cities grew, more cities came into being, adjacent towns were sucked into the city, and metropolitan areas such as Taipei-Keelung began to emerge. As national construction projects gradually spread outward and the scale of critical projects increasingly encompassed more than a single city entity, the concept of regional planning slowly began to emerge. The Taipei-Keelung Metropolitan Plan and the Regional Plan for the Expansion of Kaohsiung Port (both drawn up around 1961) signaled the beginning of the conceptual shift.

Throughout the '60s, seven regional plans were instigated though a lacuna still existed in respect of a comprehensive national land planning system which could address broader strategic issues. During this period, the following problems became ever more pressing: population and industrial density increasingly centred either at the North or the South of the country; economic development was being delayed as the slower pace of new construction work lagged behind demand for growth; infrastructural investment was underfunded; and the piecemeal and unregulated development (and destruction) of national land assets meant that environmental pollution was on the increase (Yang 1994, p.4). By 1979, the government responded by implementing a Comprehensive Development Plan to serve the country as a whole.

As a result, Taiwan's current land planning system has three tiers. As Figure 8-1 shows, the upper level refers to the comprehensive development plan, which sets out broad targets, guidelines and policies. The intermediate level governs regional planning and long-term construction projects in each department while the lower level refers to specific urban plans and land use control plans for rural areas.



Data source: Chen, 1995, P. 5

FIG. 8-1: Taiwan's land planning system

8.2.2 Regulating Changes in Land Use

Currently, control over the use of land is achieved through zoning, whereby specific areas are subject to their own special regulations which govern whether particular development activities are permitted or prohibited. Zoning criteria can be amended every two to five years, depending on changes to the status quo of urban development policies. Nevertheless, zoning decisions are reasonably inflexible and cannot be randomly altered.

Changes to urban zoning plans are regulated in terms of periodic inspections and of urgent responses to emergency situations. In the case of the former, inspections are conducted every five years which involve a thorough review of the area and which may lead to changes being introduced. In the case of the latter, there is a contingency for changes to be introduced with immediate effect following natural disasters, human accidents or other critical events. Land owners who wish to promote a new use for their land may apply to the government for a change plan.

General urban planning regulations address the timing and the methods used to introduce change, not whether specific development activities should remain permitted or banned. Thus, legal procedures can be used to apply for changes in use of any type of land, and that approval wholly depends on the urban planning committees which sit at each of the three regulatory tiers mentioned above. Arguments are frequent because zoning changes are often driven by a profit motive and there are no laws prescribing what balance should exist between profitable ventures and the provision of public facilities. However, when zoning changes are introduced to enable profitable ventures to go ahead, there are usually conditions attached. Table 8-2 itemises how zoning changes in Taipei, Kaohsiung and Taichung were approved, contingent on the donation of a certain proportion of land for public facilities. Note, however, that each city's regulations are particular to itself, and none of the zoning changes with donation condition were implemented until 1992.

As mentioned, proposed zoning changes are reviewed by the urban planning committees. The lowest committee tier is at the municipal level, the intermediate tier at the provincial level and the upper tier at the Ministry of Interior Affairs. This tiering system generally promotes a more just outcome as biases are ironed out along the way. However one consequence of this tiered system is that it generally takes a few years before a proposed zoning change becomes an actuality.[3].

Table 8-2: Changes in urban zoning plans in Taiwan's major cities and the proportion of land donated to public facilities

City	Land Application Change Type	Proportion of Land allocated to Public Facilities
Taipei	Residential area changed to commercial zone 1	15%
	Residential area changed to commercial zone 2	20%
	Residential area changed to commercial zone 3	20%
	Residential area changed to commercial zone 4	25%
	Industrial zone changed to commercial zone 1	25%
	Industrial zone changed to commercial zone 2	30%
	Industrial zone changed to commercial zone 3	30%
	Industrial zone changed to commercial zone 4	35%
Kaohsiung	Industrial zone changed to residential area	32%
	Industrial zone changed to commercial zone	42%
	Agricultural area changed to residential area	50%
	Agricultural area changed to commercial zone	60%
	Lands for public facilities changed to residential area	50%
	Lands for public facilities changed to commercial zone	60%
Taichung	Changed to commercial zone type 2	12%
	Changed to commercial zone type 3	15%
	Changed to commercial zone type 4	18%

8.2.3 Building Permits and Urban Planning

While zoning specifies the purposes to which a designated area may be put, building management is the detailed means by which land planning policies are put into effect. Land planning in Taiwan is divided into urban and rural areas. Urban areas are divided into nine types: residential, commercial, industrial,

[3] In general, it takes about two years to come to a decision on an application, though it took seven years of discussion before Taichung's urban plans were changed for the second time.

administrative, cultural and educational, scenic, protected, agricultural, and special purposes (e.g. a military base). Building permits are issued in compliance with allowable uses within each zone. Similarly, rural land is categorised into 18 types, and building permits are issued along the same zoning lines.

As mentioned, building management is the detailed method for implementing urban planning regulations though it is the latter which controls the issue of zoning (e.g. commercial, residential etc.); permitted uses of zoned land (e.g. a residential area may house small shops, factories and offices etc.); and intensity of land use (e.g., the total floor area allowed for a construction project). Building permits may be for construction, occupancy and demolition or for miscellaneous purposes (e.g. building a tower). The issuing of these various types of permit is under the control of the urban planning regulatory bodies.

8.3. HIGH-RISE DEVELOPMENT AND ITS APPROVAL SYSTEM

Taiwan's economic and industrial growth has led to high population densities and high land prices in urban areas, leading in turn to a boom in the construction of high-rises. However, these great structures have an enormous impact on the urban environment. Hence, the approval system governing high-rise projects differs from that applied to ordinary buildings. This section deals with high-rise development and its approval system in order to get a better understanding of how these structures are managed.

8.3.1 The Development of High-Rise Buildings in Taiwan

Being located in an earthquake zone, Taiwan was regarded as unsuitable terrain for high-rises until the technological innovation of vibration-resistant structures became available. R&D on new materials and new structural designs now mean that high-rises are not premised on the use of old construction techniques. Their value in crowded cities is obvious: through them, land resources can be more efficiently used, more people can be accommodated, and more activities can be undertaken within a given urban space. And so

we find more and more of them being built. However, it is not simply a case of there now being more of them. Over time, their scale has become larger, their functions more complex, their use of space - both underground and upward - more elaborate. They are therefore characterised by their height, scale and complexity.

As discussed earlier, we are using the 1994 EIA Act's definition of a high-rise as being a building of over 70 metres or having more than 20 storeys. In 1932, the 6-storey Ju Yuan department store was the tallest building in Taiwan; most others were three or four floors high, mixing residential and commercial functions. During the next two decades, several taller buildings were constructed in the central business districts of Taiwan's cities, usually in front of train stations. By the 1960s, tall buildings were the order of the day, e.g., the Far East department store, the Grand Hotel and the President Hotel were all built during this decade. In the 1970s the 20-storey Hilton Hotel took the record for the tallest building, and became the first "high-rise" according to our working definition.

Prior to 1990, building technique regulations stipulated that the height of a building was to be calculated in terms of the width of the road in front of the site; the wider the frontage, the higher the building. In 1980, the Tai-Power high-rise (the first to top 100 metres at 114.54m tall) set a new milestone for it was built on a design of four underground storeys and a further 27 above ground. Several more high-rises followed throughout the '80s, e.g., the International Trade Building (142.7m) and the Long Valley World Trade Building (220m). As Table 8-3 shows, the 85-storey Tuntex Building, completed in 1998, is currently the tallest building in Taiwan, standing at 348m. This record will not last for long: the 101-storey Taipei Financial Centre is due for completion by October 2002 and, at 509.2m, is set to become the tallest building in the world.

Table 8-3: Development of the Highest Buildings in Taiwan

Year	1975	1980	1985	1990	1995	1998	2002
Name of Building	Taipei Building	Tai-Power Building	Internat. Trade Building	Long Bun Building	Long Valley World Trade Building	Tuntex Building	Taipei Financial Centre
Location	Taipei	Taipei	Taipei	Taichung	Kaosiung	Kaosiung	Taipei
Height (m)	48.0	114.5	142.7	150.0	220.0	348.0	509.2
Storeys	12	27	34	42	50	85	101

Most of Taiwan's high-rises have been built in the last decade. Table 8-4 shows that prior to 1990 there were 149 high-rise buildings, rising to 512 in 1995 - nearly a four-fold increase - and 663 by the beginning of 1997. These gigantic structures have had a huge impact on Taiwanese cities.

Table 8-4: High-Rise Buildings in Taiwan (i.e., +20 floors)

Year	Before 1990	1991	1992	1993	1994	1995	1996
No. of Buildings	149	183	242	293	368	512	663

8.3.2 The Approval System for High-Rise Buildings

As we saw in Table 8-3, high-rise construction since 1990 has spread out from Taipei to Taichung and Kaohsiung, not without social cost. High-rise buildings are intensely busy places, and their activities often exceed those anticipated by the original urban planning regulations. For example, controls over the Floor Area Ratio (FAR) have not been exercised in most Taiwanese cities.[4]. A high-rise not only influences the normal flow of traffic in its neighbourhood, but it also engenders enormous change there by dint of the high intensity of its use upon completion. The usage intensity of these structures creates an imbalance in the allocation and distribution of activities and undermines the integral urban structure.

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[4] FAR control has only been practiced comprehensively in Taipei since 1983, with other cities gradually and unsystematically following suit. Even by 1999, only 30% of Taiwanese cities practiced FAR control prompting the Ministry of Interior Affairs, on June 8 1999, to amend its control regulations on land use so as to require that FAR control be fully implemented.

In an attempt to redress this gap in urban planning, the Kaohsiung and Taichung authorities instigated the EIA assessment system for high-rise buildings in 1991 and 1992 respectively. This system aims to examine the impact of high-rises on urban development and city traffic and to ensure that disaster prevention plans have been mounted in respect of these buildings. Assessment items include location, building allocation plans, structural plans, construction management plans, building equipment plans and occupancy management plans.

The EIA Act came into law in December 1995. To comply with the terms of the Act, offices, businesses and multi-function buildings of more than 20 floors and residential buildings of more than 30 floors must submit to an EIA assessment. Consequently, the procedures for gaining a high-rise building permit have become both more specific and more prescriptive. The permit flow chart is shown in Fig. 8-2.

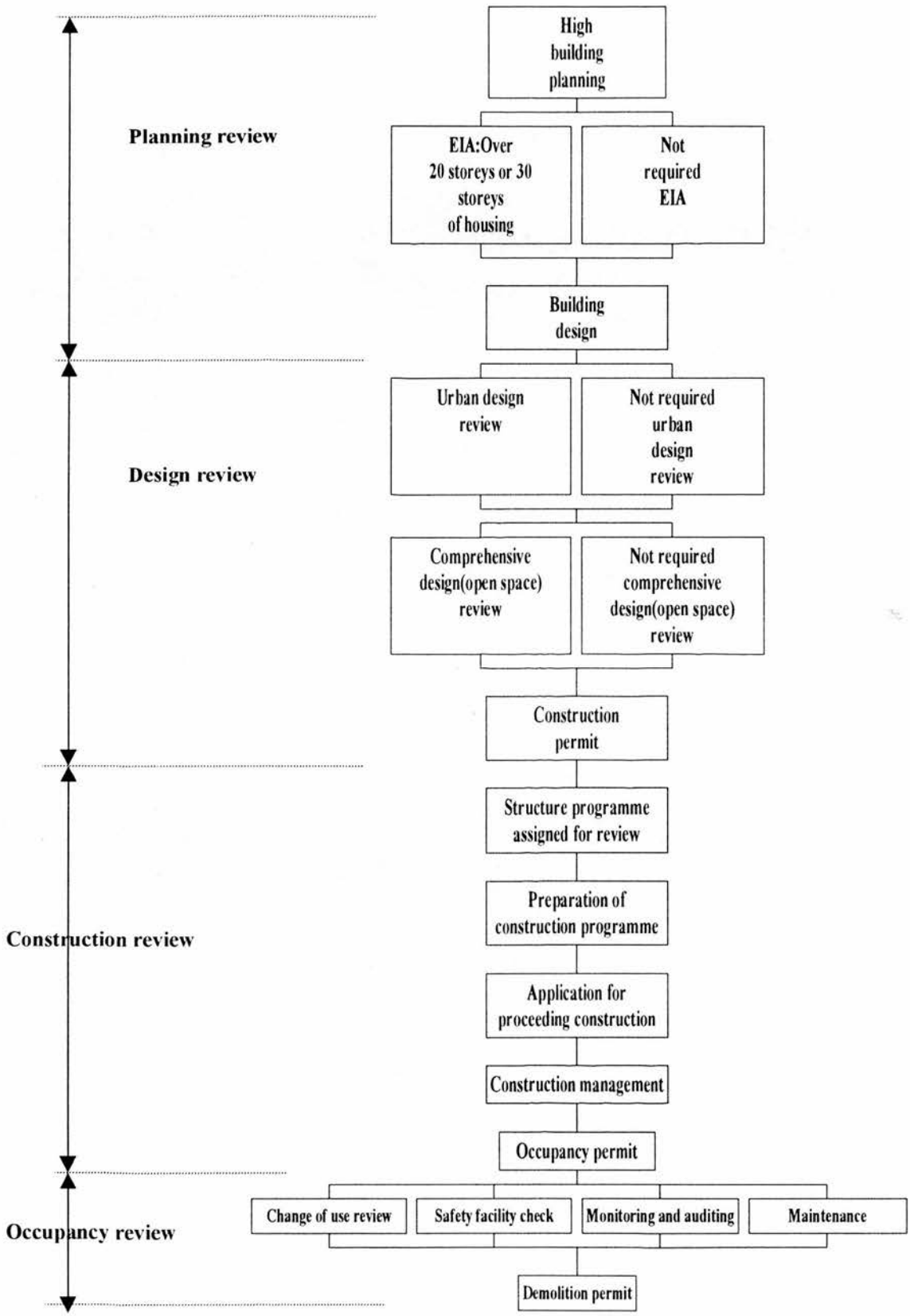


FIG. 8-2: A Flow Chart of the Approval System for High-Rise Buildings

Permits to build high-rises are sought for in four stages: planning, design, construction and occupancy. The assessment items the EIA reviewers assess during the planning stage are listed in Table 8-5 and those covered for the design stage are listed in Table 8-6.

Table 8-5: EIA Scoping of Proposed High-Rise Buildings

Category of Environment	Environmental Items
physical and chemical	terrain, geology, air quality, noise, vibration, odour, waste, insolation, disturbance of electric waves, energy
ecological	terrestrial animals/plants, aquatic animals/plants, endangered species, ecological systems
landscape and recreational	aesthetics of landscape, entertainment
socio-economic	land use, social and economic environment, traffic, social relations
cultural	educational, scientific, cultural, historic

Table 8-6: Review Items at Urban Design Meetings

Category	Item
construction project	location plan, layout plan, building plan
land use	purpose of occupancy, occupant intensity
building volume	height of building, requirements of yard, scale of site, space between buildings
open space	openness, effective areas, on-street furniture
traffic plans	allocation of parking space, off-street loading/unloading sites, preserved space connecting by overpass
Landscape design	allocation of pot plants, designs for beautification
style of building & quality of frontage materials	business signs, quality of pavement material, quality of dimensional material, hue of facade
Facilities for the handicapped	said facilities in public open space

The urban design review does not exclusively or always apply to high-rises. Construction sites of more than 3,000 m^2 come under its gaze and the review process concentrates on assessing the size of the building, its open space, its traffic flow design, its business signs and the landscaping of on-street fixtures. The items covered by the open space review is shown in Table 8-7. Where urban design and open space reviews are both required, the two are conducted by the urban design committee. If a proposed building succeeds in gaining the first two permits, a review of the construction permit is conducted to test whether the project is in compliance with the building technique regulations.

Table 8-7: Review Items at Open Space Meetings

Category	Item
condition of the site	meeting requirements, roads in the neighbourhood
effective area of open space	open space along the street & in the square
incentive items	increase of height & floor area ratio
allocation of pot plants	choice & allocation of tree species
open space design	openness, street furniture
traffic system	parking space, mobile lines for entry/egress

The construction stage review is divided into three parts. The first deals with structural design issues. It is conducted by relevant associations/institutes and the applicant is responsible for the cost. The major items reviewed are listed in Table 8-8. Following this, the construction programme is assessed. This covers construction methods, excavation methods, the waste soil plan, environment management, the piling and allocation of construction materials, the construction flow chart, etc. Finally, each floor must be inspected by the relevant construction agencies until the structural body of the top floor is finished.

Table 8-8: The Structural Design Review of High-Rise Buildings

Category	Item
structural system	shear wall, foundation, main frame system, special structure system
Designed loading	static load, live load, earthquake power, wind
Structural analysis	model of structural analysis; analysis of structure stress; variation amongst layers; earthquake shearing force
Structure materials	reinforced concrete, steel frame structure
detailed parts of structural design	supporting steel, connecting column, non-structural walls, foundation design
facilities for excavating blocking soils	retaining wall, supporting system, monitoring system
Construction techniques	construction methods, molding board system, special techniques, connection of steel frame
Structural design drawing	standard drawing, plane drawing, supporting steel drawing

Data source: Re-arranged from Liao, 1994, p.54

The occupancy permit is applied for on completion of the construction stage review. The review preceding the granting of this permit includes inspecting that the building complies with drawings and that occupancy

management and maintenance programmes are in place. Once an occupancy permit is obtained the developer must still apply to the environmental protection agency for an additional permit for waste water discharge before the building can be occupied.

Two particular features of the approval system for high-rise buildings are that expert professional reviewers sit on the committees and that the review process sub-divides into several detailed levels of investigation. This means that each salient item in the detailed design and construction of the building is minutely examined by those who are best qualified to judge. In this way, these huge structures are subject to sufficient controls to ensure that public safety and comfort is not compromised

8.4 THE ENVIRONMENTAL IMPACT OF HIGH-RISE BUILDINGS

Environmental impacts can be categorised as physical, ecological, landscape and recreational, socio-economic and cultural. Which of these categories will be emphasised with any given high-rise depends on its location. For example, Tokyo and Taiwan is located in an earthquake zone, so earthquake-resistant measures become major assessment items. Taiwan's cities lack adequate public transport systems, so traffic flow issues are treated as a top assessment priority. However, in general, all high-rises are assessed with respect to their environmental impact based on the following criteria:

physical

a) geology and soil: geology influenced, terrain changed

b) waterborne concerns: waterborne ecology destroyed, water polluted

c) noise and vibration: construction equipment, noise, noise from transportation, noise of public activities, vibration

d) micro-climate: heat pollution, waste heat, heat island effect, wind hazard

e) light and air quality: insolation, shadow, dazzling light, artificial light, atmospheric pollution

f) electrical disturbance: obstruction of electric waves

ecological

a) organisms: terrestrial and aquatic flora and fauna

b) habitats: dominant species

c) ecological system: eutrophication

landscape and recreational

a) urban landscape: visual, natural, of special interest

b) recreation: demands for recreation, entertainment resources, recreational facilities

socio-economic

a) loading of public facilities: waste treatment systems, information system, energy supply

b) transportation: pedestrian traffic, vehicular traffic, parking facilities

c) land use: scale of urban development, urban population density and space distribution, urban carrying capacity and land occupancy control, urban growth and decay

d) urban safety: accidents, safety risks

cultural

a) historic: historic architecture

b) cultural: cultural assets, preservation and conservation of historic monuments

Environmental impacts are caused during two phase, first during the construction phase and again during the occupancy phase once the building is completed. Some items crop up at both phases, others only once.

8.4.1 Physical Environment Impacts of High-rise Buildings

8.4.1.1 Geology and Soil

Improper planning or construction of high-rise buildings not only can destroy the original terrain, topography or geological structure, but also indirectly change the level of underground water, resulting in settlement and the destruction of the hydrological environment. Generally speaking, geological-related impacts of high-rises mainly refer to ground settlement, soil pollution and destruction of topography and hydrology.

Ground settlement usually occurs during construction when a great amount of underground water is withdrawn during excavation. As a result, the soil structure is spoiled and the level of underground water drops. An inappropriate design of the retaining wall during the foundation construction stage will also cause the back soil to vary, resulting in settlement cracks appearing in adjacent buildings.

Soil pollution often follows on from ground settlement as public utility pipes can then break. This not only wastes resource and causes inconvenience to the public but may also cause the leakage of pollutants into the soil. In addition, improvements made to the bearing capacity of soil strata when building foundations can result in soil pollution as, more seriously, can the improper discharge of waste water. The destruction of topography and hydrology may come about as rivers, lakes, terrain etc. are altered in the course of developing the site. This may endanger the safety of the foundations or of the building itself as water is lost from the soil. Significant water loss is a common enough phenomenon on developments located on hilly terrain.

8.4.1.2 Waterborne Pollution

Surface and underground waterborne pollution from high-rise buildings may be caused by the inappropriate

emission of waste water when the project is under construction or when the occupied building is in daily use. During construction, excavation works and soil filling and dumping expose a great deal of ground. During the rainy season, eroded soil and gravel may drain directly into surface ditches or rivers, increasing the concentration of suspended solids (SS) in the water and so influencing its quality. In addition, waste water from the occupancy, maintenance and cleaning of construction machinery may easily pollute underground and surface water. Finally, the waste water produced by construction personnel is not insignificant: a site employing 100 people will generate $6m^3$ of waste water daily.

Waste water from high-rise buildings during their occupancy varies depending on their functions. Most high-rises are used as offices, department stores, restaurants, hotels and residential apartments. Table 8-9 itemises the waste water emissions from these different kinds of usage. Restaurants also emit grease and if this is not appropriately managed, the quality of the water deteriorates and drainage systems become blocked.

Table 8-9: Waste Water Emission Volumes

Application	Occupancy Unit (people)	Unit Pollution Vol. (Litre/people per day)	BOD	Time Function
Dept. Mall	1 per 5 m^2	150	150	T=0.5-0.8
Restaurant	1 per 3 m^2 or 3/4 seats plus staff	100	400	T=0.4-0.6
Hotel	1 per 10 m^2	300	150	T=1
Office	1 per 10 m^2	100	200	T=0.4-0.6
Pub	1 per 3 m^2	250	200	T=0.5-0.8

Data source: Ministry of Interior Affairs, 1998

8.4.1.3 Noise and Vibration

Noise means the sounds that people do not want to hear. Though noise nuisance in itself does not produce or accumulate pollutants, its direct impact on people's well-being is clear; unwarranted aural intrusion can induce feelings of listlessness or agitation. The effects of noise pollution can sometimes be serious,

resulting in physical illnesses such as headache and loss of hearing. The noise from high-rise buildings can be categorised as noise emanating from construction works; from the completed building's internal systems (e.g., cooling tower, air-conditioning, air compressor, generator, etc.); from traffic entering and leaving the building; and from wind swirling round the structure.

Construction site noise emanates from heavy transportation vehicles (e.g., earthmovers) and construction machinery. En route, the noise from heavy trucks is between 80-85 dB(A). According to American EPA principles, the aural impact of an 0-5 dB(A) increase is slight; a 5-10 dB(A) increase is medium; and anything over a 10 dB(A) increase is significant. Noise from construction machinery occurs during the installation of safety supports, excavation works, concrete works, etc. The noisiest machine is the piler, at 95-106 dB(A), while others are at 75-90 dB(A) (Taiwan Provincial Government 1997,p.7.13).

The noise of traffic using the building; internal machinery servicing it; the flurries of wind around it; and the sounds of all the activities for which the building was designed are itemised in Table 8-10.

Table 8-10: The Noise Impact of High-Rise Buildings during Occupancy

Category	Type of Noise Source	Distribution of Space	Distribution of Time	Description
Noise of equipment in operation	Cooling tower, air-conditioning, exhaust fan, water pump, air compressor, self-installed incinerator, diesel generator & voltage transforming machines	Installed at the inlet/outlet near the ground floor, balcony or roof	office hours, other operational times	Depending on public facilities provided by the building itself, e.g., restaurant, sauna, laundromat, shops, barber, beauty salon
Traffic noise	motorbikes, cars, trucks, etc. using the building; honking of horns	places around the exit/entrance; residential traffic	worst at rush hour; mitigated by holidays & week-ends	as vehicles go uphill, noise increases
Other	windows and doors of high-rise buildings shake and rattle	main body of the target building or houses around	influenced by monsoon	depends on the type of building & structure of the surrounding buildings

Data source: Wu, 1992, p.57

Sources of vibration from high-rise buildings refer to machinery vibration and traffic vibration. The former is caused by excavators, compressors and rock drilling machines; the latter from vehicles transporting construction materials, waste soil etc. The power of local vibration impacts on buildings nearby and affects the physical comfort of local residents. Generally speaking, vibration volumes below 55 dB cannot be sensed; above 65 dB the vibration influences the quality of sleep; and above 75 dB the paint of affected building cracks. The vibration volumes generated by the most common types of construction machinery are listed in Table 8-11.

Table 8-11: Vibration Volumes of High-Rise Construction Machinery

Construction Machinery (Type)	Vibration Level (dB)
Bulldozer	68-74
Excavator	65-71
Dump Truck	54-58
Hole Driller	53-61
Concrete Delivery Truck	54-58
Compressor	48-52
Tow Truck	54-58
Pump for Concrete	55-60
Concrete Vibrator	64-71
Crane	53-57
Piling Machine	66-74
Road Roller	63-67

Data source: Arranged from of Taiwan Provincial Government, 1997, pp. 7-14.

8.4.1.4 Micro-climate

The impact of high-rises on the micro-climate mainly consist of changes in local temperature and wind environments. The former result from radiated heat absorbed from the surface of the building and from exhausted waste air. The latter result from the interaction between wind and the building, causing tremendous local changes of wind velocity and direction in the immediate environs, the so-called "building wind".

Urban buildings and pavements absorb a great deal of solar radiation, releasing the energy as heat. Coupled

with waste air emissions, central urban temperatures are therefore higher than elsewhere - the "heat island" effect. A larger proportion of radiated heat comes from high-rise buildings and their curtain walls of reflective glass also reflect significant heat. In addition, their consumption of fossil fuels and the pollutants (such as NO_2) which emanate from their operational machinery to lie stagnant in the air, contribute to heat gain in their vicinity. By day, they absorb reflected and emitted heat and, by night, radiate it down raising the city's temperature relative to the suburbs.

As the height of a building increases, so too does local wind velocity. In addition to the impact this has on the building's internal environment, effects such as whirling flow, penetrating flow, corner currents and back whirling flow also cause discomfort to those in the immediate environs. High-rise structures exacerbate a strong wind; its velocity can reach 110 km/hr as it approaches the building's ground level, preventing people from going in or out. A second consequence of the high-rise is the way it causes the wind to whirl around passing pedestrians making it difficult, for example, to walk or ride a bike in the immediate vicinity. Finally, building-induced wind can cause substantial damage to the local environment (Wang 1998, p.39). Wind hazards caused by high-rise buildings are listed as Table 8-12.

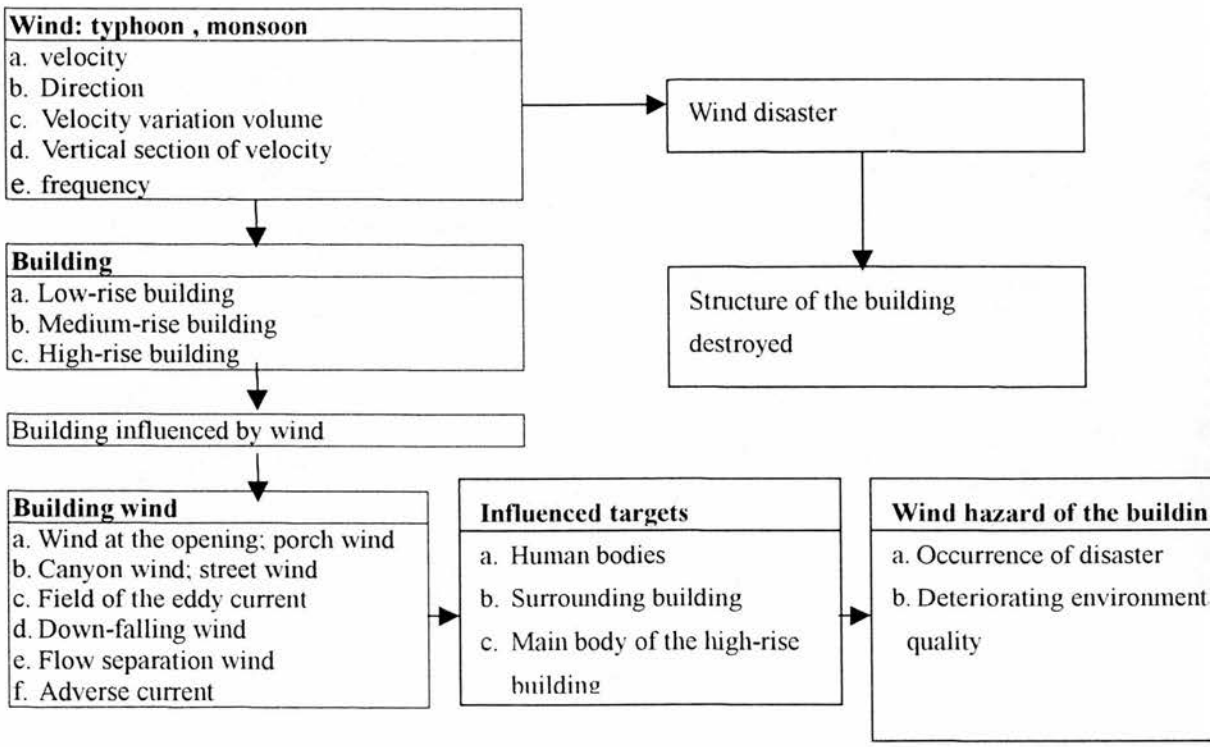
The Architecture Association of Japan classifies wind hazards into four types. The first is its effects on human activities (e.g., difficulties in walking). The second is on objects (e.g., difficulty in shutting doors/windows, being hit by falling objects, having trouble controlling motorbikes etc.) The third is on business activities whether open-air or indoors (e.g., exhibitions breaking, rain leaking in, torrential downpours etc.). The fourth is on the atmosphere, including temperature and noise (e.g., billowing smoke, drifting smells etc.) (Wang 1998, pp.39-40).

Table 8-12: Wind Hazards of High-Rise Buildings

Target	Example of Wind Hazard
Surrounding building	1. tiles falling on the roof 2. secondary accidents resulting from flying objects 3. falling & breaking of signs 4. breaking of glass windows
Living environment	1. shaking of doors/windows 2. noise disturbance 3. flying dust 4. rain leaking indoors
Pedestrian	1. flying dust 2. difficulty in walking 3. sudden gusts 4. stirring up clothes & hair 5. broken & damaged umbrellas
Main body of high-rise building	1. difficulty in opening & shutting entrance/exit 2. bad circulation or ventilation 3. noise disturbance 4. rain leaking indoors 5. unusable balcony due to strong wind
Traffic	1. broken car doors 2. cyclists blown down 3. difficulty in controlling handles
Other	1. withering & blowing down of pot plants 2. hindering business of stores

Data source: Wang, 1998, p.43

Figure 8-3 shows the relationship between wind and buildings. Being blocked by high-rise buildings, the upper wind divides up/down and left/right at 60-70% of the building's height (the dividing point). It then flows along the walls as shown in Figure 8-4. The separated left/right flow of wind is reinforced at the corners of buildings. The lower part of the separated up/down flow is influenced by the low-pressure area at the back of the building and descends along the side walls to form downdraughts. In addition, the adverse wind impacts on the low buildings in front of the high-rise, while the canyon wind between two high-rise buildings is increased (Wu 1992, pp.51-3). Changes to the wind environment caused by high-rise buildings not only affect the activities of pedestrians, but also damage buildings. As a result, wind hazard mitigation measures must be planned for in building a high-rise, as Table 8-13 shows.



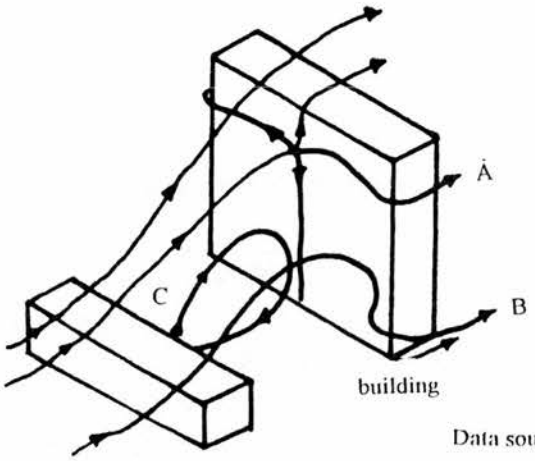
Data source: Wu 1992, p.50.

FIG. 8-3 : The Relationship between Wind and Buildings

Table 8-13: Countermeasures to Wind Impact from High-Rise Buildings

		Mitigation Measure	Type of Wind Field
Ex-ante mitigation measures	Shape of Building	1. installed on low-rise building	Down-falling wind
		2. empty building (hollow)	Down-falling wind
		3. screen	Down-falling wind
		4. canopy	Down-falling wind
		5. section of building retracted slant	Flow separation wind
		6. corner cutting on the plane of building	Flow separation wind
		7. uneven wall surface of the building	Down-falling wind
			Flow separation wind
		8. variation on plane shapes of buildings	Flow separation wind
	Allocation of building	9. longer side of the building parallel to the direction of the wind annually	Flow separation wind
		10. allocation inside the site	Flow separation wind
		11. allocation among buildings	Flow separation wind
Ex-post mitigation measures Afterwards	Fences	12. wind resistant wall (with holes)	Flow separation wind
		13. wind resistant wall (without holes)	Flow separation wind
		14. wind resistant net	Flow separation wind
	Others	15. plants	Flow separation wind
		16. continuous arcade	Down-falling wind
		17. poles (beside the passage)	Flow separation wind

Figure 8-5 shows how the velocity surrounding the high-rise building is predicted. Data in the figure are the rates (R) of the surrounding velocity between the target site with buildings and without buildings. When the number is above 1.0, the velocity of the wind increases (and vice versa). We see from this figure that velocity increases at the corners of the buildings (Wu 1992, p.119) which means the environmental impact from the wind is greatest there.



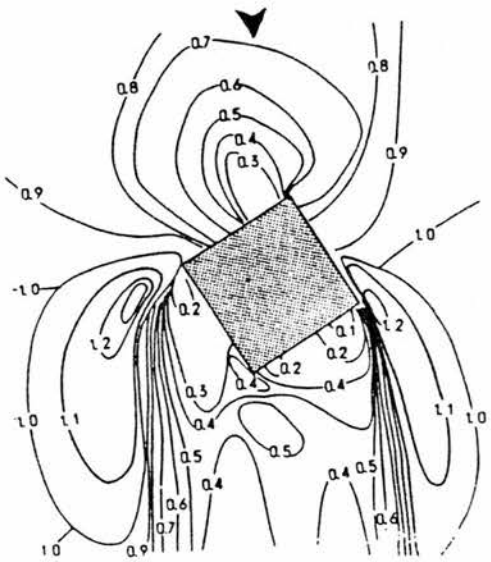
A. Flow Separation wind

B. Down-falling wind

C. Adverse wind

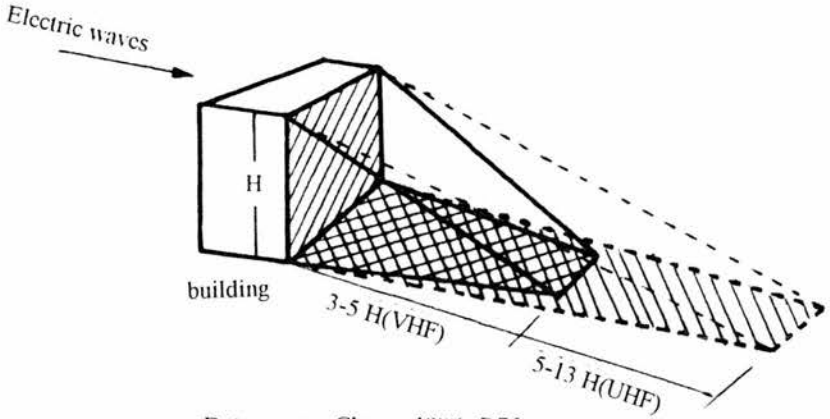
Data source: Wu,1992,P. 122.

Fig 8-4 Wind type of High-rise building



data source: Wu, 1992, P.119.

Fig 8-5 velocity increasing zone surrounding the Building



Data source: Chong, 1987, P.76.

Fig 8-6 Blocking area of High-rise building

8.4.1.5 Light and Air Quality

High-rise buildings affect light in three main ways: overshadowing other buildings and land, causing glare and casting artificial light. Overshadowing by high-rise buildings prevents neighbouring areas from receiving sufficient insolation. Because the injection angle of the winter sun is lower, this causes the insolation shadow to project onto the affected site to the north and at the same time decreases its effective insolation hours. Generally speaking, when the rate between the height of the building and the separation distance goes beyond 4:1, the canyon effect becomes evident (Su 1991, p.3.8). Even in summertime, nearby streets only enjoy quite a short period of insolation, affecting the growth of trees and plants and the activities of pedestrians.

Glare is usually caused by the curtain wall applied to the material of the outer wall of high-rise buildings. If highly reflective construction materials (such as reflecting glass or a metal curtain wall) are chosen, the result is glare in the exterior environment. This, in turn, may pose a hazard to drivers or increase the internal temperature of nearby buildings. The extent to which glare is a problem varies with seasonal insolation conditions, and monitoring this moving target is also part of the assessment process.

Artificial lighting disturbs night vision and may disrupt the sleep patterns of local residents. The extent to which high-rise buildings' artificial light is a problem depends on its quantity, intensity, height and operational time. The assessment of its impact can be pictorially- or computer-simulated.

Air pollution refers to the airborne substances which damage public health or degrade the living environment directly or indirectly. The occupancy intensity of high-rise buildings is usually higher than that of low-to-medium-rise buildings as various urban facilities (e.g., restaurants, shopping malls, swimming pools, etc.) are incorporated within them. They house energy- and fuel-consuming equipment (e.g., generators, boilers, exhaust fans in restaurants etc.), and a tremendous volume of vehicular traffic

circulates in and around them. The resulting emissions pollute the air around.

The direct air pollution caused by high-rise buildings stems from smoke exhaust equipment in kitchens, incinerators, diesel generators, boiler fuels, and the emission of waste air into the parking bays in the basements. The indirect air pollution they cause refers to the traffic they attract, resulting in the emission of suspended particulates: CO, HC, NO_2, SO_2, Pb, etc. The characteristics of air pollution sources during a high-rise's occupancy are listed in Table 8-13.

Table 8-13: Air Pollution Sources during the Occupancy of High-Rise Buildings

Classification	Type of Air Pollution Source	Model of Pollution Source	Distribution of Space	Distribution of Time	Air Pollutant
Waste air from operation of equipment in the building	Emission of waste air from cars & motor-bikes in parking bays; waste air from incinerators; air/oil exhaust fans in kitchens; diesel generators; emission of waste air from burning of boiler	Point source	Installed at the exhaust outlet near the ground level & chimneys on the roof	Worst during office hours	CO, HC, NO_x, SO_2, suspended particulate
Traffic waste air	Vehicles entering/exiting the buildings; emission of waste air from motorbikes, cars & diesel trucks	Linear source	Entrance/exit of car passages;	Worst during rush hours	CO, HC, No_x, SO_2, Pb suspended particulate

Data source: Wu , 1992, p.60

The environmental impact of each pollutant is listed in Table 8-14. The assessment of various environmental effects resulting from each air pollutant must be transformed into pollutants of equal quantity in compliance with the relative effect index before comparisons can be made.

Table 8-14: Environmental Effects of Air Pollutants Emitted by High-Rise Buildings

Environmental Effect	Index	Pollutant	Features of Pollution Source
Global warming	Global warming potential (GWP)	CO_2, CH_4 N_2O, halon, CFCs	Generated from burning of energy & fire-fighting equipment and extinguisher
Ozone layer depletion	Ozone depletion potential (ODP)	CFC, HCFC, halon	Freezing , air-conditioning & fire-fighting equipment in the building
Photochemical oxidant creation	Photochemical oxidant creation potential (POCP)	CH_4, HC, halon	Energy consumption (fossil fuel), emission from vehicles & fire-fighting equipment
Acid rain	Acidification potential (AP)	SO_2, NO_2	Energy consumption, emissions from vehicles
Eco-toxicity	Eco-toxicity aquatic, eco-toxicity terrestrial (ECA, ECT)	Pb	Emission from vehicles
Human toxicity	Human toxicity (HT)	Pb, CO, SO_2, NO_2	Emission from vehicles, energy consumption
Air pollution	Pollutant standard index (PSI)	PM_{10}, SO_2 CO, O_2, NO_2, TSP	Energy application, proliferated particulates emitted during construction, emissions from vehicles, particles due to traveling vehicles

The emission volume of each pollutant from vehicles can be obtained through multiplying the vehicle kilometre traveled (VKT) and the emission factor as per the following formula:[5]

$$Ei = EFi \times VKT$$

Ei: emission volume (g) EFi: emission factor (g/km)

VKTi: vehicle kilometre traveled (km) i: type of vehicle

An estimate of pollutant emission volume generated from consumption of energy can be acquired by multiplying the energy consumption volume and the emission factor as per the following formula[4].

$$Ei = EFi \times Vi$$

Ei: pollution emission generated from consumption of fuel i (kg)

EFi: emission factor (kg/MT or g/m^3 or kg/KL)

Vi: consumption volume of fuel i (tonnes or m^3 or KL)

In addition to air pollutants generated from vehicles and energy consumption processes, particulate

[5] This estimation formula follows the EPA approach of estimating the emission volume of each pollutant every year.

pollutants also come from construction and demolition works and from moving vehicles (such as TSP, PM_{10}). These can be estimated separately. The formula for estimating emission volumes during the construction process is as follows:

$$E_C = Vo \times EFo + A_S \times EF_S \times T_S + A_m \times EF_m \times T_m + A_C \times EF_C \times T_C$$

E_C: emission of suspended particulates during the construction process (kg)

V_O: quantity of earthwork (m^3)

EF_O: emission factor of excavation (kg/m^3)

A_S: naked surface area of the site (m^2)

EF_S: naked surface emission factor ($kg/m^2/day$)

T_S: naked surface duration (day)

A_m :storage area of construction material and waste soil (m^2)

EF_m: emission factor of the storage area of construction material and waste soil ($kg/m^2/day$)

T_m: piling time (day)

A_C: area of construction (m^2)

EF_C: emission factor of construction ($kg/m^2/day$)

T_C: time of construction (day)

The estimation of TSP generated during the demolition process can be obtained by multiplying the demolition area and the emission factor as per the following formula:

$$E_D = A \times EF_D$$

E_D: emission of TSP during demolition process

A: demolition floor area (m^2)\

EF_D: emission factor during demolition process (kg/m^2)

An estimate of the emission volume of particulates outside the construction site resulting from traveling vehicles can be calculated as follows:

$$E = V_P \times T \times EF \times N \times (1\text{-}CE)$$

E: emission volume (kg)

V_P: volume of passing vehicles (No./day)

T: affected time (day)

EF: emission factor (kg/ V_P)

N: number of the site

CE: control coefficient

A prediction of the emission volume of various pollutants at the construction site can be obtained by adding up the estimated emission volume of each pollutant. The extent of every environmental impact should be in compliance with the environmental effect index.

8.4.1.6 Interruption of Electrical Waves

Transmitted electric waves are classified in compliance with the length of wave (or frequency) and their corresponding application, including long waves (VLF), medium waves (MF), short waves (HF), super short waves (VHF), micro waves (UHF), super micro waves (EHF) and sub-super micro waves. Electric waves of different length meet different purposes. The assessment targets of disturbance to electric waves from high-rise buildings mainly aim at VHF and UHF for TV.

General electric waves are often diversely disturbed in the course of their transmission from the signal transmission station to the signal receiving point, degrading the video and audio quality of TVs. However, the accumulation of high-rise buildings in urban areas undoubtedly contributes to the blocking of waves, both by obstruction and reflection as shown in Table 8-15.

Table 8-15: Types of Blockage of Electric Waves

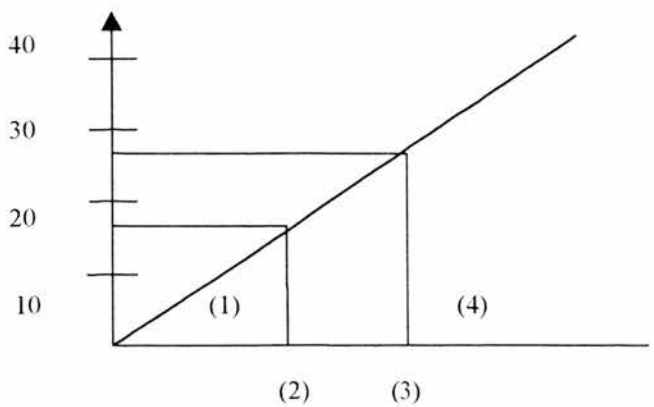
Type of Obstruction	Description
Blocking obstruction	Buildings hinder the electric waves of TV and decrease the intensity of electric waves on the signal receiving side. Ghost image and interrupted sounds appear on TV screen significantly.
Reflecting Obstruction	Reflecting waves occur during the transmission process and result in deteriorating images, such as ghosting on TV screens
Image Shaking Obstruction	TV screen is shaken and moved as trains and airplanes pass by the signal receiving area.
Pulse Sound Obstruction	Interrupted pulse sounds and spotted images on TV screen as tram cars and electric wires discharge.

Note: A ghost image describes multiple images appearing on the TV screen. The main image comes from direct electric signals received through the antenna but the antenna also receives the electric signals reflected through buildings. As the reflecting wave is slower than the direct electric wave, the ghost image occurs on the right side of the main image.

Data source: Wu, 1992, p.55

Obstruction by blocking occurs because the sheer size of building interrupts the waves coming from the transmission station causing shadows at the back of the building. Those living in the shadowed area do not then receive the signal. The extent to which blocking is a problem depends on the location of the transmission station, the intensity of electric waves, the terrain and the position of the high-rise. In general, the influential radius is about twice to three times the height of the building (Su 1991,p.3.14) (see Fig. 8-6).

Obstruction by reflection occurs because the outer wall of the high-rise is a large reflective plane. This causes the electric waves directly projected from the transmission station to interrupt those reflected from the building. The result is multiple images appearing on TVs located in the high-rise and its vicinity. This type of obstruction has a wider field of influence than has blocking and it is usually the area in the front of the building which is most affected. The extent of the interruption within the region of reflective obstruction depends on the delay-time of reflected electric waves and the intensity of the rate between direct and reflecting waves (Wu 1992,p.56). Generally speaking, the longer the delay-time of the reflected electric waves, the greater the distance between the main image and its ghost on the TV screen (see Fig. 8-7).



(1) Ghost image too strong, unable to watch
(2) Ghost image difficult to eyes, hard to watch
(3) Existence of ghost image, able to watch
(4) Without ghost image, able to watch freely. Data Source: Juong, 1987, p.77

FIG. 8-7: Rate of Direct and Reflected Waves

Three mitigation measures can be deployed by the developer to deal with the problem of blocked electric waves. The first is to alter the design of the building, e.g., adjust the height, vary the shape of the outer wall or change the materials used. The second is to improve signal reception in the vicinity of the high-rise, e.g., install a common antenna, use high performance electric wires or install a ghost demolition device. The third is to improve satellite transmission. Which amongst these various solutions is chosen depends on the particular circumstances of each case though the most commonly adopted is to community antenna television (CATV) in the local community.

8.4.2 The Ecological Impacts of High-Rise Buildings

The ecological impact of any given high-rise depends largely on where it is located; the developer of a resort hotel in a recreational park will contend with very different ecological issues to one building a downtown office block. In general, ecological assessment inquiries cover the high-rise's effect on terrestrial and aquatic flora and fauna, endangered and vulnerable species, protected groups and the ecosystem. In this section, we will deal with impacts on animals, plants, habitats and the ecological system.

8.4.2.1 Impacts on fauna and flora

A high-rise construction site often involves hewing down large amounts of trees and grassland. This spoils the site's soil structure and immediate water courses. The latter phenomenon is most commonly found in hilly construction sites. In addition, waste emitted during the construction and occupancy of the building can result in several forms of pollution - in air, soil or water - which can hinder the growth of plants and the welfare of organisms and animals.

There is a very rich variety of plant life in Taiwan. Some species are distributed across a very limited area

and others' habitats are shrinking owing to deforestation, artificial activities or natural factors. The distribution of flora in Taiwan is primarily influenced by elevation, climate and soil. Indigenous plants can be grouped into three types: alpine tundra; tropical savanna; and forest (including sub-alpine coniferous, cold temperate montane coniferous, warm temperate montane coniferous, warm temperate rain forest, tropical rain forest and Linnoral forest) (EPA 1997a,p.290). Each group is home to particular species of animal and plant life and, to greater or lesser extents, all of them are under threat from development.

Table 8-16 records the prediction assessment methods used to gauge how high-rise developments affect local flora and fauna. First, a habitat survey is conducted to outline the status quo. Then rare and endangered species in the affected area are identified and a prediction is offered of how their environment will change over time if the project does not go ahead. Next, predictions about that environment are formulated based on the assumption that the project will go ahead as planned, or will go ahead according to some alternative design. Finally a summary is produced of the critical changes each alternative would bring about. This summary not only deals with the likely fate of individual species but with the compounded fate of the ecosystem as a whole. The predictions formulated during the assessment process enable policy-makers to make informed decisions on projects' likely environmental impacts. This is especially important information when the proposed high-rise is to be located in scenic spots, recreational parks and hillside, for these are the areas where the most serious changes to local flora and fauna are likely to occur as a result of development.

Table 8-16: Assessment Items and Predictive Methods on Flora and Fauna due to the Development of High-Rise Buildings

Environmental Item	Environmental Factor	Prediction Method
Terrestrial fauna	Species & quantity	Site survey data & documentation, related factors of estimated quantity and community
	Diversity in species	Surveys & documentation, estimation or description of diversity in species
	Habitats & habits	Extent of alteration to features can be judged in compliance with site survey data, documentation and planned operational information.
	Paths & blockages	Extent of alteration to features can be judged in compliance with site survey data, documentation and planned operational information.
Terrestrial flora	Species & quantity	Estimation of flora in the demolition area is in compliance with site survey data and information on construction operation, including species and quantity.
	Diversity in species	In compliance with survey data, documentation plans or description of diversity in species
	Distribution of flora	In compliance with site surveys & documentation on related plant life
	dominant community	Growth factors are analysed and judged according to relevant information
Aquatic fauna	Species & quantity	Site survey data & documentation, related factors of estimated quantity and community
	Diversity in species	Surveys & documentation, estimation or description of diversity in species
	Location of habitats and habits	Extent of alteration to features judged in compliance with site survey data, documentation, planned operational information and hydrological information
	Immigration/ emigration & multiplication	Extent of alteration to features judged in compliance with site survey data, documentation, planned operational information and hydrological information
Aquatic flora	Species & quantity	Estimation of plant life in demolition area is in compliance with site survey data and information on construction operations
	Diversity in species	Estimation or description of diversity in species according to survey data and documentation
	Distribution of flora	In compliance with site surveys & documents
	Dominant community	Growth factors are analysed and judged according to relevant information
Endangered species & protected groups	animal	Potential impacts judged in compliance with related regulations in the documents and survey information
	Plant	Potential impacts judged in compliance with related regulations in the documents and survey information

Data source: Arranged from EPA, 1995, pp. 60-62.

8.4.2.2 Impacts on Habitats

High-rise developments impact on local habitats in three ways. First, the very act of constructing a high-rise changes the indigenous habitat. Construction work changes the topography of the area. It is not simply plant life that is destroyed, but the local habitats which that flora supported and the wildlife corridors the area provided to other species. Second, once built, the high-rise alters the local micro-climate (including where light and shadow fall, and the temperature variations found in its immediate vicinity) and so plant growth and animal habitats are altered. Third, pollutants emitted from the human activities conducted in the high-rise also affect the local habitat. For example, air pollutants hinder the growth of some species of plant, while waterborne pollutants change which kinds of organism come to dominate the local aquatic habitat.

These different kinds of impact can be direct, indirect, long-term, short-term, reversible or irreversible. During the assessment process, a survey of the distribution of animal species and of their habitats and life-cycles must be conducted so as to estimate the type and extent of the alteration that will be caused if the project goes ahead.

8.4.2.3 Impacts on the Ecological System

Impacts on the ecological system from the development of high-rise buildings consist of eutrophication and food chains. Generally speaking, eutrophication is a more pronounced problem. The impact on food chains - brought about by the alteration of the quantity and/or type of animal life in the area - is more obvious in mountainous areas or protected reserves than in urban regions.

The impact on eutrophication stems from emitted pollutants, including COD, NO_x and total nitrogen. The main source of COD is daily waste water, as is total nitrogen (N). NO_x is generated from energy consumed by the building's users and from their vehicle emissions. Detergents used (e.g. by restaurants within the

high-rise) contain phosphate, which is a major eutrophicating substance. The emission volume of each pollutant can be calculated by assessing the level of eutrophication caused by the high-rise through the nutrification potential (NP).

The ecological impacts of high-rise construction discussed in this section include organisms, habitats and the ecological system. As the relationship between organisms and their environment is interactive, the community type and geographical distribution must be surveyed when making an ecological impact assessment. A checklist should be used so that all relevant data can be collected systematically and findings presented clearly.

8.4.3 Landscape and Recreational Impacts of High-Rise Buildings

An analysis of the urban landscape is a critical part of the environmental impact assessment of high-rise buildings. However, as this involves questions of aesthetics - where objective criteria are not available and common standards are difficult to establish - this part of the impact analysis is always ignored. That said, the appearance of a high-rise has a tremendous impact on everything from the well-being of the building's occupants to the city's skyline. Good landscaping, with plenty of open space, can promote work efficiency. The visual appearance of a well-conceived high-rise not only looks good but also promotes a sense of local identity. More pragmatically, if there is a good visual relationship between the high-rise and its environment, the chances increase of the project being accepted by the public.

High-rise buildings can be - and often are - an integral part of the city's recreational facilities. Their front squares, open spaces and in-door amenities can become part of the city's fabric. However, the large crowds they attract can equally disrupt the use made of other local recreational facilities. For this reason, the recreational impact assessment must include a consideration of entertainment demands and recreational resources and activities.

8.4.3.1 Impacts on the Urban Landscape

A high-rise building may not only give a city an identifying landmark but may also alter that city's image. However, as visual aesthetics are subjective, the urban landscape impact assessment is necessarily contentious. Those who favour traditional architectural designs seldom regard high-rises as possessing any integral beauty of their own; they see them as an artistic blight (Smardon et al. 1996, p.282). Thus, to increase the objectivity of the assessment exercise, the most urgent task is to establish certain assessment principles. In general, the items covered include the main body of the high-rise, the local building group, the open spaces in and around it and the integral urban landscape (Shieh 1997, p.4.24).

The assessment of the main body of the high-rise includes a consideration of its height and proportional dimensions; the type, texture and colour of the construction materials for its outer walls; its construction equipment; its roof and any roof protrusions; how its annexes, entrances and exits have been designed; its low-tiered portions; and how pleasing is its integral shape. The assessment of the local building group (i.e., the complete assemblage of all the various structures which constitute part of the high-rise site) follows similar lines, although extra attention is paid to the complexity which accompanies the mix of high- and low-rise buildings within one site.

The assessment of the high-rise's open spaces include items such as squares, gardens, plants, shaded porches, outdoor furniture and fixtures, attached facilities and routes into and out of the parking bays (Tarn 1991, p.53). As high-rise buildings become city landmarks, they naturally shape the integral urban landscape. Assessment of this issue includes examining the urban skyline, the natural landscape and urban landmarks, and whether the building is in harmony with nearby structures. As these buildings have a massive volume, great height and are often located in city-centre sites, another issue looked at in the assessment process is how they act as a visual focus in the city and what visual obstacles they impose. The landscape assessment exercise looks at the proposed building close-up, at medium range and from a

distance to assess what kind of visual impact it has across the city as a whole.

8.4.3.2 Impacts on Recreational Activities

Since high-rise buildings attract large crowds, they undoubtedly have an impact on the local community and on the city's recreational facilities (e.g. parks, sports centres etc.). In this respect, their existence is probably a bit of a mixed blessing. On the negative side, playground and parkland space is usually compromised. In a residential community, playground area per child is about 0.8 m^2, parkland area per person 2 m^2 and stadia area per person 0.7 m^2 (Jan Ltd., 1992). A residential high-rise housing 1000 people would then be expected to allow 800 m^2 for playgrounds, 2000 m^2 for parkland and 700 m^2 for various stadia. As this is seldom the case, we can see how the high-rise creates conditions which are insufficient to meet the demand for local public facilities. To take another example, a non-residential high-rise pulls huge crowds of commuting workers and consumers towards it. As the recreational demands of these people cannot always be met locally, the quality of entertainment available within the vicinity of the building may be less than adequate. Much more positively, high-rise buildings themselves provide recreational facilities both in-door (e.g., gyms) and out-door (e.g., front squares for public use).

As Table 8-17 shows, the assessment of the high-rise's impact on recreational activities includes issues such as the demand for entertainment, and the building's recreational resources, activities and facilities. The region covered by the assessment extends beyond the immediate site of the building to include the local neighbourhood.

Table 8-17: Assessment of High-Rise Buildings' Landscape and Recreational Impacts

Environmental Item	Environmental Factor	Survey Location
1. scenic beauty	status quo prior to construction	1. side areas
	ecological scenic beauty	2. neighbouring areas
	natural landscape	3. directly affected areas
	Specific landscape items	
	visual landscape	
	consistency with local buildings	
	cultural scenic beauty	
	artificial landscape beauty	
	scenic spots & areas	
	parks & reservation areas	
2. recreation	recreational demands	
	recreational resources	
	recreational activities	
	recreational facilities	
	recreational experiences	

Data source: Arranged from EPA, 1995, pp. 63-66.

8.4.4 Socio-Economic Impacts of High-Rise Buildings

Developing a high-rise is equivalent to developing a new community within a complicated urban system. Its socio-economic impacts typically refer to job opportunities, public services (such as health or education), social structure, lifestyles and traffic. As each high-rise creates its own mix of business or residential activity, and each to different degrees, this section will consider the effects of particular types of activity in turn.

8.4.4.1 Impacts of Productive Activities

Productive activity refers to the system of manufacture, distribution and consumption of materials. What needs to be assessed is the extent to which the high-rise alters the local economy of the area. For this, some comparison must be made between the new-comers and the older businesses in the area in terms of levels of economic activity and of standards of living. The number and kinds of jobs available, and the sorts of salary they command, are useful indices of local economic activity.

High-rises, as we know, may be designated for residential use or for use as offices, hotels, shops, restaurants, hospitals etc. Often their usage is some mix of these kinds of activity. Inevitably, the non-residential office blocks change the structure of the local economy and often spawn environmental pollution which brings the developer into friction with local residents. If the indigenous social order is radically altered, social entropy may ensue. Though radical disruption of the old social order can be regarded as a negative impact, some good may also emerge as local residents band together to fight for their community's survival, thus strengthening the ties that bind them (Chang 1996, p.44).

The purpose of an economic analysis of the high-rise's impact, therefore, is to understand how the indigenous economic community is constituted, and how the high-rise will alter that. Introducing large-scale business or industrial activities via the high-rise changes the community's social stability in varying ways. The advent of the commercial high-rise may certainly trigger disputes over space etc., but the influx of crowds will also contribute hugely to the variety of productive activities the locality can profitably absorb. Either way, the entire ambiance of the neighbourhood changes. Commuters and shoppers throng around the high-rise at certain times and on certain days; at other times and on other days, the place is deserted. New entrepreneurs set up businesses around the high-rise, driving up land prices. This forces the indigenous residents either to compete or to leave. The high-rise's impacts on the system of local urban activities are listed in Table 8-18.

Table 8-18: Impacts on the System of Urban Activities due to High-Rise Developments

Activity System (Activity Body)	Type of Activity	Type of Land Use	Influenced Content
Productive Activities (manufacturers, individuals)	Merchandising; services	commerce	• change of land use (type & intensity). Impact on land prices, tax, real estate, etc. • change to the economic base: income (structure of industry);increased social status. • land compatibility; disputes over space (residuals & social disturbance)
Residential Activities (personal, residents)	residential activities, labour and leisure activities	Residential area	• changes to structure & residential population; community identification • community safety; crime • more public facilities (required installation); consolidation or segregation of community • increasing load of local or regional public facilities; poorer quality of life
Public Welfare Activities (government)	public administration, human resource development, community development	related public facilities	• change to the financial structure
Traffic Activities (all activity bodies above)		related roads	• increased no. of trips; level of service (mobility) • noise pollution; status of residential parking

Data source: Arranged from Chang , 1996, p. 48

The assessment is limited to the target area and its neighbouring community and issues to be explored include job categories, economic activities (including local finance), land ownership, land prices and living standards (see Table 8-19). The analysis should aim to explicate the employment categories and growth rates of the current working population as well as the potential new job categories and opportunities which will result if the project goes ahead. The local economic structure, incomes, estimates of consumer status, changes to related economies and finance, changes to the type and transfer of land applications, possible changes of land price and changes in income and living standards of local residents should be analysed.

Table 8-19: Socio-Economic Assessment Items

Environmental Item	Environmental Factor	Survey Area
Land Use	use type; features of development of nearby land	planned site area; neighbouring towns
Social Environment	population & component public facilities; public service; public health & safety	
Traffic	traffic transportation	planned site area & roads used by construction & transportation vehicles
Economic Environment	jobs and economic activities (including local finance) land ownership; price of land; living standards	planned site area; neighbouring towns
Social Relationships	social system; social psychology; social security (related items of human disasters)	planned site area; neighbouring towns

Data source: Arranged from EPA, 1995 , pp. 67-70

8.4.4.2 Impacts on Residential Activities

High-rise buildings change indigenous residential activities. The different values and behaviours of the established population vis-à-vis the new-comers will certainly challenge - perhaps even destroy - the local social order. The area's sense of community will change as will neighbourly relations. While a substantial residential environment possessing outdoor spaces and public facilities can enable its inhabitants to socialise normally, past experience of residential high-rises suggests that they atomise people, reinforcing the phenomenon of a socially-differentiated stratum (Chang 1996, p.45).

High-rise residential living involves the usual daily round of activity: work activities such as jobs, education, housework, commuting, shopping, etc., and leisure activities such as recreational, social and cultural pursuits. To promote a sense of community, there must be an adequate level and range of service facilities. So, analysing the impact of the high-rise on the life of the community means evaluating the increase in demand for various facilities to meet the increased population density.

The assessment items include social relationships and the social environment. For the former, emphasis

should be placed on easing the transition towards assimilating the new-comers. Interviews can be conducted or questionnaires issued to established residents to elicit their views on how they think the proposed project will impact upon them. The main focus for assessing the latter issue (i.e., the social environment) is to estimate population growth and mobility patterns. This kind of focus allows predictions to be made about the extent to which existing public facilities need to be upgraded or new facilities put in place

8.4.4.3 Impacts on Public Welfare Activities

Public welfare activities mainly encompass services provided by the government, human resource development and community development. High-rise buildings have the effect of increasing local taxes and the cost of local public facilities. Past experience of urban development in Taiwan demonstrates that public sector provision lags behind private sector enterprise. As cities grow ever larger, the burden on local government finances also increases as government growth management plans are sadly imprecise. This, in turn, leads to a degradation in public welfare provision (Chang 1996, p.46). When a new high-rise is built, this usually exacerbates the existing problem.

When assessing the high-rise's impact, a survey of the type and quality of existing public services should be undertaken. Estimates of how the high-rise will increase the demand for such services can be derived from population growth predictions, while the relationship between population growth and current levels of public service provision can be used to address whether more facilities are warranted.

When assessing the impact on public health and safety, the current status of public health and safety provisions should be ascertained, e.g., standards of environmental hygiene. The increase in the local population which the high-rise will bring can then be added to the equation so that a judgment can be made as to the adequacies or inadequacies of the status quo.

8.4.4.4 Impacts of Traffic Activities

High-rise developments generate traffic. The level of service (LOS) on feeder roads deteriorates and parking on nearby streets becomes more and more difficult. The traffic problems that a high-rise produces can be divided into the project's construction stage and its occupancy stage. During the building work, construction vehicles are the villain of the piece. Those transporting machinery, materials and equipment increase the sheer volume of traffic; the access routes to the site are usually blocked as most construction vehicles are huge; and the LOS on traffic routes used by these vehicles is compromised.

During occupancy, the high-rise generates traffic by dint of the activities taking place within it. This impacts on the LOS on the roads; on the LOS at intersections; and on demands for parking slots. The LOS on roads decreases because vehicles coming to the high-rise affect flow capacity, especially during rush hours. This difference can be quantified by measuring the volume of traffic prior to the development against the volume afterwards, and by measuring the distribution of trips per hour, including rush hours. Variation found in the LOS on roads follows the limits imposed by the roads' capacity. Increased usage of a road not only lengthens the time that each trip takes but also contributes to the further deterioration of that road's LOS. The impact on the LOS at intersections is due to increased traffic flow, lengthening each driver's delay time and further contributing to a poorer LOS in general. Finally, all this increase in traffic is matched by an increased demands for parking spaces.

The amount of trips the high-rise is likely to generate must be estimated prior to assessing the project's impact on traffic, since the uses to which the high-rise is put will determine what kind of traffic it will attract and at what times. The volume of traffic the building is likely to attract can be estimated by multiplying the rate of new journeys with the space available in the site area. This figure can then serve as a reference point for calculating the distribution of trips and for assessing the extent to which the LOS on

roads and intersections is likely to deteriorate. On this basis, mitigation measures can be proposed to counteract the worst difficulties.

8.4.5 Cultural Impacts of High-Rise Buildings

As Table 8-20 shows, the assessment of the cultural impact of high-rises includes educational, historic and scientific environmental issues. The factors addressed include architecture, ecology, geology, interesting structures, religious temples and churches as well as various cultural practices, activities and events. High-rise developments may threaten historic buildings etc. with demolition and indigenous cultural practices (especially when the proposed site is in an aboriginal area) can similarly be subject to radical change. The assessment process needs to include a survey of the cultural structures, artifacts and practices which exist within the vicinity of the proposed site, so that the impact of the project on them can be estimated and any preservation measures be put in place.

Table 8-20: Prediction and Assessment Methods of Cultural Impacts from High-Rise Buildings

Environmental Item	Environmental Factor	Estimation Approach
educational & scientific	Architecture	description of the models, features, maintenance & occupancy status of buildings
	Ecology	description of the status quo, values, maintenance & preservation methods of the ecological system
	geology	description of the terrain, planning value & current use of special geological sites
historic	buildings, structures	description of characteristics, historic value, maintenance & application status
	religious temple, church	description of historical religious temples, locations, types, historic values, maintenance & application status
cultural	activity, event	description of historic meanings of related activities & events and explanation of re-educational & cultural functions
	practices	description of customs with cultural values and analysis of features & preservation
	culture	description of category, status quo & future demands for preserving cultural resources

Data source: EPA, 1995, pp.71-72

8.5 SUMMARY

As the purpose and background vary, the definition of high-rise buildings varies as well. Generally speaking, considered dimensions include disaster prevention and evacuation aspect, technical aspect of structure safety, aspect of fire-fighting equipment, aspect of relative height and environmental impact aspect, etc. Based on the environmental impact aspect, this research classifies approaches in compliance with the EIA Act and defines a high-rise building as a building over 20 floors or above 70 metres.

The land planning system of Taiwan develops adversely, which means urban plan comes up first, then the regional plan and national comprehensive development project appears at last. Land use control in Taiwan belongs to a rigid system, applies land zoning control and prescribes permitted and prohibited items in each zone for monitoring. Under this kind of land planning system, land use zoning can't be changed once designated. It takes 2 to 5 years for a brand new discussion on the suitability of each zone and adjustment can be made until then. However, re-adjustment and change of zoning always result in windfall and wipeout. As a result, additional interests from zoning change should be returned to the public Besides, the landowner is required to donate part of his land or money as feedback for the costs of public facilities. So-Go and Formosa buildings are changed from residential zone to commercial zone and are demanded to donate 200 m^2 for parking space and 4 million pounds as feedback money respectively.

Building management is controlled by the categories of land zoning in the urban plan. Consequently, building management is the tool to realize the goal of the urban plan. By 1990, permit procedure for high-rise buildings and the general buildings were the same in Taiwan. Nevertheless, as high-rise buildings increased rapidly after 1990, approval procedures for high-rise buildings were adjusted. A system of sectional permit is adopted, which includes phases of planning review, design review, construction review and occupancy review, etc. During the planning review phase, EIA process is mainly applied to business

and office buildings above 20 floors and residence buildings over 30 stories. The design review phase is divided into urban design review, comprehensive review (open space review) and construction permit review, etc. As for the construction review phase, structure program review and proceeding construction review are included. The occupancy review phase upon completion consists of occupancy review, interior trim review and use change review, etc.

The flourishing development of high-rise buildings in Taiwan has been a decade. By 1990, there were only 149 high-rise buildings in Taiwan; however, 663 high-rise buildings came into existence in 1996 with a growth rate of almost five times. In addition, the highest building in Taiwan in 1975 had only 12 floors with a height of 48 metres (in Taipei); whereas, the height exceeded 100 metres (114.5 metres) with 27 floors (Tai-Power Building) in 1980 and the height reached to 170 metres with 39 stories in 1990, which was also the first time that the highest building changed from Taipei to other cities (Taichung). In 1995, the height of Long Valley World Trade Building (Kaohsiung) was beyond 200 metres (220 metres) with 50 floors, which also moved the highest landmark southward. In 1998, the Tunnex Building of Kaohsiung had a height of 348 metres and 85 stories and became the highest building in Taiwan. Nevertheless, the Taipei Financial Center building with a height of 508 metres will be completed in 2002, which will become the highest building in the world then. But, its height might be modified and reduced upon discovering that the air traffic of Taipei Domestic Airport is affected during construction process.

Due to its gigantic dimension, tremendous energy requirements and great crowds rushing in and out, environmental impact imposed by high-rise buildings is generally concerned. The big earthquake (7.3 on Richter Scale) happened on September 21, 1999 tore down 20,815 buildings completely, 17,918 buildings halfway and made 200,000 people become homeless, which aroused the environmental impact of high-rise buildings to be a focused issue again. Environmental impacts imposed by high-rise buildings include physical environment, ecology, landscape and recreation, socio-economic environment and culture, etc. For

physical environment, items are like geology and soils, waterborne pollution, noise and vibration, micro-climate, light and air quality and electric wave interference, etc. Ecological issues include fauna and flora of terrestrial and aquatic fields, habitating environment for living creature and the ecological system, etc. Landscape and recreation cover impacts of urban landscape as well as recreation. For socio-economic impacts, issues comprise with load of public facilities, traffic transportation, land use, industrial activities, population in the community and urban safety, etc. As for culture impacts, they refer to historic and cultural influence. EIA process is primarily applied to the occupancy phase, rather than the constructing phase. However, compared with the requirement of EIA Act and actual evaluations for high-rise building projects, the concept of "whole life-cycle" has not been applied to EIA yet. Thus, we attempt to apply the whole life-cycle approach (from cradle to grave) to the environmental impact assessment for high-rise buildings from Chapter 12.

CHAPTER NINE: A CASE STUDY OF THE SO-GO BUILDING

The So-Go building is situated in the western area of Taichung City, at the intersection of Taichung-kan Road and Mei-tsui Road. This is the booming commercial centre of the city, with important roads connecting to outlying areas. The site area for this building is 4,694 square metres. It is 21 storeys high and has a total floor area of 79,523 square metres(Kua-San Company 1993, p.1.1.1). A department store occupies the first 16 floors while the upper storeys are used as office premises and mechanic operating rooms.

The building was constructed in 1994 and formally opened on November 11th 1995. Its Environmental Impact Assessment (EIA) report was approved in 1993 - the first time that the EIA system was applied to a high-rise building project of this kind.

9.1 A DESCRIPTION OF THE SO-GO BUILDING

9.1.1 The Building's Location

9.1.1.1 The Site Location

The building, located in the commercial centre of Taichung City at the intersection of Taichung-kan Road and Mei-tsui Road (see Figure 9-1), is surrounded by important roads -Taichung-kan Road, in particular - which link the city with outlying districts. It is only 1.5 km from the motorway and 3 km from downtown. This area is classified as a commercial zone in the city's urban plans. Both older and newly-built office blocks are located along both sides of Taichung-kan Road.

Since 1986, several new office blocks have been constructed along Taichung-kan Road. Twelve high-rise buildings were opened in 1992 alone. As a result, this region is characterised by its concentration of office blocks. While there are two three-storey buildings on this site, the demands on space imposed by an urban environment mean that they are no longer appropriate for the area. By now, 88% of the available land in the vicinity has been developed.[1]

[1] The average residence occupancy rate refers to the proportion of developed buildings to land that can be utilised for construction. The rate for this area is quoted from the EIA report of Kua-San Company (p.2-1-1, Kua-San Company, 1993).

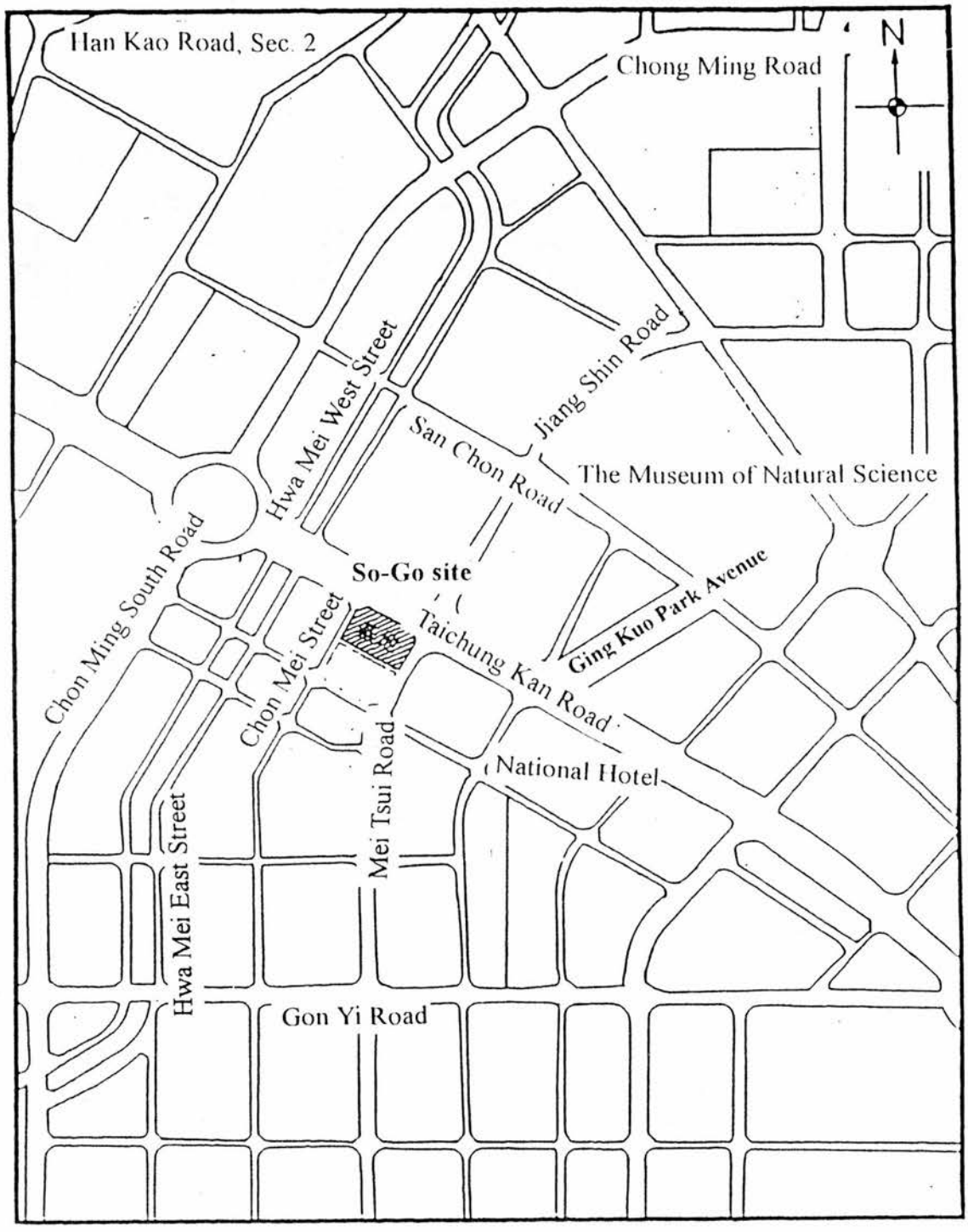


FIG. 9-1: Sketch of the Site Location

9.1.1.2 Status Quo of Urban Development

The growth and development of a city is hugely influenced by the incessant changes in urban activities. If urban development can be effectively controlled and resources invested efficiently, then the development process can be managed to the benefit of the whole area.

The population of Taichung City has grown from 470,317 to 916,381 over the past three decades. Limited by how the city's planners had then zoned the urban areas, the rate of population growth slowed prior to 1980. Since that time, annual population growth is around 2% due to the active promotion of reclaiming land and of creating new urban hubs. By 1999, the population will reach 930,000. Analysing each part of the city, we can see that the inner city population has fallen while that of the western districts - Peitun, Nantun and Hsitun especially - has grown rapidly. This western region has now become the centre of a booming economy and a commensurate boom in office block developments.

Taichung's secondary and tertiary industries are well developed. Secondary industries account for 24% of employment while tertiary industries account for 68%. The industrial structure has gradually transformed itself into a service-oriented economy in line with the trend seen elsewhere in large metropolitan areas.

9.1.1.3 Status Quo of the Traffic Adjacent to the Site

Because of the growth of the population and its economy, traffic management has become an issue of close concern. The distribution of roads around the site are shown in Fig. 9-1 (see above). Taichung Kan Road is to the north of the site; Mei Tsui Road to the east; Alley 18 to the south; and Chon Mei Street to the west. The road system which is relevant to the site's location includes main thoroughfares such as Taichung Kan Road; Mei Tsui Road; Jiang Shin Road; Chong Ming South Road; His Tun Road; Gon Yi Road; In Tsai Road; and various streets and alleys nearby.

Taichung Kan Road is an important East-West route in Taichung. It connects the motorway, the Taichung Industrial Park and Taichung Harbour in the west with the inner city in the east, and is 40m to 60m wide. Jiang Shin Road is an inner circular road connecting the southern, northern and western areas through its North-South axis. It joins with Mei Tsui Road and commuters can access Zhon Hwa County in the south via Fu Hsin Road. Chon Ming South Road, a central circular road which is 30m wide, links the northern areas, Peitun and the southern areas. In Tsai Road, an inner circular road, is the major downtown North-South route. Features of the individual roads are described in Table 9-1 and Table 9-2 below.

Table 9-1: Classification of Level of Service on the Road

Class	Intersection Delay Of Each Car (sec.)	Section 1 km/hr	Characteristics of Traffic
A	- 15	33	free traffic flow
B	15.1 – 30.0	33 - 25	stable traffic flow (little delay)
C	30.1 – 45.0	25 – 20	stable traffic flow (acceptable delay)
D	45.1 – 60.0	20 – 16	close to unstable (endurable delay)
E	60.1 – 80.0	16 – 10	unstable traffic flow (unendurable delay)
F	80.1 -	10 -	forcible traffic flow (traffic jam)

Data source:, Taichung City Government, 1993a, P. 56.

Table 9-2 : Features of Main Roads around the Site

Name of Road	Width of Road (m)	Function	Volume (PCU)	Number of Lanes	V/C	Level of Service
Taichung Kan Road	60	Connecting Road	7984	8	1.09	F
Jiang Shin Road	20	Regional Road	2033	4	0.71	C
Mei Tsui Road	20	Regional Road	2061	4	0.88	E
Chon Ming South Road	30	Connecting Route	4366	4	0.71	C
In Tsai Road	20	Regional Road	2469	4	0.85	D

Note: PCU means passenger car unit, V/C means volume / capacity

9.1.2 The Construction Plan

The So-Go building is located in Taichung Kan Road. It has 21 floors above ground level and four underground floors and reaches a total height of 91 metres. The block houses a department store (which

occupies the lower basement up to the 16th floor) and various offices (from the 17th floor upward). The plant rate of the building covered is 73.59%[2] and the total floor area is 79,523 square metres.

9.1.2.1 Allocation Principles and Design Concepts

With the exception of a parking lot in the north-western side of the site, the 21-floor building has a square block-like shape. As mentioned, its major application use is as a department store, with the lowest three underground floors being allocated as parking bays. The main gate faces Taichung Kan Road and Mei Tsui Road. The service entrance faces onto a six-metre wide alley, and the entrance/exit driveway for the parking area faces onto the 10-metre wide Chon Mei Street.

The principles underpinning the design of the building are safety, convenience and comfort. Special evacuation stairwells are allocated at the four corners of the building. Not only are they obviously located and signposted, but they are also safe and easy for customers to use. Elevators, built as vertical mobile lines, are at the main gate facing the intersection of Mei Tsui Road and Taichung Kan Road and are intended to be used by people who want to ascend directly to the higher floors. Escalators for transporting shoppers are installed at the centre of the building and they offer a continuously linked connection between all floors, including the lower basement.

To manage and control the building efficiently, a central control station is located on the ground floor to monitor thefts and fire hazards and it is equipped to take appropriate preventive action. A freezing and treatment room disposes of 7.5 tonnes of rubbish each day.

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[2] The rate of building covered refers to the area of the ground floor divided by that of the sit. According to Taiwan's urban planning regulations, this rate in a commercial zone cannot exceed 80%.

The building is designed to appear natural, poised, tasteful and friendly. Special events can be hosted in the square in front of the department store. The colour scheme is warm and all the lower floors have demarcation barriers to reduce the scale of the space to a comfortable level. In the upper floors, lighter colours are used for the facades, which have horizontal inlet and outlet ports for air-conditioning. This three-dimensional internal landscape is truly a breakthrough in the design principles which typically underpin mall shopping with few windows (see Plate. 9-2).

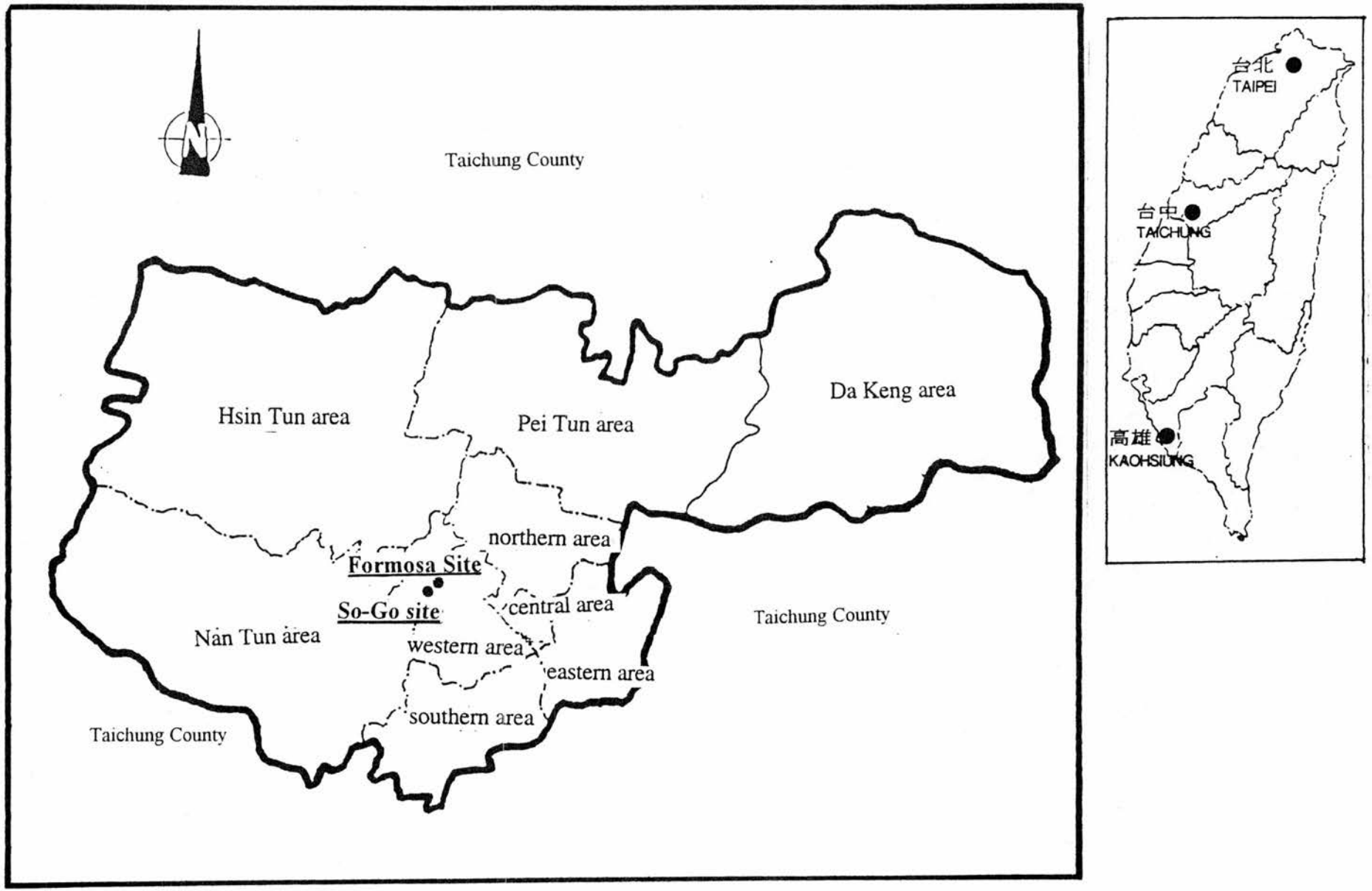


FIG. 9-2: Map of Taichung City

9.1.2.2 The Plan for Mobile Traffic Lines

Many people visit department stores; the average number of trips is 17,572 daily (see 9.2.4.2). Thus, it is important to ensure ease of mobility in entering and exiting buildings. The So-Go building uses the principle of separating people and vehicles. It has distinct traffic management plans for pedestrians, cars, and motorbikes and for entry/exit routes to the parking bays.

In the pedestrian mobile lines, customers usually come by public transport and then walk along Taichung Kan Road and Jiang Shin Road. These customers enter the So-Go building by the pedestrian underpasses in Taichung Kan Road and Mei Tsui Road, a route which carries few implications for the vehicular traffic flow on those roads.

Entry and exit routes into parking lots often cause traffic congestion at those points. To reduce this hazard, the optimum choice is to place the access routes at locations which would otherwise carry relatively little traffic. The So-Go building uses the 10m wide Chon Mei Street as its vehicular entry/exit route and as this is a local and non-thoroughfare street, this choice reduces traffic problems. As a centre of merchandise trading, the volume of usage of the car parks in the So-Go building has reached 309 cars per hour.

9.1.2.3 The Structural Plan of the System

As the building is sited on an earthquake belt whose risk status is in the mid-range, its plane is close to rectangular and it possesses a rigid frame with a brace. The structure of each floor is the same although the 15th and 16th floors are designed so that they can be re-assembled into one space with double the ceiling height for multi-functional conference uses. As Fig. 9-3 and 9-4 (below) show, the outline structure of the building is as follows:

(a) number of floors : 21 above ground, four underground

(b) **building height :** 4.6m floor-to-ceiling from the lower basement to the 4th floor. The ground floor is 5.4m tall, while the other floors vary from 4.2m to 4.9m. The total depth of the basement is 20.9m and the total height above ground is c. 91m.

(c) **building dimensions:** the 2nd and 3rd floors are about 60m long and 54m wide. The 4th through to the 21st floors are about 60m long and 50m wide.

(c) **structural system :**the four basement floors and the ground floor are constructed with SRC columns, beams and shear walls, and have wave-like decks. Floors above the ground level are built as a rigid frame braced by steel columns and beams, using RC slabs.

(d) **foundation :** floating foundation

(e) **outer wall:** metal curtain wall

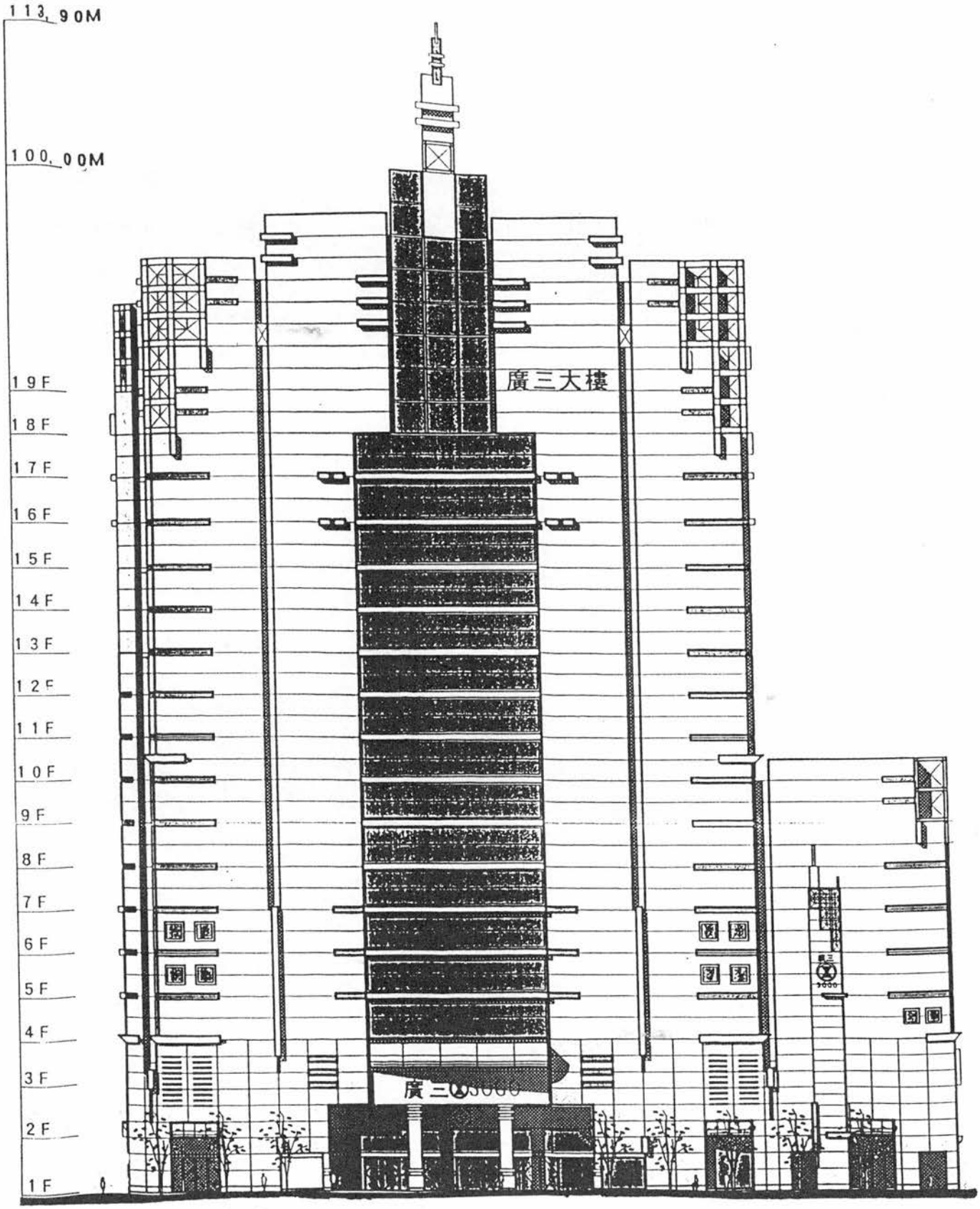
(f) **inner wall** : light separate wall

(g) **excavation of basement :** in compliance with open cut

Plate 9-1: Townscape before So-Go and Formosa Building Project

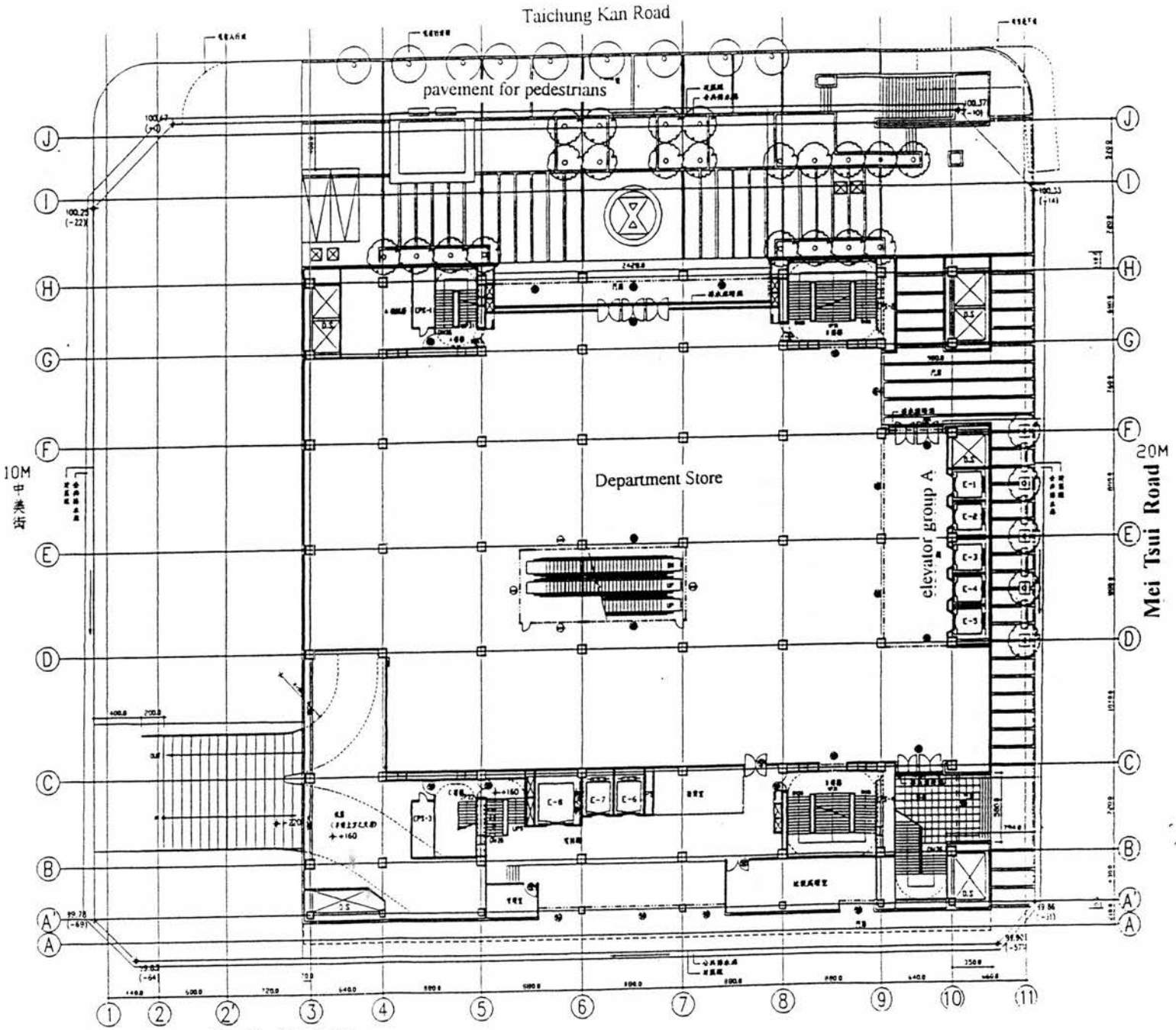
(Courtesy : Lin Ding Ltd.)

Plate 9-2 : So-Go Building (Courtesy : So-Go Company)



Data Source : Kua San Company

FIG. 9-3 : Northern Elevation



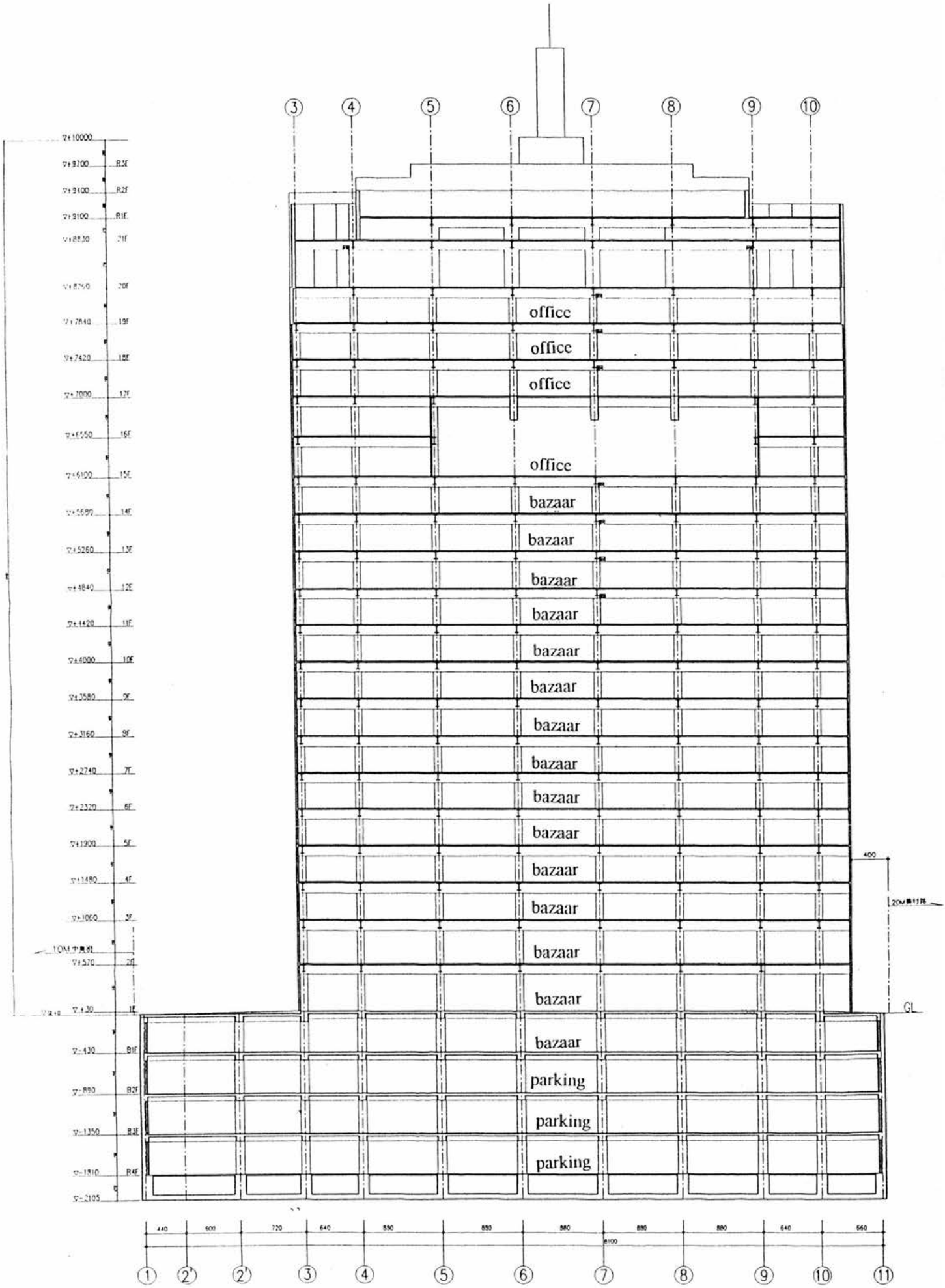
Data source: Kua-San Company

FIG. 9-4 : The Plane of the Ground Floor

9.1.2.4 The Landscape Plan

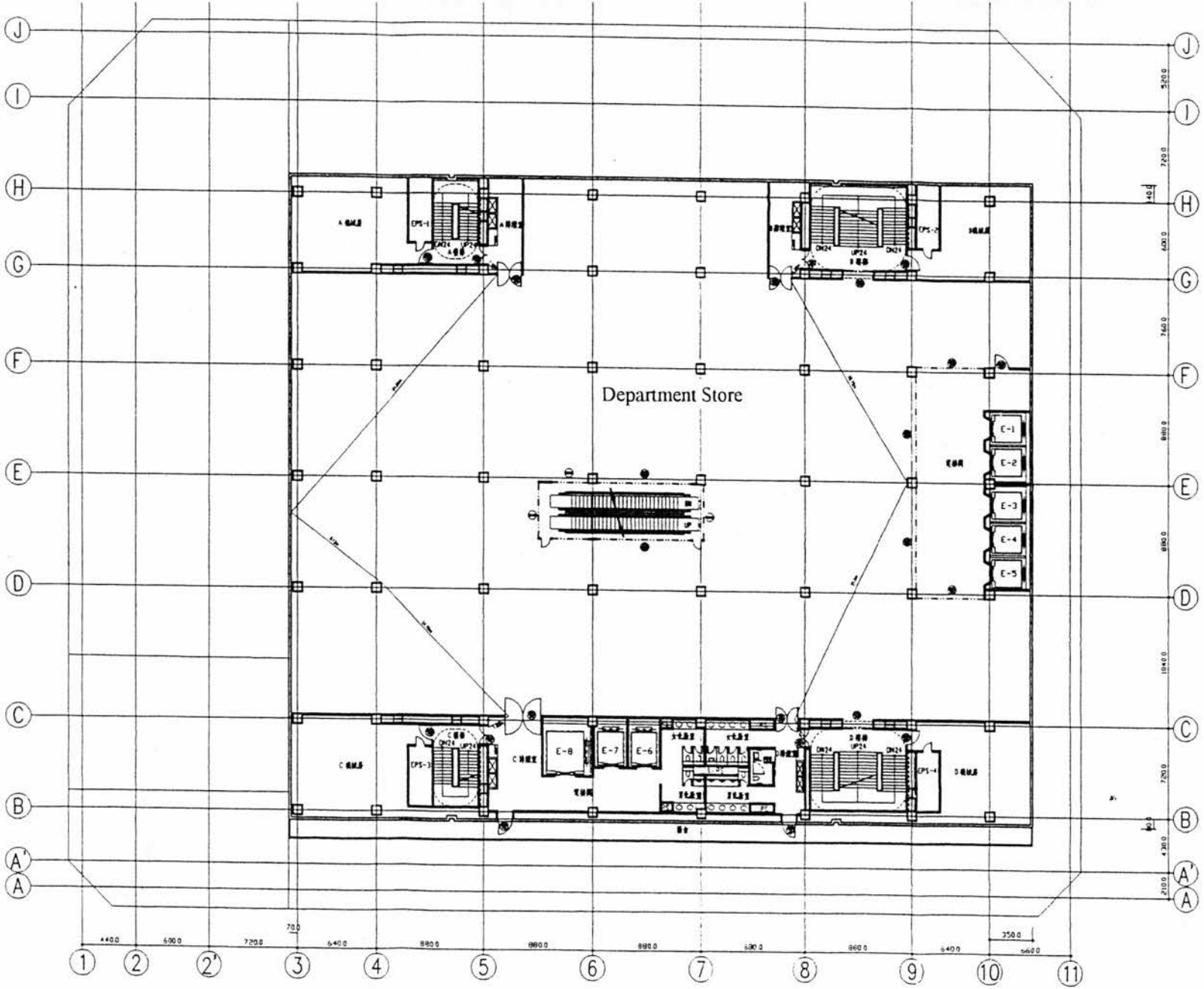
As Taichung Kan Road is critical to the city's financial and commercial life, and the So-Go building is coincidentally situated at its heart, So-Go's architecture must cope with the wide roads around the area and blend in with the street's existing buildings. Consequently, the So-Go project needed to strike a balance between the 'look' of its landscape while being mindful of the building's volume and height.

Located at the central point of Taichung Kan Road - implying that So-Go is the street's natural visual focus - the architects' aim was to design So-Go as a regional landmark for shoppers. Thus, the building takes advantage of a three-dimensional shape within the confined square space of Taichung Kan Road. Its characteristics indeed make for a strong visual statement (see Fig. 9-3).



Data source: Kua-San Company

FIG. 9-5 : Vertical Section Drawing



Data source: Kua-San Company

FIG. 9-6: Plan of Standard Floor

To cope with the mass gathering of people in the shopping areas, as well as to enable festivals to be staged out front, the pavement along Taichung Kan Road was narrowed by 15 metres; evergreens have been cultivated at the main square; and the ground outside is paved with marble to reinforce a humane and friendly urban atmosphere.

9.1.2.5 The Disaster Prevention Plan

The Disaster Prevention Plan is sub-divided into four categories: preventive facilities; alarm equipment; fire-fighting equipment; and escape facilities. The core issue in the first instance is to prevent problems from escalating into disaster scenarios (the main thrust of the Preventive Facilities section of the plan). In the event of difficulties, the Alarm Equipment section of the plan calls for early intervention. The Escape Facilities section presents solutions for the safe and speedy evacuation of the area if it were to become necessary, while the Fire-fighting Equipment section devises methods to minimise casualties and fatalities.

Table 9-3 outlines the specific nature and location of the fire prevention and fire-fighting armoury. The central control station, with its electronic monitoring equipment, lies on the ground floor. Two designated lifts for use in emergencies can move from the lowest basement levels up to the highest floor. Emergency escape stairways and exit points are scattered throughout the building to facilitate multi-directional routes to safety.

Horizontal and vertical fire blocks are set into the building's structure. On every floor, the maximum walking distance to an escape route is limited to 35 metres. Should fires occur, the air inlet ports of the designated emergency stairwells automatically pressurise so as to prevent the in-rush of smoke and so facilitate a smooth evacuation of the area. From the 10th storey down, the outer walls of the building are equipped with escape windows, which enable evacuees to reach the ground directly.

Table 9-3: Fire Alarm & Fire Protection Equipment

Use Item	Parking lot	bazaar	Public place(office)	Indoor(office)	Roof
Fire alarm system	●	●	●	●	
Emergency P.A. System	●	●	●		
Emergency Exit Signs	●	●	●		
Emergency Power Supply	●	●	●		
Exitway Lighting	●	●	●	●	
Stand Pipe System	●	●	●		●
Automatic Sprinkler System		●	●	●	
Automatic form System	●				
Smoke control System	●	●	●		

Data Source: Kua-San Company, 1993, P. 4-6-2.

9.2 PREDICTIONS ABOUT THE ENVIRONMENTAL IMPACT OF THE DEVELOPMENT

9.2.1 THE PHYSICAL ENVIRONMENT

9.2.1.1 The Topography and Geology

(a) terrain and topography: The general terrain of this region is flat. While some of the land around is open as yet, there are many developed streets in the area. During the construction of So-Go (which was excavated to a depth of 20.9 metres) the local topography changed in the process. The construction and refilling work involved in undertaking the project served to generate new shapes and spaces. The new building complies with the design principle of creating elegant curves and conveys a sense of space and greenery. Thus, the original features of the terrain have been completely transformed and a beautiful visual landscape has taken its place.

(b) settlement and expansion of soils: Geologically, the soil on this site is a mix of pebbles, grit, stones and rock and thus acts as bedrock with good load-bearing capacity. However, although the site was excavated to a depth of 20.9 metres, the work was somewhat constrained by the existence of roads near the site. For this reason, the adverse cast method was used in the construction of the foundations to reduce the likelihood of subsidence and to allay any negative knock-on effects from the movement of terrain nearby. Once the ground floor was built, it served a dual purpose as the depository for building stocks and as the operational area for the remaining construction work. Accordingly, the maximum differential settlement was about 2.9 cm with a diagonal variable of 1/897, which is within the allowed range. As a result, the task of building So-Go actually had very little impact on the existing soil and geology of the site(Kua-San Company, 1993, p.7.5.1). Expansion as a result of excavation may affect buildings adjacent to this site. Expansion figures for the centre of the excavation surface is less than 5cm. Surrounding road serves as a buffer zone so reducing the impact to a minimum with no significiant impact to surrounding buildings.

(c) waste soils: The volume of surplus soil came to 98,700 cubic metres as the site area was 4,694 square metres and the excavated depth was to 20.9 metres. If the coefficient of the consolidation of soil is 1.15, then the volume of the residual soil comes to 113,500 cubic metres. As the construction of the foundations took 100 days, 1,135 cubic metres of soil were produced daily. This soil was sent to a gravel plant for re-cycling and was reprocessed as sand and stone for use as concrete (Kua-San Company, 1993, p.6.6.3).

9.2.1.2 Hydrology and Water Quality

(a) hydrological balance: The natural water table of the site runs three to four metres underground during the dry season and one to two metres underground during the rainy season. Thus, the water level needed

to be siphoned below the excavation surface during construction. Areas adjacent to the site and within the building were required to draw off water, section by section. So, prior to each stage of construction, the underground water level had to be reduced to approximately three metres below the excavation surface. The estimated radius for lowering the water level was within 500 to 1,000 metres. However, as the pumping out of underground water was a temporary measure, the construction work did not appear to have a huge impact on the integral underground water near the area.

Each day, about 200 construction staff worked on the site with about 50 of them living there also. Their estimated water consumption per person per day was about 30 litres and 350 litres respectively, resulting in a daily waste water rate of 22 cubic metres. Their sewage was treated and disposed of through the waste water treatment facilities.

(b) water quality: During the operational phase of the project, underground water does not need to be drawn off as its level is no longer relevant. However, the building in use generates 400 cubic metres of sewage daily (Kua-San Company, 1993, p.4.2.5), meaning that the volume of waste water is 0.0046 cubic metres per second. After being sterilised and treated at the sewage disposal plant, it drains into the Mei Chuan river.

(c) water drainage : In addition, as the ground surface is paved over, drainage is affected. In the rationalised formula ($Q = C \times I \times A / 360$), the coefficient of run-off (c) is 1.0; the area of the water-gathering basin (A) is 0.65 hectares; and the intensity of rainfall (I) is 343 mm/hr in the Taichung area. From this formula, we know that the volume of surface water is 0.6 cubic metres per second. The capacity of the rainwater sewers near the site is 3.6 cubic metres per second. Thus, the run-off volume of the storm drains is more than adequate for the site.

9.2.1.3 Air Quality

(a) construction stage : The construction phase can be subdivided into three processes: land clearance, underground excavation and construction of the superstructure. The emission factor set down by the Environmental Protection Administration (EPA) is multiplied by the duration of the construction work and by the area being redeveloped. As Table 9-4 outlines, this formula indicates the amount of particulate pollutants produced at each of the construction stages.

TABLE 9-4: Emission factor of Total Suspended Particulates(TSP)during Construction phase

		Emission Factor	Construction Duration (Day)	Construction Area (m^2)	Total Exhaust Volume (kg)	Emission factor Of TSP ($g/m^2/s$)
Underground Excavation stage	Excavation	0.1206 kg/m^3	100	4,100	11,903	3.3602×10^{-4}
	Bare surface of the earth Inside the construction Site	4.257×10^{-4} $kg/m^2/day$	100	1,200	51	4.9190×10^{-6}
Construction stage	Construction Period	0.424 kg/m2/ month	300	3,100	13,144	1.6358×10^{-4}
	Bare surface of the earth inside the construction site	4.257×10^{-4} kg/m2/day	300	600	77	4.9511×10^{-6}
	Depositing field of surplus soils & construction materials	4.257×10^{-4} kg/m2/day	300	200	26	5.0154×10^{-6}

Notes: a. Emission factors are quoted from the statistics data provided by EPA in 1996.

b. Daily operating time is sited on eight hours.

The air pollution produced by building plant can be estimated by combining the exhaust output of all the construction machinery being used, resulting in a figure of 0.2205 g/s of TSP (Total Suspended Particulates); 1.0684 g/s of CO; 2.77 g/s of Nox; 0.3112 g/s of Sox; and 0.1749 g/s of HC. Based on this estimate, particulate pollutants seem to generate the largest exhausts (Kua-San Company, 1993, p.9.3.6).

Simulating the influence of TSPs on the environment during the underground excavation stage, we find that air pollution was mainly confined to areas at or near the construction site. The maximum average annual growth was 1.7 ug per cubic metres, found around the south-western side of the site. The maximum average daily growth was 4.9 ug per cubic metres, found at the south of the site (Kua-San Company, 1993, p.9.3.7). This is shown in Table 9-5 below.

Table 9-5 : Concentration of TSP Simulation during Construction Period

Stage	Average Time	Background Concentration (a) (ug /m^3)	Background Concentration (b) (ug /m^3)	Synergistic Concentration (μg /m^3)	Air Quality Standard (μg /m^3)
Excavation Stage	24 hours on the average	186		190.9	250
	annual average		126	127.7	130
Construction Stage	24 hours on the average	186		188.9	250
	annual average		126	127.1	130

Notes: a. The background concentration is the maximum value measured on the site site.

b.. The background concentration is the annual averaged TSP of air quality in Taichung in 1993.

Data source: Kua-San company, 1993, P9-3-5

The particulate pollution problem improved significantly during the construction of the superstructure, as this mostly involved manipulating a steel frame structure. The maximum average daily growth fell to 2.9 ug per cubic metre and the maximum average annual growth to 1.1 ug per cubic metre. It probably goes without saying that the annual average value found at this third phase of construction was quite close to the normal standard of air quality.

(b) transportation: Transportation vehicles generate air pollution through their exhausts and the TSPs they emit. The formula for calculating the TSP level of the exhausts is described as follows:

$$Q = (Q1 + Q2) \times V$$

- Q1 refers to TSPs emitted by vehicles, at an emission factor of 3.00 g/km per car.
- Q2 refers to other sources, including the surface dust on cars and roads which is thrown into the air as the vehicles move.

$$Q2 = (3 \times 10\text{-}6) S \times L \times W$$

- S refers to the mud on the surfaces of vehicles (5%).
- L refers to the dust on the road (150 lb/mile).
- W refers to the weight of the vehicles (20 tons).

Thus Q2 = 12.8 g/km.

- V refers to the frequency of vehicles per day.

Surplus soil amounts to 113,500 cubic metres (8 cubic metres per car). With the construction phase taking 100 workdays, this results in 140 daily trips and a round trip makes 280 in total.

$$Q = (3.00 + 12.8) \times 280/8/3600 = 0.153 \text{ g /km.sec.} = 153 \text{ ug /km.sec.}$$

Exhaust of waste air :

- Q = emission factor x daily trips

If the velocity of vehicles is 40 km/hr and the emission factor for SOx, NOx and CO are 1.303 g/km/per car; 16.92 g/km/per car; and 7.31 g/km/per car respectively, then

SOx = 1.131 x 10-2 g/s/km

NOx = 1.468 x 10-1 g/s/km

CO = 4.772 x 10-2 g/s/km

The dispersion of each air pollutant can be estimated through the following formula.

$$C = \frac{2Q}{(2\pi)^{1/2}\ \mu\ \sigma_2 \sin\theta}\ EXP\ [-1/2\ (H/\sigma_2)^2]$$

The results are shown in Tables 9-6 and 9-7. The increased concentration of TSPs is 14.2 ug per cubic metre. SO2 is 0.34 ppb; NOx is 6.8 ppb; and CO is 3.7 ppb within 50 metres of Taichung Kan Road (Kua-San Company 1993, p.9.3.7).

Table 9-6 : Emission factors of Air Pollutants from Transportation Trucks

unit : g/km

Velocity of speed (km/hr)	Particulate Pollutant	SO_x	NO_x	CO
10	3.00	1.303	27.45	22.27
15	3.00	1.303	24.47	17.7
20	3.00	1.303	22.11	14.32
30	3.00	1.303	18.82	9.88
40	3.00	1.303	16.92	7.31
50	3.00	1.303	16.07	5.81
60	3.00	1.303	16.13	4.95
70	3.00	1.303	17.09	4.52

Data source: EPA, 1993, p.3.141.

Table 9-7: Dispersion Concentration of Air Pollutants Resulting from Transportation trucks during Construction Stage

Type of Pollutant / Distance (m)	TSP ($\mu g/m^3$)	SO_x (ppb)	NO_x (ppb)	CO (ppb)
10	51.1	12.6	23.1	12.8
20	30.8	0.75	13.8	7.8
30	22.1	0.54	10.0	5.6
40	17.1	0.44	8.1	4.4
50	14.2	0.34	6.8	3.7
60	12.7	0.31	5.7	3.2
70	11.2	0.27	5.2	2.8
80	10.4	0.25	4.2	2.5
90	9.4	0.23	4.0	2.2
100	8.1	0.21	3.6	2.0

Data 7 source: Kua-San Company, 1993 P. 9-3-8.

(c) operation phase: Estimated exhaust pollutants derived from increased traffic volume during the operational phase of the SO-Go building are outlined in Table 9-8. This estimate takes the velocity of a car as being 40 km/hr with emission factors of TSP, SOx, NOx and CO as being 0.2075 g/km, 0.116 g/km, 2.07 g/km and 29.39 g/km respectively. Table 9-8 shows that the concentration of various pollutants is highest on Taichung Kan Road and that the maximum increased concentration during peak hour is 59.33 PPb of Nox.

Table 9-8 : Increased Concentration of Air Pollutants in Adjoining Roads during Operational Stage

Name of Road	From - To	Maximum Increased Concentration Per Hour During Peak Hour			
		TSP ($\mu g/m^3$)	SO_2 (ppb)	NO_2 (ppb)	CO (ppm)
Taichung Kan Road	Mei Tsui Road – Avenue	10.65	2.31	56.20	1.31
	Mei Tsui Rd. – Chon Ming Rd.	11.36	2.34	59.33	1.39
Mei Tsui Road	Taichung Kan Rd. – Chang Chun St.	3.16	0.77	16.80	0.41

Data source: Kua-San Company, 1993, p 9-3-9.

9.2.1.4 Micro-climatic Effects

(a) local wind effects: The impact of the construction on the surrounding micro-climate mainly refers to changes in the direction and velocity of the wind field. Generally speaking, the atmosphere at the top of a tall building has a higher dynamic pressure than is found on the ground (1 ~ 2 m.), and the velocity of the wind is faster too. As air is obstructed by the building, the air current will flow towards either side and down towards the site of the building. In addition, the air has a stronger momentum coming as it does from a higher stratum. Therefore, wind velocity increases at the site of the building. This is hardly a problem when the prevailing wind is a soft breeze. But if the building is designed inappropriately, turbulent currents and strong winds can be felt by pedestrians when the weather picks up a bit. So this issue of the wind field should be taken most seriously in designing the building to minimise pedestrians' discomfort.

How a pedestrian reacts to the feel of the wind varies depending on the regional climate and on the person's age, health, clothing etc. In addition, whether pedestrians experience the breeze as comfortable or not will also vary depending on what they are actually doing on the street. For example, a wind velocity of 0 ~ 17 km/hr is comfortable while sitting; 0 ~ 25 km/hr while standing; and 0 ~ 32 km/hr while walking. A wind velocity of between 32 ~ 95 km/hr makes people feel uncomfortable; when it rises above 95 km/hr it feels dangerous. Wind tunnel studies indicate that if the wind velocity is between 0 ~ 32 km/hr more than 80% of the time (about 5.6 days per week), then it can be judged to be within the 'comfort zone' where activities such as sitting, walking and standing are agreeable or acceptable. If the wind velocity exceeds 32 km/hr more than 20% of the time (about 1.5 days per week), then the windy place will be experienced as uncomfortable. And if the wind velocity exceeds 95 km/hr more than 0.1% of the time (i.e. about four such events occurring per year), then the windy place will be deemed to be dangerous.

As the height of the So-Go building is under 100 metres, there was no requirement for a wind tunnel testing process to be instigated. However, we can take as a reference the results of the wind tunnel tests conducted on a high-rise opposite So-Go which was built at the same time. These tests found that there is an 87% chance of ground-level gusts of less than 30 km/hr and a 76% chance of ground-level gusts of less than 22 km/hr.[3] This shows that changes of wind velocity still lie within the comfort zone. That is to say, the wind field in the neighbourhood will not produce strong and turbulent gusting.

9.2.1.5 Noise and Vibration Impact

(a) Construction phase : The noise problem was most evident during the construction phase of the project, coming primarily as it did from the transportation vehicles and plant machinery. As the noise made by the construction machinery ceased as each stage of the work was completed, its impact was temporary. Generally speaking, if the change of sound intensity is less than 3dB(A), this will be barely detectable by the human ear, while an increase of 10dB(A) is broadly perceived as a doubling of loudness (Morris et al. 1995, p.50). Consequently, a 0 ~ 5dB(A) level of increased noise due to construction work is deemed to have only a slight impact which requires no mitigation measures. If the increased noise level lies between 5 ~ 10dB(A), then we can consider it to have a medium impact which might need mitigation measures. More than 10dB(A) of an increase is regarded as having a major adverse impact which will certainly require noise mitigation measures or the use of alternatives.[4]

Excavators and dump trucks are the main machinery deployed during the construction stage. The noise produced by an excavator at a distance of five metres is 97.8dB(A) and the distance between the

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[3] Wind scales are in compliance with the Beaufort Scale, modified by the RWDI company in Canada. These serve as the measure for judging the wind tunnels of buildings. For the wind tunnel results, refer to Chung-Kan Company, 1993.

[4] Refer to You-Jiuh Company , 1997, pp.7-26.

excavating site and the nearest building is 20 metres. Thus, as Table 9-9 shows, the attenuated noise level is 85.8 dB(A).

Table 9-9 : Maximum Noise levels of Various Operating Machinery in Different Distances During Construction Stage

Unit : dB(A)

Name of Operating Machinery	Noise level 5 metres from Sound source	Noise level 10 metres from Sound source	Noise level 20 metres from Sound source	Noise level 40 metres from Sound source
Generator	93.6	87.6	81.6	75.6
Water Pump	83.9	77.9	71.9	65.9
Electric ,Welding Kan	86.4	80.4	74.4	68.4
Dump Truck	84.1	78.1	72.1	66.1
Pick-up Truck	87.0	81.0	75.0	69.0
Belt Crane	89.7	83.7	77.7	71.7
Excavator	97.8	91.8	85.8	79.8
Bulldozer	87.8	81.8	75.8	69.8
Roller	80.0	74.0	68.0	62.0

Data source: You-Jiuh Company, 1997 P. 7-27.

In 1993, the level of background noise at this spot was measured to be 64.4 dB(A).[5] From this, we can derive the following formula for noise attenuation:

$$Leq = L1 + 10 \log10 (1+10 -(L1-L2)/10) \text{ (adding two noise sources)}$$

$$Leq = L0-10 \log (Dn/Do) 2 \text{ (noise attenuation)}$$

- Leq: noise level of the receiver
- L1 and L2: noise source
- Lo: noise level of sound source
- Dn: distance between noise source and receiver
- Do: measured distance of noise source

From the formula, we discover that the noise level of the adjacent building was 73.4 dB(A) and that the noise level increased by 9 dB(A) - a level which lies within the medium impact category and which therefore requires preventive measures to be taken (Kua-San Company 1993, p.9.1.8).

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[5] This noise level data was requested by the EIA Committee and was made available to the EIA Review team when the So-Go Building was being assessed by them.

(b) noise impact from transporting vehicles: The removal of surplus earth required the use of 140 trucks daily. In all, about 160 vehicles were back and forth at the site each day when we include vehicles delivering building materials during the construction phase. Each day, over the course of an 8-hour day, 20 vehicles per hour travelled into and out of the site. The noise made by these vehicles can be estimated using the formula described in the EPA's Noise Control Manual.

$$Li = 10 \times \log (1/3600) \times \{[3600 - (N \times T) \times 10^{Leq/10}] + N \times T \times 10^{Lc/10}\}$$

- Li: Leq level of hourly operation
- N: entry and exit number of vehicles
- T: delay span of transportation vehicles on sensitive roads (assume 8 seconds)
- Lc: noise level of transportation vehicles at a spot one metre away from the road of 75 dB(A), assuming the vehicles' speed is 40 km/hr.

The calculated results are shown in Table 9-10. The greatest noise was experienced between 10am and 11am, at a noise level of 5.0 dB(A) (Kua San Company 1993, p.9.1.11).

Table 9-10 : predicted noise levels and hourly variations in increased noise from transportation vehicles during the construction phase

Unit : db(A)

Period	Leq	Predicted level	Increased level
8:00 ~ 9:00	59.3	63.5	4.2
9:00 ~10:00	58.1	63.1	5.0
10:00~ 11:00	58.0	63.0	5.0
11:00~ 12:00	62.7	65.0	2.3
13:00~ 14:00	61.5	64.4	2.9
14:00~ 15:00	60.3	63.9	3.6
15:00~ 16:00	64.1	65.9	1.8
16:00~ 17:00	61.5	64.4	2.9

Notes: a. Measuring spots are at Alley 18 and Mei Tsui Road.

b. The predicted level is calculated with 20 vehicles per hour.

Data source: Kua San Company 1993, p.9.1.9

9.2.1.6 Impact of Vibration

As for vibration, the construction period suggests several possible sources. However, being short-term, they are often ignored. General vibration activities include earthwork, excavation work and the use of various other plant. Table 9-11 lists the vibration levels of particular construction machinery as measured at different distances, using measures devised by the Environmental Administration of Japan.

Table 9-11 : Suggested Vibration levels of building plant

Name of Constructing Machinery	Vibration level (dB)	
	5 Metres	10 Metres
Board Breaker	84	79
Large-scale Breaker (pneumatic)	-	70
General Breaker (pneumatic)	68	61
General Breaker (oil pressed)	-	70
Steel-balled Destroyer	71	69
Bulldozer	75	71
Drill for Ground Digging	53	53
Hole Excavator	65	57
Reverse Machine	-	58
Press-in Excavator	55	55
Hammer of Diesel Oil	82	80
Vibrating Hammer	90	82
Falling Hammer	85	79
Dump Truck (20 tonnes)	58	56

Data source: Kua-San Company, 1993 P. 9-2-4.

The formula for the attenuation process of distance is as follows[6]:

$$VLr = VLo - 20 \log (r/ro)n$$

VLr: the vibration level of the spot at r metres from the vibrating source; r (m)

VLo: the vibration level of the spot at ro metres from the vibrating source; ro (m)

Since the geology of Taichung is pebbles, grit, rock and stones, every doubling of distance results in an attenuated level of 3-5 dB. Of all the machinery used at the site, the bulldozer had the greatest vibration level of 75 dB (from a distance of five metres). The vibration level of buildings 20 metres away from

[6] This formula is quoted from that applied by the Environmental Administration of Japan. Refer to the Kua-San Company, 1993, p. 9-2-3.

Alley 18 was 60 dB. This level has some impact on the human body, but not enough to affect sleeping as Table 9-12 shows.

Table 9-12 : Vibration impacts on buildings and people's ordinary living environment

Vibration level	Weather Administration Of Japan	JIS of Japan	
	Scale of Earthquake	Physical Impact	Sleeping Impact
Under 55dB	Scale 0 – senseless	Frequent slight gravity	---
55 – 65dB	Scale I – slight vibration	Start to feel vibration	No sleeping impact
65 – 75 dB	Scale II-light vibration	---	Shallow sleepers are Aware.
75 – 85 dB	Scale III-weak vibration	Factory workers sense Uncomfortable for Eight (8) hours.	Deep sleepers are Aware.
85 – 95 dB	Scale IV-medium vibration	Human body starts to have physical impact.	Deep sleepers are Aware.
95 – 105 dB	Scale V-strong vibration	Significant physical Impact	---
105 – 110 dB	Scale VI-violent vibration	---	---
Above 110 dB	Scale VII-extreme vibration	---	---

Data source:You-Jiuh Company, 1997, P. 7-29.

(b) operation stage: During the operational phase of the building, the main sources of noise are the air-conditioning, vehicles and general din from office premises. As the air-conditioning, cooling tower and machinery facilities are installed on the 20th and 21st floors, these do not have a significant impact on the building's users. Noise emanating from offices can be absorbed and improved through their interior trim. As for the noises from vehicles, the increased volume can be calculated using the method mentioned above, and results in an estimation of about 5 ~ 10 dB(A).

9.2.1.7 Waste

(a) waste : Waste can be classified into general rubbish and specific types of effluent and discarded materials. The daily waste produced by the builders during the construction stage amounted to only 100 kg (200 people x 0.5 kg = 100 kg). Waste during the operational phase mainly comes from customers and employees. It is estimated that the number of shoppers visiting So-Go every day is around 14,000 and the building also houses 1,000 employees. This results in 0.4-0.5 kg of rubbish per shopper per day and 0.7

kg per employee per day. Therefore, the daily waste for the building as a whole is between 6,300 and 7,700 kgs. Let us assume 7,100 kgs as an average estimate.

The car parks cover 9,843 square metres of ground. Assuming each square metre generates 0.005 kg of rubbish per day, 50 kgs need to be disposed of daily from the parking bays alone (Kan-San company 1993, p.4.4.2). Offices take up 6,362 square metres of space. If we assume that one person occupies 10 square metres, and that 623 employees are in the building on any given day, and that the daily rubbish produced by each person is 0.5 kg, the daily waste from the offices therefore comes to 320 kgs. As a result, during the building's operational phase, 7,500 kgs of rubbish need to be disposed of in the incinerator each day.

Specific wastes primarily refer to materials left over from the construction of the building and to the sludge produced at the sewage treatment plant during the operational phase. Discarded building materials such as metal, plastic and glass are recycled and reused. The sludge generated by the building in use amounts to about 14 cubic metres per day and this is assigned for treatment.

9.2.1.8 Insolation and Overshadowing

As high-rise buildings begin to dominate the urban landscape, cities' citizens are increasingly asserting their right to adequate sunlight. This concern about insolation refers to the beneficial psychological effect which warm sunlight has on residents and pedestrians as well as to the comfort people experience when they are engaged in outdoor urban activities in the sun. Sunshine varies with the sun's path through the heavens. The sun passes through the intersection of the ecliptic and equator in the Spring equinox and again in the Autumn equinox. During this period, the sun rises in the east and sets in the west. After the vernal equinox, the sun moves northward along the ecliptic and reaches its most northerly point at the Tropic of Cancer at the Summer solstice (+23.5 degrees). During this period, the sun rises in the

Northeast and sets in the Northwest. Following the autumnal equinox, the sun moves southward along the ecliptic and reaches its most southerly point at the Tropic of Capricorn at the Winter solstice (-23.5 degrees). During this period, the sun rises in the Southeast and sets in the Southwest. According to Article 24 of the Building Code, there should be more than one hour of effective insolation around the building on the Winter solstice.

The level of effective sunlight is assessed in compliance with the idea of the boundary of the sunlight/shadow frame. When the southern, south-eastern and south-western sides of a building receive sunlight, this results in a commensurate shadow boundary on the ground. It is the level of ambient light during the winter which is of greatest concern as the noon-time sun is then at its lowest angle of elevation. Therefore, the light falling on land adjacent to the north, north-eastern and north-western sides of a proposed high-rise building project should be taken into consideration during its construction.

The length of the insolation shadow from a building is related to the angle of elevation of the sun and the height of the building. It is calculated according to the following formula:

$$Sc = H/ (\tan SA)$$

Sc: length of shadow (m)
H: height of building (m)
SA: angle of elevation of the sun

The So-Go building is 91 metres tall and the projected length of its shadow during its operational phase can be calculated with the angle of elevation of the sun in winter as Table 9-12 indicates.

Table 9-13 shows that even on the Winter solstice (23rd December) when the noon-time sun is at its lowest angle of elevation and when So-Go therefore casts its longest shadow, the insolation duration can still last more than four hours on the buildings and lands around it (see Fig. 9-9).

Table 9-13: Analysis Chart of Insolation on Winter Solstice Day (December 23rd) at So-Go Building

Time	Azimuth of Sun	Height of Sun	Length of Sun Projection
0700 1700	SE 62° 33' SW	3° 05'	1689.4
0800 1600	SE 55° 16' SW	14° 49'	344.1
0900 1500	SE 45° 54' SW	25° 24'	191.6
1000 1400	SE 33° 41' SW	34° 12'	133.9
1100 1300	SE 18° 07' SW	40° 13'	107.6
1200	0°	42° 24'	99.7

Data source : Kan-San company , 1993, p 8-5-12

Note: The height of the building is 91 metres.

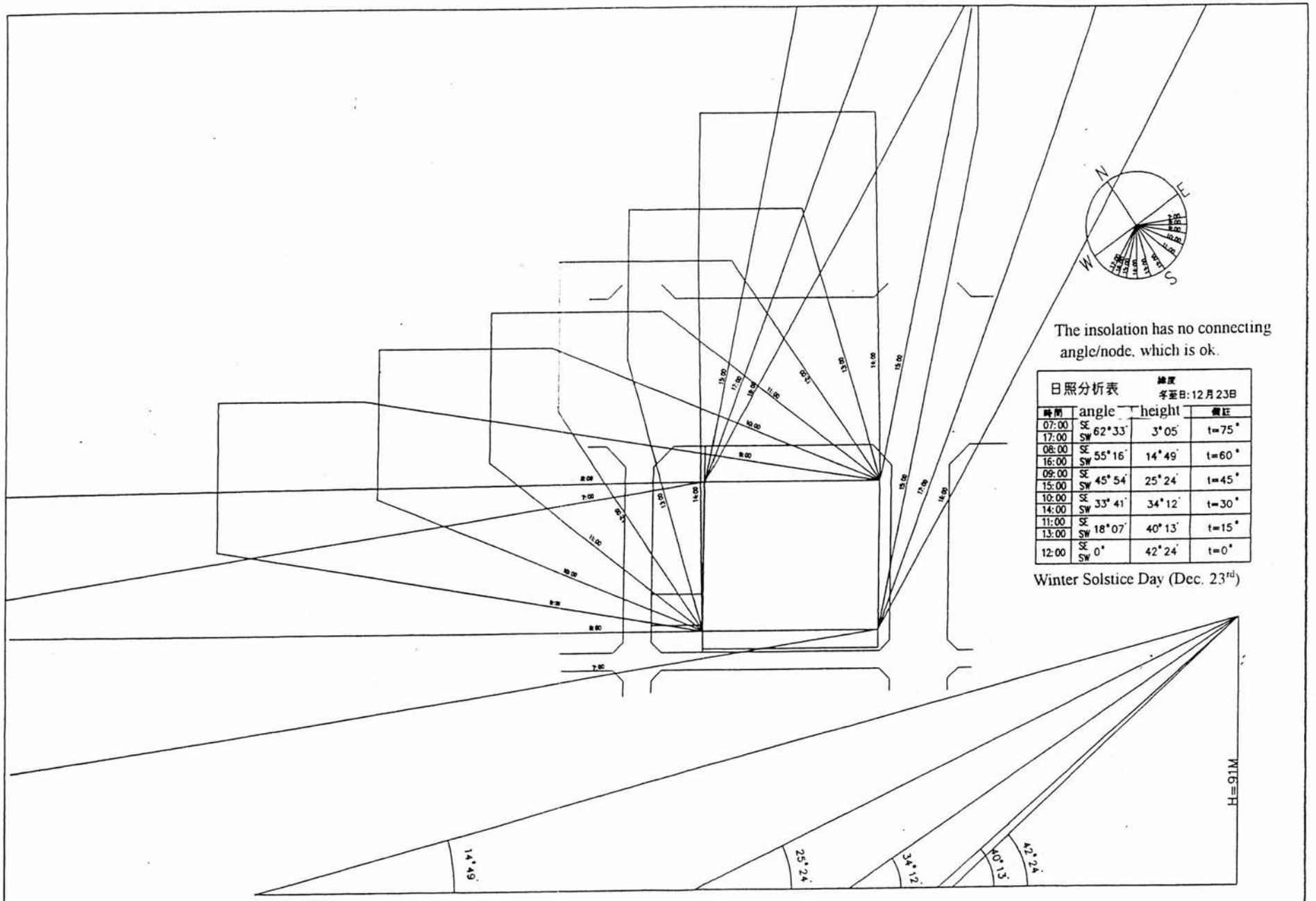


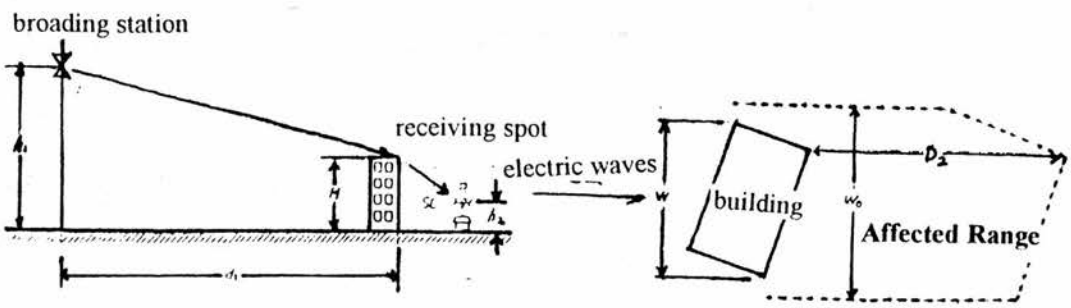
FIG. 9-7 : Analysis Drawing of Insolation of SoGo Building

Data source: Kua-San Company

9.2.1.9 Interference of Electric Waves

Areas of electric wave disturbance are affected by the location, the building's distance, the transmitting capability of the broadcasting station, the terrain and nearby buildings etc. Generally speaking, the phenomenon of electric wave interference is identical with the behaviour of insolation obstruction. It can be divided into blocking obstacles and reflecting obstacles; the former being analogous to insolation obstructions and the latter to the glare caused by reflection. Both types are affected by buildings themselves and their specific locations and also by inappropriate materials being used on outer walls.

The prediction of the affected range of electric waves is determined by the height and width of buildings; by the elevation height; by the frequency of the electric wave of the broadcasting station; and by the distance between the broadcasting station and the target building (see Fig. 9-8).



Data Source: Wu, 1992, p.156

FIG. 9-8: Affected Range of Blocking Electric Waves

The blocking distance resulting from the proposed building is D2 and its width is Wo. The calculation formula is as follows[7]

$$D2 = 1/ (1/d_2' + 1/d_2o) \qquad Wo = W + (D_2)^{1/2}$$

- D2: the blocking distance (m) resulting from the horizontal transmission method of the electric waves (angle of elevation is 0o)

$$d_2' = fw(H-h_2)/ 6\{Ex_1 * Ex_2/(H-h_2) + 16 (H-h_2) /W\} \ 10^{-(sl/10)}$$

- d_2o: the blocking distance (m) of optical theory

$$d_2o = H-h_2/ (h_1-H) d_1$$

- W: width of the building (m) vertical to the direction of electric waves
- H: height (m) of the proposed building
- f: frequency (MHz)
- h_1: elevation height (m) of the electric wave broadcasting station
- h_2: height (m) of the signal receiving antenna
- d_1: distance (m) between the broadcasting station and the proposed building
- Ex_1: intensity rate of the roof of electric wave between the building and the signal
- receiving spot (taking the impact of the ground reflecting waves into consideration)
- Ex_2: urban attention rate

From Figs. 9-9, 9-10 and 9-11, we know that this building is 91 metres high and 54 metres wide; that the broadcasting station is situated at the top of Da Du mountain, which is about 600 metres high; and that the distance between Da Du and So-Go is about four kilometres. As Fig. 9-9 shows, the basic blocking length is 500 metres (LO). Fig. 9-10 reveals that the modified coefficient is 0.35 (C1). Fig. 9-11 shows that the modified value under the frequency of 220 MHZ is 1.3 (C2).

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[7] The method for calculating the blocking of electric waves is to assume that the height of the building is less than half of the transmitting/launching station's height. Refer to Wu, 1992, p. 156.

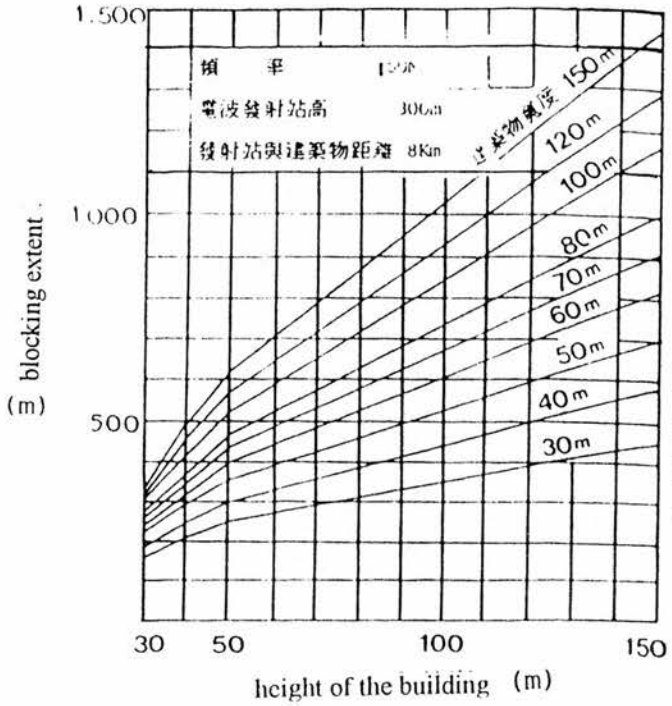


FIG. 9-9 : Affected Distance of Blocking Electric Waves

Data Source : Wu Woo Yi , 1992, p158

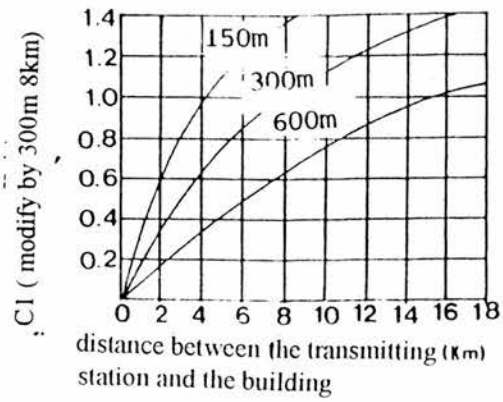


FIG. 9-10 : Modification of Blocking Electric Waves

Data Source : Wu Woo Yi , 1992, p158

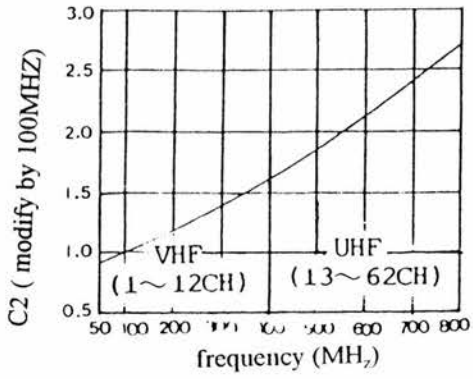


FIG. 9-11 : Frequency Modification of Blocking Electric Waves

Data Source : Wu Woo Yi , 1992, p158

Thus, the blocking length is as follows:

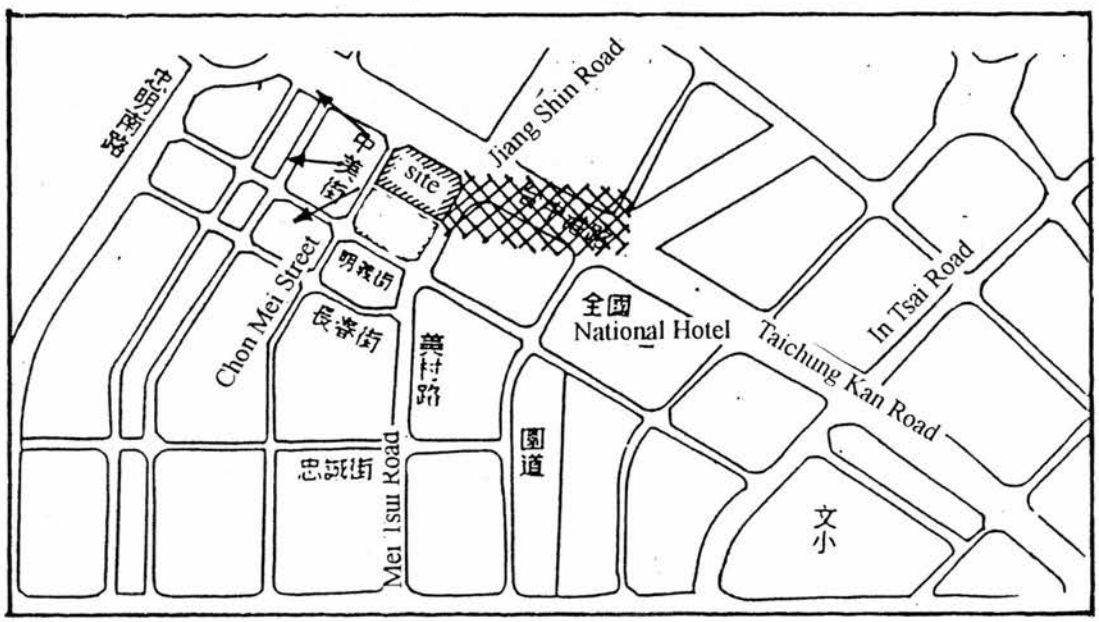
$D2 = L_0 \times C_1 \times C_2 = 500 \times 0.35 \times 1.3 = 227.5$ (m)

And the blocking width is:

$Wo = W + \sqrt{(D2)} = 54 + \sqrt{(227.5)} = 69$ (m)

Figure 9-12 shows the extent of the electric wave blocking range by So-Go.

FIG 9-12 : Electric Wave Blocking Range by So-Go



Notes:

■ refers to the blocking area

→ refers to the reflecting area

9.2.2 The Ecological Environment And Energy

9.2.2.1 Fauna Ecological Environment

This building is at the heart of a urban region and both the site itself and adjacent streets and blocks are all earmarked for redevelopment. As this is not a woodland environment - and, hence, not a natural habitat for wildlife - no particular species are threatened by the So-Go project. The only wildlife in evidence are some ordinary birds on the pavements.

It is possible that the vibration and noise pollution produced in the construction phase (though largely confined to the immediate vacinity of the site) nevertheless reduced the chances of birds flying nearby. However, this kind of disturbance was only temporary, and peace has since been restored.

Now that So-Go is in use, open spaces inside the site are preserved, and plants and trees have been cultivated along the pavements and in the locality's public park. Therefore, we can expect that the numbers of insects and birds will increase in the future and that the So-Go project should not have any significant impact on the pre-existing animal ecology.

9.2.2.2 Ecological Environment for Flora

As the site used to be grassland surrounding two old houses, it goes without saying that the grass and plants were removed during construction. However, as these were not rare or ancient species, So-Go has not had a significant impact on the local flora. To mitigate the increased dust landing on the trees lining the transportation routes during the construction phase, a water sprinkling system was put in place to reduce the impact. In addition, six trees lining the pavement in front of the site were especially protected during the course of the construction work. All in all, the process of building So-Go has had very little impact on the pre-existing floral ecology.

9.2.2.3 Energy Depletion and Water use

Two thirds of the island of Taiwan is steeply mountainous, with its rivers cascading into the oceans. Thus, despite abundant rainfall, only 21% of Taiwan's water supply comes directly from rain water. It is the water in the rivers, dams and underground which constitute the main reservoirs for domestic and commercial use.

During the construction of So-Go, 200 construction staff worked at the site every day - 50 of them actually lived there. They consumed 50 litres and 350 litres of water respectively each day. As a result, the daily water consumption was 22 CMD.

At the operational stage, the numbers of people using the building are estimated in terms of the functional use of different floors (e.g. shops, offices, car parks) and the estimated requirement for water is then based on those numbers. For example, one customer uses up 25 square metres of floor area in the car park (0.04 person per square metre); 1.5 customers occupy one square metre of space on the ground floor and the lower basement; and one customer occupies one square metre of space in the rest of the shopping floors. As Table 9-14 outlines, 366 CMD of water are required every day.

Table 9-14 : Estimation Table of Daily Water Requirement

Floor	Use	User	Effective floor area (m_2)	Person / m^2	Liter/per day.per person	Demand m^3/per day	Total (m^3/per day)	Remarks
B4-B2	Parking Lot	Customer	9843.00	0.040	5	2.000	365.493	(not including cooling water of air-conditioning)
B1	Bazaar	Customer	2576.90	1.500	5	19.327		
		Employee	2576.90	0.045	110	12.756		
1 F	Bazaar	Customer	2005.77	1.500	5	15.043		
		Employee	2005.77	0.045	100	9.026		
2 F	Bazaar	Customer	2113.10	1.000	5	10.566		
		Employee	2113.10	0.030	100	6.340		
3 F	Bazaar	Customer	2106.30	1.000	5	1.503		
		Employee	2106.30	0.030	100	6.319		
4-10 F	Bazaar	Customer	15279.46	1.000	5	76.398		
		Employee	15279.46	0.030	100	45.839		
11 F	Bazaar	Customer	1950.21	1.000	5	9.751		
		Employee	1950.21	0.030	100	5.851		
12-14 F	Bazaar	Customer	6548.34	1.000	5	32.742		
		Employee	6548.34	0.030	100	19.645		
15 F	Bazaar	Customer	569.58	1.000	5	2.848		
	Offices	Employee	569.58	0.030	100	1.709		
			1633.19	0.100	100	16.332		
16 F	Bazaar	Customer	547.69	1.000	5	2.738		
	Offices	Employee	547.69	0.030	100	1.643		
			722.70	0.100	100	7.227		
17-19 F	Bazaar	Customer	2571.96	1.000	5	12.86		
	Offices	Employee	2571.96	0.030	100	7.716		
			3976.38	0.100	100	39.674		
20 F	Operating Room		1424.92					
21 F	Operating Room		518.63					

Data source: Kua-San Company, 1993, P. 4-2-4.

As for power requirements, once the building is completed, lights and sockets require 4,000 KW of power; general power uses up 1,500 KW; power for the air-conditioning accounts for 2,700 KW; and spare power (10%) comes to 800 KW. Consequently, the total power requirement is 9,000 KW. Power distribution rooms are installed on the lower basement and on the 9th floor to supply power to the whole building.

So-Go's delicatessens and restaurants are the main consumers of natural gas, using 150 cubic metres per day. If we assume that meal times span five hours, the requirement for natural gas is 30 cubic metres per hour. This figure is calculated as follows:

600 Kcal/meal x 2,225 people = 133,500 Kcal

1,335,000 / 8,900 Kcal/m3 = 150 m3

9.2.3 The Landscape And Recreational Environment

(a) Construction phase: The western area of Taichung does not possess any especially noteworthy features in its landscape, though there are a few interesting buildings on Taichung Kan Road. As building sites are generally quite ugly to look at with their machinery; their stock-piles of building materials; their piles of earth; their assemblage of pre-fab huts and temporary houses; their bare steel structure etc., something more restful on the eye was needed for passers-by during the construction phase. The colour of So-Go's blocking fences around the site during construction was chosen to blend in with the background. And, the construction phase being relatively short, any impact on the environmental landscape was only temporary.

(b) operation phase : Because So-Go is almost 100 metres high and is located at a critical route to the city centre, it is an important visual focus-point. Indeed, the very shape of this building changes the street's landscape in an important way for it was designed quite explicitly to develop a new kind of skyline in the locality. Two different styles of design idea of the upper and the lower building is adopted, so the facades are more flexible and changeable. Open spaces are retained to prevent pedestrians from feeling overwhelmed by its towering bulk and So-Go's skyline draws on - and substantially contributes to - the region's characteristic 'look'. Its use of colour is interesting, for it mixes dark and light patterns to diminish the gigantic feel of the edifice so as to generate an image of friendliness. So-Go was designed to look elegantly modern. The contours of its exterior are revealed and it suggests an evening-time ambiance

through its nocturnal lighting equipment. Its graceful architecture and plentiful open spaces improve the environmental landscape greatly.

9.2.4 Traffic Impact

9.2.4.1 Impact on Traffic during Construction Phase

It took 400 days to build So-Go. As the entry and exit of construction vehicles and some of the building activities altered traffic flows, the level of the service quality (LOS) of surrounding roads was also affected. The traffic implications during the construction stage can be assessed by looking first at the knock-on effect of the entry/exit of construction vehicles and then at the impact of road occupation by construction plant during building work.

As mentioned before, So-Go is 91 metres high with a total floor area of 79,523 square metres. Building something this size engenders significant new traffic. During excavation, 160 trucks used the site daily if we include the lorries which were delivering materials to the site, generating traffic of 20 vehicles per hour. To allay some of the resulting snarls, the construction vehicles - with the exception of the earthwork trucks - were instructed to make their deliveries in off-peak hours. In addition, their routes to and from the site were distributed over three roads (50 metres wide, 20 metres wide, and 10 metres wide respectively).

When construction vehicles need to occupy the roads for a period, the traffic flow of certain lanes is blocked, forcing cars to change into other lanes. This occupancy not only interrupts smooth traffic flow, but also reduces the number of available lanes. Together these diminish traffic capacity, influencing the level of service quality on the roads. To tackle this problem, it is advisable to build a supporting platform inside the construction site for storing machinery and materials. As far as possible, construction activities

should only be performed within the site. However, building So-Go did impose some additional congestion on the slow lane of Taichung Kan Road during the construction period.

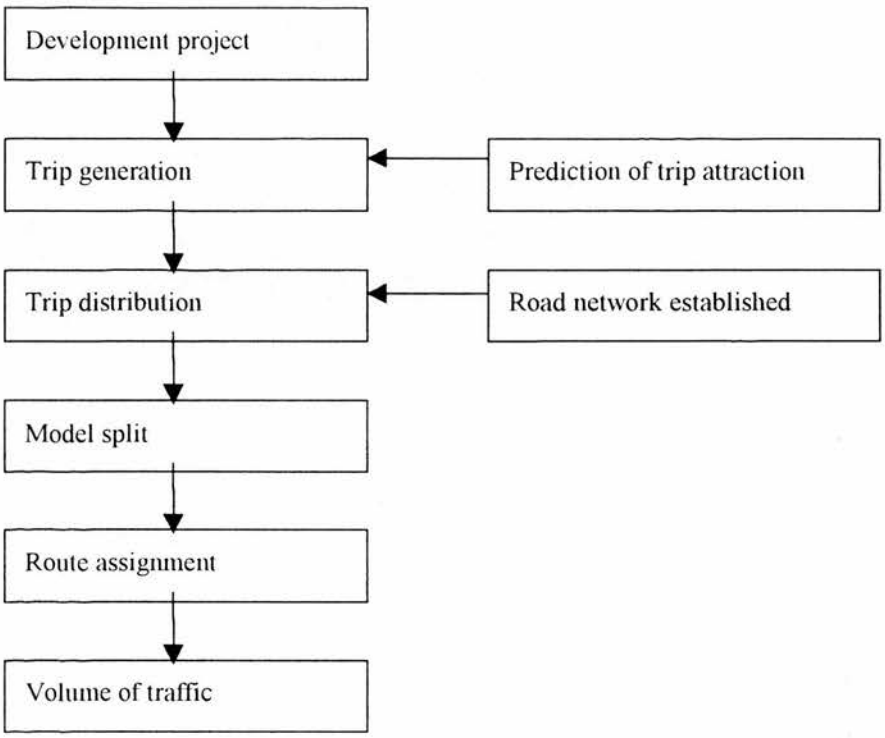
The area for disposing of excess soil is located in the Nan Tun district. During excavation, about 18 trucks per hour travelled back and forth - a rate of one earthmover per three minutes. To minimise their disruptiveness, these vehicles attempted to avoid using the roads at peak hours.

9.2.4.2 Predictions of Traffic Volume when So-Go is Operational

Land development spawns many kinds of economic activity which, taken together, create multi-functional transportation needs. These influence the traffic on the regional road system near the development. Thus, predicting the increase in traffic at or near So-Go is the main issue in assessing the building's impact on the local transportation infrastructure. The Aggregate Sequential Demand Model is the method most generally adopted for this purpose. It is divided into four procedures: trip generation; trip distribution; model split; and network assignment. This model also combines the possible volume of journeys to the site with trips into the neighbouring road systems and further analyses the combined impact on regional roads after the site is developed. Figure 9-13 outlines the process of assessing the impact So-Go has on traffic flow.[8]

[8] Refer to Kua-San Company, 1993, p. 3-2-1 to 3-2-13.

FIG 9-13: flow chart of aggregate sequential demand model



The purpose of this assessment is to estimate the number of journeys into and out of the site once it is operational. The analysis first depends on establishing the building's intended purpose and size. Then the number of trips per hour during peak hours to and from the commercial site are found. From this, the number of peak-hour journeys to and from all the relevant land area can be calculated. The formula is as follows.

$$T = \Sigma_j A_j * t_j$$

- T: the number of trips generated in the future
- A_j: the floor area of type 'j' of land use in the future
- t_j: the number of trips of type 'j' land use per unit of floor area

The result:

- shops: 36,269 square metres * 0.1031 = 3,739 (people)
- offices: 6,332 square metres * 0.201 = 127 (people)
- total: 3,866 people

This finding indicates that So-Go will generate 3,866 trips per hour during peak hours. According to the report "the Mass Rapid Transit (MRT) System Project of Metropolitan Taichung" the coefficient of the peak time is 0.22. Consequently, So-Go will attract 17,572 (person) trips per day after the site is developed.

Table 9-15 shows the rate at which trips are generated per hour during peak hours at a major commercial building. Table 9-16 lists the distribution rates of the model split for uses of the various shops and offices.

Table 9-15 : Trip Rates per Hour during Rush Hours at Major Business Locations

Item Location	People & Trips During Survey Time (people/2 hrs)	Total Area Of Floors (100 m^2)	Trip Rate Per Hour During Rush Hour (people/100 m^2/hr)	Average Value
Lai Lai Dept. Store	1479	182.82	4.04	10.31
Long Hsin Dept. Store	3515	157.74	11.14	
Evergreen Dept. Store	2129	67.65	15.74	
National Hotel	743	200.20	1.86	1.48
Plaza Hotel	361	165.16	1.10	
Sun Tun Hun	57	13.87	2.06	3.62
New World Boutique	453	43.74	5.18	
Bank of Communications	306	2.00	76.50	44.29
Citibank	223	2.40	46.46	
Chinatrust Commercial Bank	732	36.96	9.90	
Bank of Shi Hwa	418	92.40	2.26	2.01
Kuo Tai Building	873	248.40	1.76	
Lotus Garden Restaurant	458	32.67	7.01	5.83
Jin Bee Yuan Restaurant	56	22.44	1.25	
Tsui Heng Cun Restaurant	133	7.20	9.24	

Data Source : Taichung City Government, 1993a, p.138

Table 9-16: Distribution Rates of Model Split for Various Land Applications

Application Type / Model Split	Residence %	Dept. Store Supermarket %	Hotel %	Boutique Shop %	Financial Bank %	Business Building %	Large Restaurant %
Bus	6.8	8.52	0.81	0.00	0.83	0.90	0.11
Taxi Cab	0.6	10.61	10.58	1.21	4.06	3.82	12.02
Private Car	16.2	21.33	55.23	46.65	40.65	46.77	73.96
Motorbike & Bike	54.1	44.59	0.54	16.77	35.48	48.33	5.02
Others	22.3	14.95	32.84	35.37	18.98	0.18	8.89
Total	100.0	100.00	100.00	100.00	100.00	100.00	100.00

Data source: Taichung City Government, 1993a, p.140

Table 9-17 indicates the trips made via each model type to So-Go's shops and offices during peak hours. Motorbikes are the most popular mode of transport, accounting for 1,728 trips, followed by private cars which account for 856 trips. Public transport is the least used mode, accounting for only 321 journeys - less than 10% of the total number of trips made. Table 9-18 shows the loading rates of each of the major modes of transport.

Table 9-17 :Statistics of People & Trips of Each Model Split Type per Hour at the Base during Rush Hour

Unit : people . trip

Application of building	Mass transportation	Taxi cab	Private car	Motorbike	Others (walking)	Total
Office	2	5	59	61	0	127
Bazaar	319	397	797	1667	559	3739
Total	321	402	856	1728	559	3866

Table 9-18: Loading Rate of Every Model Split

Type of model split	Bus	Taxi cab	Private car	Motorbike
Loading Rate	22	1.6	1.6	1.3

Data source:, You Jiuh Constructing Company, 1997, P. 7-36.

Based on those rates, Table 9-19 indicates the increase in the volume of traffic broken down by mode of transport. It is estimated that 1,244 Passenger Car Units (PCUs) per hour visit and leave the site at peak

hour every day. As the principle of consistent traffic flow is adhered to, the increased traffic volume is distributed onto roads near the site.

Table 9-19 : Increasing Volume of Traffic after Developing the Base

Model Split	Bus	Taxi Cab	Private Car	Motorbike	PCU
Office	0	3	37	47	54
Bazaar	15	248	498	1282	1190
Total	15	251	535	1329	1244

Note: PCU stands for Passenger Car Unit. Based on a small private car, a big truck is 1.6 PCU and a motorbike is 0.3 PCU.

9.2.4.3 Assessment of Traffic Impact when So-Go is Operational

Estimating the distribution of journeys to and from the building means comparing the present distribution in the area with the distribution found once So-Go is fully up and running. As Table 9-18 shows (see above), So-Go's offices and shops are the main reasons for journeys there during peak hours - generating about 1,244 PCU trips per peak-hour.

Apart from the specific traffic increases that So-Go generates, we must also consider the natural growth of traffic volume. Taken together, these two indicate the likely traffic flow per hour during peak hours that we can expect to see on the neighbourhood's main roads and intersections. We will look at the relevant roads and intersections separately, and consider them in terms of their pre- and post-So-Go status.

9.2.4.3.1 Assessment of the Service Level on the Roads

From analyses of the results of traffic volume discussed above, we find the value of volume/capacity (V/C), which stands for the volume of traffic per peak-hour in relation to the estimated capacity prior to and after So-Go's development. From this value we can deduce the Congested Time Function and then the travelling velocity per peak-hour at each stage can be calculated. Table 9-20 outlines the service level on nearby roads during peak hours pre- and post-development of the So-Go site.

Table 9-20: Analysis of Level of Service (LOS) during Rush Hours prior to & after the Development of the Base

Name of Road	Section of Road	Traffic Volume Before Developing (PCU)	Predicted Travel Rate (KPH)	Level Of Service (LOS)	Traffic Volume After Developing (PCU)	Predicted Travel Rate	Level Of Service (LOS)
Taichung Kan Road	Chon Ming South Rd. – Park Path (fast lane)	5589	17.40	F	6209	12.70	F
	Chon Ming South Rd. – Park Path (slow lane)	2395	17.10	F	2672	12.40	F
Jiang Shin Road	Taichung Gun Road – San Chon Rd	2033	24.58	C	2236	24.02	C
Mei Tsui Road	Taichung Gun Road – Gon Yi Road	2061	22.56	C	2267	19.80	D
In Tsai Road	Taichung Gun Road – Gon Yi Road	2469	23.93	C	2713	23.25	C
Ming Yi Street	Chon Ming South Rd. – Park Path	360	32.69	B	726	24.79	C

Note: Data prior to development is based on, Taichung City Government, 1993a, pp. 82-84.

The findings reveal that the service level on Taichung Kan Road both before and after So-Go's development is ranked as class 'F' - meaning that delays on the intersection last longer than 80 seconds and that the volume of traffic is more than the road can comfortably handle. Jiang Shin Road is ranked as class 'C' both prior to and after development, indicating an acceptable level of delay. The service level of Mei Tsui Road deteriorates post-So-Go, for its ranking slips from class 'C' (acceptable delay) to class 'D' (endurable delay). The average delay on the intersection is longer than 45 seconds; all vehicles must now at least pause there and some even have to wait for the next green light. The service level of Ming Yi Street similarly deteriorates post-So-Go, slipping from a 'B' ranking to a 'C' - meaning that the delay at this intersection now exceeds 30 seconds(see figure 9-14).

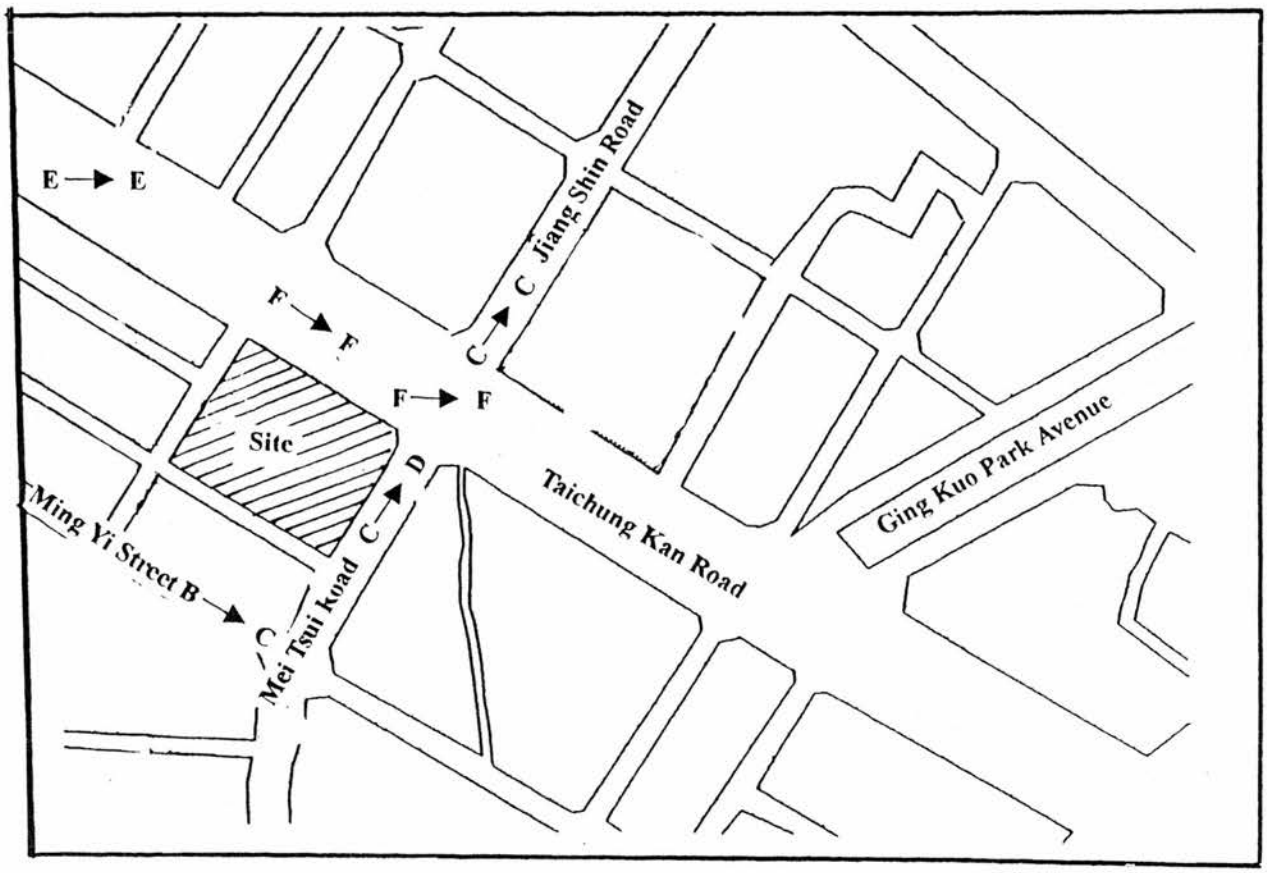


FIG 9-14: Impact on the service level of the road and Intersection

9.2.4.3.2 Impact Assessment of the Intersection Service Level

To gauge the level of service at intersections, we can apply the index of average delay time per car at that spot. The assessment begins by calculating the Movement Delay (dm), then figures out the Approach Delay (dA) and concludes with the average additional traffic flow at each approach intersection. This yields the average delay at the intersection (dI).

Since the traffic flow on Taichung Kan Road during peak hour is already saturated, the level of service at related intersections is affected. This results in the degradation of the service level at major intersections prior to development to below class 'E'. In addition, the traffic capacity of Mei Tsui Road is low (just two lanes) which means the average delay time between the intersection of Taichung Kan Road and Mei Tsui Road is more than 80 seconds, giving it a ranking of class 'F'.

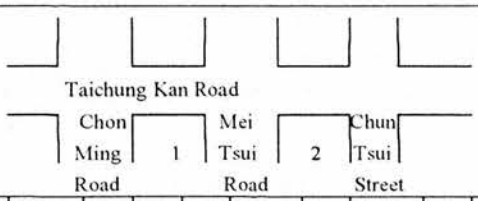
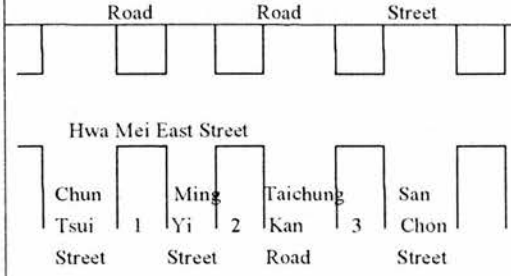
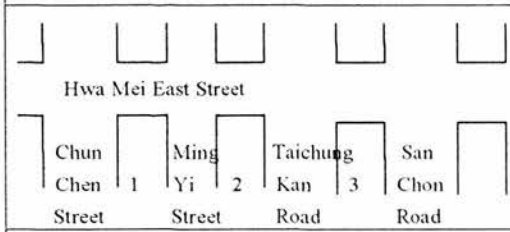
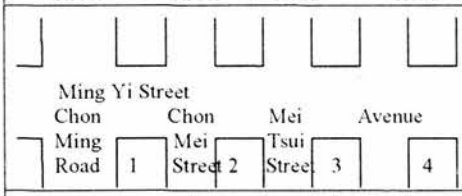
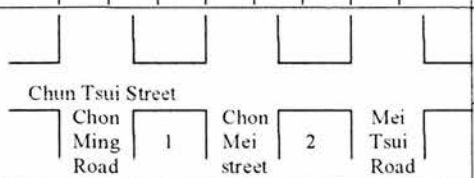
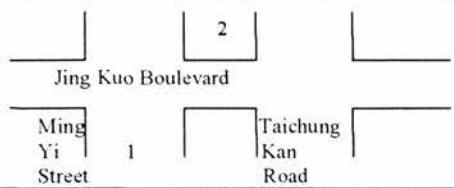
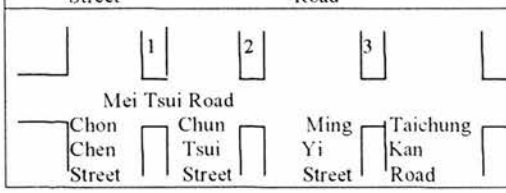
Once So-Go became operational, the average delay time at major intersections became longer than was the case prior to its development. Nevertheless, being poor to start with, the ranking of the service levels at these intersections has not yet changed, as Table 9-21 and Figure 9-14 shows.

Table 9-21: Analysis of the Level of Service before & after Development of the site

Number of Approach Intersection	Before Development of the site						After Development of the site				
	Number	Traffic Flow At Peak Time (PCU)	Approach Delay (SEC)	Level Of Service	Intersection Delay (SEC)	Level of Service at intersection	Traffic Flow At Peak Time (PCU)	Approach Delay (SEC)	Level Of Service	Intersection Delay (SEC)	Level of Service at intersection
Taichung Kan Road / Chon Ming South Road / Chon Ming Road	1	2132	53.72	D		E	2196	55.34	D	79.89	E
	2	6069	93.22	F	77.67		6322	97.09	F		
	3	2234	56.82	D			2302	58.54	D		
	4	4535	78.40	E			4548	78.63	E		
Taichung Kan Road / Mei Tsui Road / Jing Shin Road	1	970	64.25	E	85.51	F	1085	78.64	E	92.36	F
	2	5795	89.63	F			6024	97.88	F		
	3	1046	71.39	E			1153	78.75	E		
	4	4376	88.13	F			4557	91.79	F		
Taichung Kan Road / Ging Kuo Boulevard	1	561	36.96	C	67.88	E	570	37.58	C	69.72	E
	2	5865	73.49	E			5985	74.99	E		
	3	334	35.43	C			340	36.02	C		
	4	3820	66.65	E			3971	69.28	E		

Data source: Kua-San Company , 1993, P. 3-3-8

Table 9-22: Survey of Parking on Every Major & Minor Roads near the Site

Name of Major Roads & Intersection	Block	Arrangement of parking Space	Parking Spaces Demanded	Parking Spaces Supply	Rate of Demanded & Supply(D/S)
	1	Yes	21	46	2.19
	2	Yes	11	26	2.36
	1	No	15	21	1.40
	2	No	16	29	1.81
	3	Yes	34	60	1.76
	1	No	6	9	1.28
	2	No	26	40	1.53
	3	No	18	29	1.60
	1	No	20	24	1.20
	2	No	19	27	1.40
	3	No	30	41	1.37
	4	No	9	14	1.50
	1	No	31	44	1.42
	2	No	29	40	1.38
	1	Yes	18	30	1.67
	2	Yes	17	31	1.82
	1	No	32	65	2.00
	2	No	9	12	1.30
	3	No	15	19	1.72

9.2.4.4 Status Quo of the Parking Adjacent to the Site

At the end of 1992, the Kua-San Company conducted a survey of the major and minor roads within 300 metres of the site.[9] Kerb-side parking and the actual amount of parking spaces available are listed in Table 9-22.As Table 9-22 indicates, the proportionate demand and supply (D/S) of parking space on both sides of Taichung Kan Road is 2.36. Surveys have found that many drivers violate the parking rules by leaving their cars on pavements and slow traffic lanes, a pattern of behaviour which is also frequently found on minor roads. Cars parking spaces are perpendicular in front of the majority of shops on Mei Tsui Road. This lay-out not only takes up more of the available road area and worsens the problems at the intersection, but it also affects the flow of traffic during peak hours. Parking spaces adjacent to the site are obviously insufficient since the rate of demand and supply (D/S) exceeds 1.2, which shows that the parking problem has become critical in this area.

9.2.4.5 Parking Impact Assessment

The analysis of parking requirement varies depending on what the land is to be used for, e.g. shops, offices, etc. So, taking account of this, the parking requirements for cars and motorbikes during peak hours are related to the frequency of journeys; the distribution of the model split; the average parking time; and the average number of passengers per car, etc. The formula for estimating parking requirements is as follows:

$$Pij = \frac{Di \times Mj \times T}{Fj}$$

- Pij: rate of parking requirement for model split type' j' for use' i' during peak hours
- Di: trips generation rate of journeys for use 'i' during peak time
- Mj: distribution rate of model split type' j'
- T: average parking time (50 minutes for mall shopping)

[9] The surveys were conducted in September and October of 1992 to assess the demand and supply of parking spaces to serve as a reference for planning and design prior to building the department store. Refer to the Kua-San Company, 1993, pp. 3-1-28 to 3-1-32.

- Fj: average loading rate of model split type 'j'

The estimated result is listed in Table 9-24. Four hundred and fifty two (452) car parking spaces are required and the parking space requirement for motorbikes is 1,115. As Table 9-23 shows, the Taichung Municipal Government conducted a survey in 1992 of parking rates in all kinds of buildings during peak hours. It is estimated that the parking requirement for visits to shops and offices is 633 spaces (see Table 9-24). The Building Code prescribes the minimum requirements of parking spaces for all types of building. As Table 9-24 shows, 285 spaces is in compliance with this code. In addition, based on the EIA's Principles for High-Rise Buildings in Taichung, cars require 366 spaces and motorbikes 548.

Table 9-23 : Rates of Parking Requirement during Rush Hour for All Buildings

Application	Rate of Parking Requirement during Rush Hour (parking space/hr/100 m^2)
Residence	0.49
Department Store, Supermarket	1.64
Hotel	0.51
Boutique	1.04
Financial Bank	11.80
Office Building	0.62
Large Restaurant	2.56

Data source: Taichung City Government, 1993a, p.148, Table 5-3.

Table 9-24 : Comparison of Estimated Parking Requirement of SoGo Building

Application	**Prediction Model Of Taichung Government (parking space)**	**Estimation Model of Trips (parking space)**	**Requirement of Legal Regulation (parking space)**	**EIA Principle of High-rise Buildings in Taichung (parking space)**
Bazaars in Dept. Store	594	415	242	312
Office	39	37	43	54
Total	633	452	285	366

Notes: a. 1,115 parking spaces for motorbikes are also included in the estimation model of trips.

b. The EIA principle of high-rise buildings in Taichung also requires 548 parking spaces for motorbikes additionally.

The So-Go building provides 368 car parking spaces and 550 motorbike parking spaces. These are located on the lowest three levels of the basement. Though this provision meets the EIA's guidelines laid down in their Principles for High-Rise Buildings in Taichung, it still cannot satisfy the estimated parking requirements of So-Go's visiting shoppers and office employees. Nor does it measure up to the number of parking slots the Taichung Municipal Government's survey identified were necessary. However, there is a public car park to the west of the So-Go site which, through joint development, could provide an additional 120 spaces. Consequently, we can conclude that the full tally of parking spaces supplied in or near this site is 486.

In addition, Taichung Kan Road is one of the scheduled route stops of the Mass Rapid Transit (MRT) system. As a result, people wanting to visit So-Go should find the MRT system attractive to use once the MRT is completed.

As vehicles using So-Go's parking facilities have to come and go via the building's own entry/exit route, bottlenecks occur there all the time. For this reason, So-Go's access route is located on a 10-metre wide non-thoroughfare road. This provision should go some way towards ameliorating the traffic burden on the major roads nearby.

9.2.4.6 The Impact of the Public Transport System

When So-Go is fully operational, it will attract 3,866 trips in peak hour. However, 8.52% of those visits to So-Go's department store and 0.9% of those to its office premises are made via public transport, as we saw in Table 9-16 above. There are 20 bus routes operating in the near vacinity of So-Go, with bus stops spaced every 250 metres along their routes. So, every hour public transport can provide an average of 113 bus journeys carrying 3,955 passengers, who are travelling to the western district from all over Taichung.

As a result, the current public transport system around So-Go is capable of satisfying additional demands even after the site is fully developed.

9.2.5 Social and Economic Impacts

9.2.5.1 Land Use

So-Go's impact on the use of land can be divided into its construction and operational stages. During construction, as the site's original old houses and surrounding gardens were demolished, the area was transformed into a working building site, complete with its temporary housing etc. In particular, the terrain was changed beyond recognition during the laying of the foundations. The final product of a 91-metre tall high-rise permanently altered the use being made of the land. As the site is located in Taichung's commercial heart, this building not only became a new visual focus but also promoted the development of further high-rises around the neighbourhood. During construction, the visual impact of the building work was ameliorated by the attractive fencing erected around the site.

Once completed, the land is primarily designated for use as a commercial centre. However, plenty of open space is also provided for pedestrians, shoppers and office staff. Therefore, in addition to So-Go's business functions, this land now also serves as a place for recreation and entertainment.

9.2.5.2 The Impact on the Economic Environment

9.2.5.2.1 Employment

In 1992, the population of Taichung was 794,960 with a growth rate of 2.68%. The population density was 5,221 people per square kilometre. Sub-divided into districts, the population of the central and eastern districts actually declined; by -2.56% and -0.97% respectively in 1992. However, the population

grew in the other six districts of the city. The growth rate in the western district, where the site is located, was 0.97% in 1992 - a rate far lower than the average for Taichung City as a whole. The rate of of unemployment was 1.63%.

The kinds of employment offered by Taichung - the central metropolis of mid-Taiwan possessing the assets of a superb geographical location and a convenient transportation system - are those associated with a busy commercial and industrial hub. Tertiary industry is well-developed, employing 63.25% of all the workers in this city. Most citizens are employed in business, transportation, finance, insurance, real estate and service industries.

In 1986, there were 32,312 stores and shops in Taichung. By 1992, this number had increased to 37,053. However, by 1995, the number had fallen to 21,431 indicating the impact of the economic recession on commercial activities.

During construction, So-Go required 200 building workers, augmenting the employment opportunities in that sector. However, as the building phase only lasted 400 days, this was a temporary increase which did not greatly impact on the integral employment structure.

Once operational as shops and offices, So-Go offers close to 500 employment opportunities (see Table 9-25). As this figure represents 0.13% of employment in Taichung in 1995, it can be considered as having a significant impact due to business competition, Job loss in the central business district is predicted as 250 jobs.

Table 9-25 So-Go's employment opportunities

Type	Floor (m^2)	Rate of employment attracted (persons/m^2 day)	Employed persons (persons/day)	Local (%)	Non-local (%)
Department store	33,537	0.010	336	90	10
Office	6,332	0.007	44	15	85
Restaurant	1,531	0.015	23	90	10
Recreation	1,201	0.009	11	40	60
Parking	9,844	0.002	20	90	10
Total			434	89	11
Job loss in CBD			250		

Note: a. The rate of employment attracted is according to the EIS (appendix p8-1) of Taichung Regional shopping Mall, see Taiwan Sugar Corporation , 1997

b. local labour is employees already in residence in the site daily commuting zone being recruited , the rate according to Morris(1995 , p.23) Predicted employment of So-Go Building

9.2.5.2.2 Economic Activities

During the construction phase, So-Go's impact on economic activities included the consumption of building materials and the employment offered to construction-related workers such as plumbers, electricians and interior decorators. At the operational stage, the remaining construction workers and the employees of So-Go's shops and offices live and consume near the site, which probably has a positive effect on the immediate local economy. It is estimated that £6m of business tax can be generated annually from So-Go when it is up and running.

9.2.5.2.3 Land Prices

Land is scarce and precious in Taiwan because of its narrowness and its dense population. This is even more the case in its urban areas. Under the inexorable logic of demand and supply, the price of land is rising as land resources gradually diminish, especially in areas possessing well-developed public infrastructures. So-Go's shoppers and office employees promote further local economic activity and expedite the development of land around the district. Thus the price of land near the area should also increase.

9.2.5.2.4 Living Standards

As a large number of consumers will be attracted to this building after its completion, So-Go is bound to have some impact on the living standards of the district. However, as this impact is most likely to be highly localised in its effect, So-Go will probably have a negligible impact on living standards in Taichung as a whole.

9.2.5.3 Impact on the Social Environment

9.2.5.3.1 Population Structure

So-Go's 200 construction workers (50 of them living on the site) will migrate to other sites once the building work is finished. Their temporary presence has no obvious impact on the numbers or structure of the local population.

The operational stage employs 434 employees (see Table 9-25 above) - a mere 0.4% of the western district's population. The daily shoppers and clients come to 17,572 which represents a much bigger proportion (16%) of the western district's population. However, as most of these are commuters, their impact on the local population is negligible.

9.2.5.3.2 Public Facilities

Public facilities in the area include car parks, schools, parks and the transport infrastructure. Most of the roads near the site are already developed though their capacity is a cause for concern since most of the Volume/ Capacity(V/C) ratios are more than 0.9 affecting their levels of service.

We have already seen from the survey conducted by the Kua-San Company in 1992 that parking facilities in the district are obviously insufficient. The rate of demand and supply is mostly above 1.5[10], which means that there are only two parking spaces for every three cars wanting to use them. Taichung Kan Road is the worst affected; its rate of demand and supply is around 2.36.

As for educational facilities, there are six primary schools and five junior high schools in the area, with an average area of 1.93 square metres per person in the former and 1.75 square metres per person in the latter (see Table 9-26 below). There facilities are sufficient for the moment. However, it is estimated that 10% of employees (approx. 45 people) will move into this district as Table 9-25 shows above.

Table 9-26 public facilities in the western district

Public Facility	Total No.	Area(ha)	Area for Each Person (m^2/person)	Minimum Required Area For 1 Person (m^2/person)	Result
Junior High School	5	17.5	1.75	1.3	Sufficient
Elementary School	6	19.3	1.93	1.6	Sufficient
Park	13	22.5	2.25	2.5	Insufficient
Gym/Stadium	1	4.6	0.46	0.7	Insufficient
Parking Lot	10	4.3	0.43	0.5	Insufficient
Children Playground	4	3.8	0.38	0.8	Insufficient

Note: The minimum required area for each person is based on the lowest standard prescribed in the periodic review and performance regulations of the urban project.

There are 13 parks in this region covering a total area of 22.5 hectares (see Table 9-26). The average park area per capita is 2.2 square metres, which is insufficient. But, as population numbers are not likely to rise significantly, this is not likely to become a serious issue for the district.

[10] Refer to Kua-San, 1993, pp. 3-1-28 to 3-1-30.

For playground and sport facilities, there is a stadium in the western district with a total area of 4.6 hectares and an average area of 0.46 square metres for each local resident. It goes without saying that the land designated for recreational use is not enough.

9-3 Mitigation Measures

geology

(a) preliminary construction & drainage: Earthwork excavation reduces the pressure of the land, which causes the earth layer to bloat and the ground bulge. Thus, the earthwork should be based on the principle of divided layers in separate areas to reduce the axial pressure decreasing speed. Besides, earth blockade ought to be implemented prior to excavation to prevent soils from moving sidewards. Furthermore, the maximum moving distance occurs at the spot of 19.2 meters underground through the analysis of the Rido model. Consequently, slope of the building is about 1/1800, which is within the acceptable extent.

(b) tracing & monitoring: To reduce the impact on adjacent houses and public facilities to rational extent, incessant monitoring during construction needs to be performed to control the difference between actuality and estimation and to take other mitigation measures if necessary. A monitoring system for safety should include following items.

hydrology

Water pollutants will be produced during constructing and operating stages, mitigation measures need to be taken to reduce pollution.

(a) mitigation measure during construction stage: To avoid draining polluted water into Mei Chuan river directly affecting its water quality, a package of wastewater treatment facilities will be adopted and then hand it to the sewage company. In addition, slurry from construction and wastewater from tire cleaning will be precipitated, treated and disposed at the sand pool and then drained to the drainage facilities.

(b) mitigation measure during operation stage: There will be 400 CMD of wastewater in this building

daily, with a COD of 300 ppm, a BOD_5 of 180 ppm and an SS of 110 ppm. Direct drainage will impose serious impact on the quality of water in the river. In order to lessen the impact, a wastewater treatment facility will be set up 14. The quality of water after treatment has a COD under 60 ppm, a BOD_5 under 27 ppm, an SS under 25 ppm, an amount of intestinal bacillus less than 500 unit/ml and a PH value between 6 to 9.

noise

(a) mitigation measure during construction stage: The sensitive belt around the base is the southern residence area, which is at the opposite side of the construction site divided by a 6-m wide of road. As a result, noise during construction will definitely affect the nearby residents. Based on the environmental prediction results mentioned above, the increased amount of noise from constructing machinery is 9 dB(A), whose most affected area is the southern residence. Therefore, mitigation measures have to be taken. A 3-m high of sound-proof wall will be established at the south of the construction base and 3 – 5 dB(A) of noise amount is estimated to be able to reduce. Consequently, the increasing amount of noise from constructing machinery can be decreased below 5 dB(A).

(b) mitigation measure during operating stage: As this district belongs to type II noise control area, the standard of noise control is 65 dB(A) day and night and 50 dB(A) at late night. The source of noise during operation comes from business places since this building is served as a department store, which will interrupt the neighborhood undoubtedly. And the business hours last until 10:30 pm, which shall impose impact on the evening quietness as well. As a result, sound absorbing materials will be utilized inside the building to decrease noise.

traffic impact

(a) mitigation measure during construction: The traffic impact during construction mainly refers to the

impact of the level of service on current roads, which is resulted from traffic flow of transportation vehicles. The other impact refers to the occupation or closing-down of the road because of construction procedures or materials, which will affect traffic flow and generate a bottleneck of traffic. Thus, mitigation measures during construction include excavation and construction in different areas in different periods, enough space inside the base to allow the operation of construction machinery as well as the storage of construction materials and avoidance of traveling transportation trucks during rush hours to reduce traffic flow.

(b) mitigation measure during operation: The traffic impacts during operation stage refer to parking of derived vehicles, obstruction of traffic flow due to pick-up/dump trucks and the impact on nearby roads and residents because of entrance/exit of vehicles at the parking lot. For reducing parking impact of derived vehicles, vehicles of customers and employees should not be parked along the sides of nearby roads because entrance and exit of residents and the capacity of traffic flow will be affected.

9.4 THE EIA PROCESS AND THE SO-GO BUILDING

As a huge department store, the impact of the So-Go Building on the city of Taichung is considerable. As this project in now up and running, our understanding of the application of the EIA system to high-rise buildings is enhanced by considering this case.

9.4.1 The EIA Implementation Process for the So-Go Building

The site is located on an important artery of Taichung, an area that was originally residential. As the region was already emerging as a bustling shopping area and Taichung's commercial activities were in any event spreading westwards towards the proposed site, Taichung city government agreed to change the neighbourhood's zoning status from residential to commercial - a rezoning process that began in 1987 and

concluded in May 1990. The land reclamation of the site was completed in February 1992 and about 200 m^2 along the side of Taichung kan Road was designated as a car park.[11]

Prior to the EIA Act coming into force in December 1994, the EIA system operated in compliance with the "Programme of Strengthening EIA" This programme did not cover all proposed projects, and high-rises were one of the excluded categories. On January 16 1991, the Ministry of Interior Affairs announced "Awards of Integrated Design for Controlled Areas without Implementation of a Floor Area Ratio". This deemed that if the total floor area was ten times more than the area of the site when the construction permit was being applied for, then an urban plan complete with a traffic impact report was to be presented. This new regulation gave the EIA system a gateway into assessing high-rises projects. Shortly afterwards, in July 1992, the Taichung city government announced the "Guidelines for the Implementation of the EIA Process for High-Rise Buildings in Taichung", a regulation which formalised that high-rises must now submit to EIA examination.[12].

The EIA report on the So-Go Building was presented for review in October 1992. In the month preceding this presentation the So-Go company had consulted with relevant government authorities and public utility enterprises (e.g., water, power, gas, etc.) and had canvassed the neighbourhood for local opinion. Table 9-27 outlines the timing of events relating to its EIA activities. To further analyse the implementation process, we will divide it into four stages: urban planning changes, preparing the EIA report, reviewing the EIA report and EIA monitoring and auditing.

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[11] According to urban zoning regulations, the owner of the land gets the benefit from alterations. Thus, the attached conditions demanded the donation of parking space as a replacement for construction funds or the donation of land to the local government.

[12] Taichung was the second Taiwanese city to implement an EIA system for high-rise buildings, preceded only by Kaoshiung. The author of this dissertation was the main promoter of the scheme, in his then role of head of the Building Management Division of Taichung city government.

Table 9-27: Summary of EIA Implementation Events relating to the So-Go Building

Date	Events
1987.10	Land zoning change sought
1990.5	Zone changes from residential to commercial status
1992.2	Condition attached to zoning change for this site is that 200 m^2 of land be donated to the city government
1992.7	Taichung Government publishes "Guidelines for the EIA Process for High-Rise Buildings in Taichung" & "Principles"
1992.8	So-Go company consult with relevant government authorities and public utility enterprises
1992.10	So-Go Building application for EIA review is submitted
1992.10	Public Works Bureau of Taichung City Government (the competent authority) consult with other government authorities for views on this development
1992.11	Public Works Bureau conduct a site review and a briefing meeting
1992.12	EIA Committee convene the 1st review meeting. The So-Go project is rejected (Dec. 2nd)
1992.12	So-Go company send supplemental instructions concerning environmental impacts
1993.1	EIA Committee convene the 2nd review meeting. The project is passed (Jan.13)
1993.6	Taichung City Government announce the result of the EIA review (June 1st)
1993.10	Neighbours near the site appeal against the decision on the grounds of the project's likely impact on local traffic conditions
1994.2	So-Go company rent the donated parking lot for £500,000 and integrate parking space requirements into the department store plans
1994.5	So-Go company is fined for starting construction before being issued with a permit
1994.9	Taichung City Government issue the construction permit
1995.10	So-Go Building is completed and Taichung city government issue the occupancy permit
1995.11	So-Go department store formally opens (Nov. 11th)
1996.12	So-Go company claims annual sales in excess of £100m
1998.11	The president of So-Go dept. store is subpoenaed during the Asian financial crisis

9.4.1.1 Phase One (1987-1992): Urban Planning Changes

The site, located in the westside of Taichung, had been designated as belonging within an agricultural and residential zone. By 1980 the region's population had exceeded 600,000 causing business activities to concentrate excessively in the downtown area. Taichung city government expected to establish a multi-core city, pulling business and population to the westside. In compliance with the demands for urban development, suburban areas were changed to business districts one after another.

In 1987 Taichung city government initiated the zoning change process which was completed by 1990, with the condition attached that lands could not be developed until the developers had implemented land reclamation. The So-Go company finished land reclamation in 1992 which included establishing an

infrastructure (e.g., roads and car parks) and donating land to the city government for public facilities - which included a car park on the northwestern side of the site of about 200m^2. With this done, and the zoning change formalised, the land owner was free to apply for permission to build So-Go.

9.4.1.2 Phase Two (1991-1992): Prediction and Assessment of Environmental Impacts and Preparation of the EIA Report

To comply with the out-of-town policy of the city government, the So-Go company proposed to construct a high-rise building housing a department store and shopping malls. According to the company's planning report, this building was to achieve the following goals:

a) to develop the site in a way which would sustain the business activities of Taichung kan Road;

b) to introduce new commercial activity to the region so as to take some pressure off the city centre, balancing it with regional development;

c) to develop the site in a way which would reduce the concentration of journeys made by non-commuting traffic so as to prevent congestion;

d) to enhance the land value of So-Go's neighbourhood so as to motivate re-development of surrounding districts, expedite urban renewal and promote the environmental quality of the area; and

e) to combine site development and urban landscape design so as to establish a pleasing regional image.

(Kua-San Company 1993, pp. 2-1-18, 2-1-19)

The So-Go company, through its sub-contracted consultancy firm, began to prepare the EIA report in November 1991 which included sections on the physical, social and economic environments, traffic, landscaping, engineering techniques and financial assessments. In August 1992 the So-Go company began the process of consulting with relevant government agencies and public utility enterprises. No cast-iron arguments against developing the project emerged during this consultation stage (see Table 9-28). The company canvassed local opinion of the proposal in mid-September and again received no major

objections. Consequently, it went ahead with preparing its report and applied to the city government for an EIA review in October 1992.

Table 9-28: Agencies and Organisations Consulted during the Preparation of the EIA Report

Consultees	Comments
Water supply company	400mm pipes installed near the site can provide water for the building. This site is not located within a water source protection area.
Telecommunications company	Lines can be supplied through the engine room of Chung Ming on completion of the building. A telecommunication room (about 59 m^2) inside the building should be preserved.
Taiwan Power company	Agree to supply required power.
Bureau of Reconstruction	This site is not located in a preservation area or wildlife protection area.
Bureau of Public Works	This site is not situated in a flood area but is within an underground water control area.
Environmental Protection Bureau	This site is within the control area of water pollution, air pollution (NO_2, SO_2, Pb etc. at 2nd level control category and CO, TSP & O_3 at 3rd level control category) and 2nd level noise pollution category. So pollutant emission standards must be met.
Bureau of Public Affairs	This site is not located within a specified cultural property area, nor in a flight control area.
Civil Aeronautics Administration	This site is not located within a flight control area

9.4.1.3 Phase Three (1992-1993): Review of the EIA Report

On receipt of the EIA report in October 1992, the Bureau of Public Works consulted with relevant authorities about its contents. As no objections were raised, the competent authority then published it so as to garner feedback from interested public groups and a site review was conducted. The first round of public consultation did not provoke objections so the first review meeting was convened on December 2 1992. The findings were that the building was too close to a major artery (Taichung Kan Road); that allocated parking space was inadequate; and that traffic flow was likely to be severely affected by the lack of adequate space for shoppers to disembark from buses etc. in order to enter the building. The review concluded that parking and traffic management arrangements needed further work.

The So-Go company responded to these findings by retracting the building plan back from the road; reserving a rectangular square for temporary parking; allocating extra parking spaces beyond the

regulation's formal requirement; and integrating the building's parking facilities with those of the car park on the land donated to the city government. A second review meeting was convened on January 13, 1993 and this time the project was passed. The report of the EIA review decision was published in June of that year.

After receiving the approval report, local residents then appealed against the decision on the grounds that the traffic the building would generate was unacceptably high, making their streets noisy and dangerous. In response, the city government required the So-Go company to consult with local residents; guarantee that the company would direct traffic during the building's operational hours; and ensure that its construction vehicles would by-pass the community while So-Go was being built.

Public participation was quite limited for the So-Go project. Local residents were the only group to take an active interest, and even then only at a late stage of the review process. Environmental protection groups did not avail themselves of the opportunity to participate - probably because the So-Go project was the first high-rise to be subject to the EIA process and the general public was not yet familiar with how that process operated. In addition, the So-Go building was not inherently contentious for local residents. Having it would boost the local economy and increase job opportunities yet not impose the kinds of direct environmental damage that might be wrought by, say, a factory or a power station.

9.4.1.4 Phase Four (1994-): Monitoring and Auditing

After the city government approved the EIA review in 1993, the So-Go company began detailed design and applied for a construction permit in compliance with the decision report of the EIA committee. This took much longer than normal because a small area of land (about $20m^2$) within the construction site belonged to another owner who would not sell to the So-Go company, requiring the city government to levy the land and bid for its sale. Though the company did eventually receive its permit in September

1994, it commenced construction in May of that year and was fined and forced to suspend building work for the intervening four months while the permit was being authorised.

The city government monitored and audited the construction work to ensure it complied with the terms of the EIA approval report. They found that the building work exceeded agreed noise levels in respect of the task of steel board piling. The company was required to provide countermeasures which it did in the form of installing isolation devices (walls of steel boards) on the east side of the site to prevent the direct transmission of noise. In addition, they were required to suspend building work during the lunch hour. These improvements brought noise levels to within the agreed standard.

The company acquired its occupancy permit in October 1995 and formally opened that November. The city government monitored the company's traffic plan to ensure it complied with the terms of the approval report and to oversee that So-Go employees were directing traffic at the main, minor and parking bay entrances during business hours. Despite this monitoring, traffic flow deteriorated and illegal parking was commonplace.

The auditors also identified a wind hazard on the west side of the building in winter. This had been overlooked in the review report because So-Go's height (91m) did not make it mandatory that the developer conduct wind tunnel tests. In response to this newly-apparent hazard, the city government required that the company plant arbour trees on the west side to reduce wind velocity. The remedial effect of this countermeasure has only been partial however, as there is very little open space at that part of the site. Apart from this unanticipated issue, the So-Go Building has met the occupancy requirements of the EIA committee. Table 9-29 outlines the monitoring of the construction stage, while Table 9-30 presents the mitigation measures laid down in the EIA review conclusions. We can see from this table that three items have not yet been implemented.

Table9-29: EIA Monitoring and Auditing of the So-Go Building

Item	Result
Personnel in charge of environmental protection organisation	The environmental protection team is organised.
Funds for environmental protection work	Environmental protection costs £339,000: £3,000 for monitoring air quality, £6,500 water quality, £9,000 noise & vibration, £21,000 waste water treatment, £119,000 wastes & soils, £11,000 transportation, £150,000 landscaping, £15,000 geology, £2,500 sunk sand pool and £2,000 for air pollution control.
Treatment of public hazard disputes	(a) Residents petitioned against noise pollution from construction of the basement; mitigation measures were undertaken. (b) Construction materials piled on the side of the road and construction vehicles on roads influenced traffic; improvements made.
Abnormalities	None
Other serious issues	None
Implementation of monitoring system	Monitoring instruments operate normally.
Implementation of mitigation measures	Noise and traffic impact mitigation measures have not been implemented completely.

Data source: Collected from files of Taichung city government, information from So-Go company and Tseng Hsien Hsin architectural firm

Table 9-30: Site Review Report of EIA Implementation by the So-Go Company

	Item	Impact Description	Content of Mitigation Measure	Performance
Mitigation Measure	Infrastructural construction & water drainage	Rapid withdrawal of water will cause neighbouring ground to settle	Multi-layer water withdrawal and soil blocking facility will reduce this effect. Apply settlement markers for monitoring	Done
	Pollution of water	Daily waste water mud/slurry during construction.	A package for daily waste water treatment adopted to reduce pollution volume; sunk sand pools & guidance ditches dug to prevent out-flowing of mud/slurry	Except for the polluted surface of the road due to piling of materials, others implemented
	Noise	Noise of construction disturbs the peace	Noise-barrier walls installed and vehicle routes planned	Not implemented at first, but done after being notified
	Traffic	Construction vehicles occupy roads & obstruct the flow of cars	Avoid rush hours, build construction platforms & reduce road occupancy	Not done completely
	Landscape	The site influences city landscape	Fences built and colourfully painted	Done
	Obstruction of electric waves	Buildings block waves & affect local signal reception.	Common signal receiving equipment installed	Done
Status of implementation of EIA review conclusion	Traffic	Main entrances should be retracted as a square for temporary parking	The facade retracted more than 10 meters	Done
	Landscape	As a city landmark, the building needs a night-vision plan	Night lighting & a cartoon clock installed	Done
	Parking	Cars queue at the entrance to the parking lot and affect local traffic	Entrances extended to 3 lanes (2 entry, 1 exit)	Done
	Parking	Internal parking to be coupled with use of local car park	This car park has been acquired and designed for construction work	Done

Though it is conceptually convenient to separate out four stages to the EIA process, in practice they overlap. In total, the process from urban planning alterations to occupancy took eight years: rezoning and land reclamation (five years); preparing the EIA report (11 months); and reviewing the report (seven months, the review itself taking three months and the decision four). The final monitoring stage is continuous as auditing is done from construction through to occupancy to ensure that the terms of the EIA approval report are adhered to.

9.4.2 Decision Process

This section analyses the EIA decision-making process in terms of professional control, controls exerted directly by the public or by outside agencies, and various procedural controls.[13]. Note that judicial controls do not apply in the case of the So-Go building as it was assessed prior to the EIA Act coming into law.

9.4.2.1 Professional Control Mechanisms

To prevent policy-makers from dictating EIA review outcomes, EIA committees must possess a quota of professional experts (by law, exceeding two-thirds of the full committee membership), though the Chair tends to be appointed from the governmental policy-making ranks. In general, professionals not only possess relevant knowledge but their judgement tends to be informed by criteria other than local political interests. Table 9-31 shows the backgrounds of the EIA committee which assessed the So-Go case. As the EIA Act was not law at that time, the EIA article stipulating that professional representation must exceed two-thirds of the membership did not apply in this case. Almost half the members were governmental officials. The remainder (7 scholars and experts) accounted for 54% of the total membership.

Table 9-31: Composition of the So-Go EIA Review Committee

Background	No. of People	Proportion %	Representative Unit
Government Officials	6	46	public works, building management, law administration, urban planning, fire-fighting
Scholars	5	38	construction, traffic, civil engineering, urban planning, structure
Experts	2	16	guild of architects, guild of construction investment
Total	13	100	

[13] Generally, internal organisational control mechanisms are procedural, evaluative, judicial and professional. Other sources of control are development aid agencies, outside agencies and the public. See Tu , 1994, pp. 15-23.

Table 9-32 itemises the issues raised after the first review, most focusing on traffic and landscaping concerns while environmental management, energy economy and sustainable building issues were less in evidence. This particular emphasis reflects the disciplinary backgrounds of the So-Go committee members: most came with construction, traffic and urban planning expertise rather than environmental and resource management expertise. This mix was chosen because the main legal reference was to building law and the Bureau of Public Works was the main planning approval agency.

Table 9-32: Issues Raised by the EIA Committee on the First Review of the So-Go Building Proposal

Comments	Responses
Main entrances of buildings should be retracted for temporary parking. A night-view plan should be considered.	The front of the building retracted by 12 meters. Night lighting equipment and landmark landscaping installed on the roof.
Parking requirements need to be addressed further	Property rights on the adjacent car park have been bid for and integrally planned using a co-construction method.
Parking facilities for cars and motorbikes should be improved.	Done.
Plans for transportation control and evacuation during construction should be added.	Done.
Figures and descriptions of waste soil disposal plans should be attached.	Done.
Water supply and drainage and waste water treatment facilities should be modified in compliance with EIA principles.	Done. Standards of discharge of waste water designed according to 1998 standards.

Data source: files of Taichung city government , 1992

The second review meeting, held in January 1993, concluded that:

a) the EIA report is passed after being reviewed and agreed on;

b) a plan for including open space needs to be presented to the open space review committee; and

c) a detailed construction report is to be sent to the open space review committee.

As policy-makers cannot issue permits without the EIA committee's approval of a project, we can see how the professional control mechanism operates within the EIA process - in this case, contributing hugely to the management of So-Go's environmental impacts.

9.4.2.2 Controls exerted by outside agencies and directly by the public

Prior to 1994 there was little public participation since the EIA Act was not then law. Except for public information dissemination and site surveys, the mechanism of control by public sentiment was not effectively in place. In the So-Go review, public participation was largely limited to eliciting and reacting to the views of local residents. In addition, as this proposal was for a department store, it did not excite public concern about its environmental impacts in the way that, say, a power plant or chemical factory might. So, in this case, both the general public and agencies such as the mass media were not following every move - though it has to be said that when the media reported that the (Japanese) So-Go developers had begun construction work without being in possession of a permit, the city government was then obliged to act on that media coverage and demand that building work cease.

9.4.2.3 Procedural Controls

Procedures guide the manner and the order in which work is done. The EIA procedural process ensures that policy-makers cannot assume too much administrative discretion (Tu 1994, p.17). Clear and compulsory procedures must be followed in the course of assessing the EIS/EIR of a proposed high-rise, e.g., consultation with others, site surveys, etc. Other procedures aim to prohibit policy-makers from altering the due process. Table 9-33 lists the bodies consulted in connection with the So-Go Building and, as we can see, none raised objections to its construction. As a whole, procedural controls in the So-Go case did indeed shape the decision-making process.

Table 9-33: Consultation on the So-Go Building Proposal

Consultees	Comments
Divisions Consulted (Statutory)	
Urban Planning	No objections to zoning change
Water Utilisation	No objections; prohibit use of underground water
Agriculture & Forestry	No objections; trees on pavements need protection during construction
Maintenance & Service	No objections; road occupancy should be permitted in advance
Fire-fighting Department	No objections
Other Bodies Consulted	
Reclamation Division	No objections; land reclamation finished
Civil Engineering Division	No comments
Local Administrative Office of the Westside District	No comments
Industry & Commerce Division	Department stores to apply for occupancy permits prior to opening

Data Source: Files of Taichung City Government, 1992

Of the three mechanisms, professional control was the most influential in the So-Go case. Procedural controls did work but not all of them were in place for this particular assessment. Control by means of public participation and outside agencies was the weakest of the three. The procedures for ensuring public participation were not completely established, and the public itself was not yet conversant with the EIA system.

9.4.3 Key Issues about the EIA Process in relation to the So-Go Building

9.3.3.1 Local Prosperity v. Negative Impacts

Both the city government and local residents felt positive about the So-Go project during the planning stage, judging that it would augment the district's prosperity and boost local job opportunities. However, some members of the urban planning committee questioned the general benefits of the region's zoning

change, arguing that the only real beneficiaries would be the land developers.[14] Professional urban planners on the committee held a similar view. However, other committee members thought that So-Go would not only increase regional job opportunities and local government revenues (estimated at increased annual sales tax of £6m) but also provide a spur for further industrial development. These views were held by governmental officials, local residents and some of the experts on the committee (architectural and economics).

Though a debate between these competing views was in evidence in the So-Go case, the majority tended to be pro-business, which eventually led to the approval of the zoning change. Thereafter, few arguments surfaced during the EIA review and policy-making process on this case.

9.4.3.2 So-Go as a City Landmark v. as an Isolated High-Rise

The style and facade of the So-Go building was a topic of some concern during the EIA review. The building is located on a main route (Taichung kan Road) in the midst of established buildings. A row of single- and double-storey terraces and a 33-floor main structure built of steel and with a glass curtain wall are situated on the west side of the site along Taichung kan Road. Some felt that to position such an edifice on Taichung kan Road would be detrimental to the area's landscape; that So-Go's height, colour, volume and skyline would unbalance the look and feel of the street. Of course, the So-Go company took an opposite view, arguing that a high-rise department store here, complete with its metal curtain wall and square shape, would stand as a testament to the vigour and modernity of Taichung.

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[14] Taiwan's urban planning system stipulates that zoning changes have to be approved by Taichung City Government; by the central government's urban planning committee (i.e., the Ministry of Internal Affairs); and by Taiwan Province.

It emerged during the review process that the majority of the committee felt that So-Go's proposed shape needed modification if it was to harmonise with its surroundings. The developers responded at the second review session by drawing up computer simulations of how So-Go would fit into the landscaping of the street. Using these simulations, they outlined four alternative facades from which a choice could be made. The committee selected a milk-white frontage with a metal curtain wall and demanded that the building be retracted back from Taichung kan Road to reduce its overwhelming dominance, so that it might not become an isolated monolith in the street. We can see in this instance how the EIA process did indeed meet its environmental goals by effecting a useful modification of So-Go's facade and colour so as to augment the harmony of the cityscape.

9.4.3.3 Traffic Impacts

Traffic congestion and parking were undoubtedly the EIA's major concerns in assessing So-Go. Of the two, parking was the easiest to consider in that building regulations explicitly specify the parking spaces that a building of So-Go's size must supply. However, there is no equivalent regulatory measure for assessing the increase in traffic or commensurate decrease in LOS on roads near the site. In principle, a project may be proposed using the maximum floor area permitted by the building regulations and yet not have to concern itself with any traffic implications other than parking.

In practice, however, the committee did ensure that some mitigation measures were put in place. It was estimated that the So-Go Building would demote the LOS on some sections of adjacent roads to class D or E, especially during rush hours. Recognising this, the committee demanded that the So-Go company retract the front of the building to provide temporary parking space; arrange for goods deliveries to be unloaded in the basement rather than on the street; and route the traffic using So-Go's basement parking bays away from the main thoroughfares.

The committee also demanded additional parking measures over and above those required by the building regulations. The So-Go company had to allocate extra space internally and integrate the adjacent car park into the building's parking plans.

9.4.3.4 Regional Development v. Inner-City Decay

The most contentious socio-economic issue about So-Go was its location. While this choice would presumably vitalise the westside district, it was also proved that it would contribute to the commercial decline of the inner city. In the first month of So-Go's trading, the sales volumes of the five city-centre department stores declined by more than 20%[15](see Table 9-34). By 1999 - the third year of So-Go's commercial existence - three out of those same five shops had ceased trading.

Table 9-34: Sales Figures for So-Go Department Store and City-Centre Department Stores

Year	Sales Status of So-Go Dept. Store	Sales Status of 5 City Centre Dept. Stores
Nov. 1995	£25m sales volume in first month	Average decrease in turnover of 20%
1996	£116m annual sales	Fortune Dept. Store closes
1997	£156m annual sales	Long Hsin Dept. Store closes
1998	£148m annual sales	Evergreen Dept. Store closes. Only the Far East & Future dept. stores remain in business.

Data Source: Personal Interview with Tsai, Deputy President of the So-Go Company, 1999.

Note: The exchange rate between the pound and the N.T. was 1:43 in 1995, 1996 and 1997 and 1:54 in 1998. Thus, though annual sales grew slightly in 1997 and 1998, the figures appear as negative growth due to the exchange rate.

The EIA committee also debated whether So-Go's location in the westside was an unqualified blessing for local firms. Some argued that the store would detract from other businesses in the area given the sheer volume and range of its products. Others felt that the crowds that So-Go would attract would have the effect of agglomerating the local economy, creating more business opportunities for everyone. Socio-

[15] Information supplied by Tsai January, 1999, Deputy President of the So-Go department store, in interview with the author.

economic impacts are extremely difficult to assess. As the EIA review is conducted after the urban plan has already been decided, related cumulative impacts cannot adequately be taken into account and alternatives are difficult to contemplate. What this shows is that the "3 Ps" (policy, plan & programme) need to be incorporated into the EIA system.

Of the issues about the EIA process thrown up by the So-Go case, traffic is the most amenable to rigorous assessment methodologies. Landscaping issues, while unquantifiable, can at least be analysed using computer simulations and a consensus thereby arrived at. Socio-economic impacts, being inherently uncertain, are difficult to both analyse and judge. Socio-economic analysis is intrinsically tied up with the goals of urban development - a framework larger than any particular case which the EIA system is set up to assess.

9.5 Summary

The So-Go building project has been invested in, and constructed by, the private development sector for the single purpose of a department store. It is 91m tall, with 21 stories above ground level, and 4 floors below. The total floor area is 79,523m^2. This was the first EIA high-rise building case in Taichung. It was approved in 1993, construction began in 1994, and the building was completed on 11 November 1995.

As this building is likely to bring in large crowds, and with its location on a main artery road in Taichung, the urban environmental impacts are emphasised. Impacts include physical and ecological environmental impacts, the use of energy, landscape and recreational, traffic, and socio-economic impacts. The physical impacts include the production of 113,500m^3 of waste soils during the construction stage with 14,188 trucks needed for transportation, which in turn produces polluting exhaust fumes and dust. The

constructing procedure and the operation of machinery are sources of atmospheric pollution. An estimate of total suspended particulate (TSP) emissions due to construction is 25.2 tonnes. The average increase in concentration in a 24 hour period is 4.9μg m^{-3} with a maximum concentration of 190.9μg m^{-3}, which still meets air quality standards. The increased TSP volume from transporting trucks is 14.2μg m^{-3} while the concentration increase of NO_x generated by vehicle exhausts is 59.33ppb, which when averaged still meets air quality standards.

Noise pollution from construction machinery and transporting trucks increases by 9dB(A) and 5dB respectively. As both are in the medium impact range, mitigation measures should be implemented. The bulldozer has the highest vibration impact 60dB. This is of slight impact, and has no influence on sleeping. On a daily basis, 1.678 tonnes ($987m^3$) of waste soil is produced during the excavation phase and 7.5 tonnes of solid waste is produced during the occupancy phase. The disposal of such waste imposes secondary impacts on the urban environment. The overshadowing impact of the So-Go Building is within the set limits as there is four hours of insolation at the winter Solstice. Electric wave interference can be divided into reflection and obstruction interference; the former occurs at the front and the latter at the back of buildings. The area of influence is 227.5m in length and 69m in width covering 1.6ha and 200 households.

This region is an urban area so the ecological impact is slight. However, the greater floor area together with an increased population consumes more energy. On a daily basis $366m^3$ (CMD) of water is needed for the building together with $150m^3$ of natural gas. The So-Go building is situated on an artery in Taichung so will become a visual focus, and a new landmark. Therefore, gigantic dimensions and outlandish colouring will bring about an unbalanced feel to the landscape.

Changes in traffic volume, initially by construction vehicles and later by vehicles when in the building is in operation, will have an impact on local and regional roads. Impacts during the construction phase is from machinery occupying the roads, the piling of materials affecting the traffic flow, and transportation trucks influencing the level of service (LOS). There were 14,188 trips by transportation vehicles during the excavation phase, whilst 17,572 people-trips have been recorded daily during occupancy phase. According to model split and model loading rate analysis, 1,244 passenger car unit (PCU) arrive at the site during peak hours. This may reduce the level of service on Mei Tsui Road from level C (delayed, acceptable) to level D (delay, bearable) with that on Taichung Kan Road remaining at the lowest level F (traffic jam). Levels of service at the intersection are level E (delayed, unbearable) and level F (traffic jam). In addition to traffic, the parking impact is a critical issue in this case study; currently the rate of parking demand on nearby roads is 1.5 times that of parking supply. This impact has increased upon building completion, and although 368 are spaces available, 633 spaces are needed to satisfy parking demands.

Looking at the socio-economic environmental impact, a new business centre has been formed through land-use change and the promotion of the development of nearby land. Five hundred job opportunities have been created in the occupancy phase, which may account for 0.13% of the employed population in Taichung, it helps increase the GDP of the tertiary industry in central Taiwan. Public facilities, gyms, parking lots, and playgrounds are currently insufficient, with the situation expected to deteriorate when employees emigrate and customers travel on completion of the building.

As some environmental impacts caused by the So-Go Building project are greater than 'medium impact', mitigation measures are necessary to reduce these negative impacts (including reduction of water pollution, noise, traffic, parking, and landscape impacts, and electric wave interference). Nevertheless, no alternatives were ever presented for this project, although mitigation measures actually only reduce part of

the impact. However, some impacts at the EIA project level cannot be resolved effectively e.g. public facilities, and the traffic system.

The development process of the So-Go Building project adopted the incremental approach. This entails development idea followed by a zoning change in the urban plan, an EIA process, a detailed design followed by construction and occupancy. This is a top to bottom approach, which can take a long time (e.g. 8 years) with little argument. The preparation of EIA report for the So-Go Building took 4 months (16 weeks). This is shorter than the UK (22 weeks), shorter than Germany (80 weeks), and the Netherlands (40 weeks) (Therivel 1996, p. 186). However, the short duration for the So-Go Building implies the EIA report preparation was not sufficient. This is further supported by human resource data, as 20 people-months are needed in the EIA process for the So-Go Buildings. It is lower than the 40 people-months in EU (Therivel, 1996, p. 186).

The cost for preparing the EIA reports accounted for 0.083% of the total project costs for the So-Go Buildings. It rates are substantially lower than the 0.5% of other countries (Wood 1995, p. 254) and the 0.6% in the UK (Commission for EIA, 1998a, p.249). Regarding the length of the EIA reports, the So-Go Building project was 255 pages. These are longer than both the UK and Germany. Looking at the report structure, the prediction of environmental impact, mitigation measures and alternatives merit 41.5% of the report length for the So-Go Building. This indicates that the most critical and important section of the report accounts for less than half of the report length. Thus, project description and environmental setting are apportioned more than half the report length. This implies that EIA costs for both case studies are too low, and that the report structure is inadequate.

The EIA committee reviewed reports for So-Go buildings. The competent authority is responsible for administrating the EIA procedure during the report preparation phase. Although public briefings were

held prior to the review of the EIA report, there were less than ten people with no public comment. In Germany, 64% of cases have 1 to 50 public comment petitions, and 16% have more than 100 public comment petitions (Marr, 1997, p. 241). This indicates that the public participation timing and attendance in Taiwan is both too late in the process, and too low.

The So-Go project review process only took three months. The decision-making process took four months for So-Go Building project. The government took seven months (28 weeks) to deal with the EIA for the So-Go Building project (including EIA report review and decision-making time). These timings are longer than the 23 weeks in the UK, but shorter than 60 weeks in Germany (Marr 1997, pp. 223-33).

Decision-making control mechanisms for the So-Go Building project included professional and procedural control mechanisms. As well as these, the Formosa Building also underwent public and outside agency control mechanisms(see next chapter). This implies that the decision-making processes together with public pressure are already having an influence on the role of policymakers.

CHAPTER TEN : A CASE STUDY OF THE FORMOSA BUILDING

The Formosa Building is located at the intersection of Jian Shin Road and Taichung Kan Road, which used to be a wholesale fishmarket, and is now a metropolitan hub. This new commercial centre is well situated, as Taichung Kan Road is an artery road affording good connections both with other parts of this and other cities. The building plan was to build 32 floors aboveground with six floors below. It will be a multi-functional edifice combining offices with recreation and resort hotels. With the increase in the Taiwanese economy Taichung City has become the dominant city in central Taiwan

The EIA review for the Formosa Building was applied for in 1992, which was passed allowing construction to commence in 1993. It was completed and operational by 1998. Underground, the sixth up to the third floor is used for parking. The section of the building from second floor underground through to the tenth floor aboveground is office space whilst the 11th to 15th floors are restaurants. The 16th to 26th floors is office space again with the upper floors (27th to 32nd) is hotel accommodation. The building has a total floor area of 118,437m^2 and is 117.25m in height.

10.1 PROPOSAL DETAILS

10.1.1 The Building's Location

10.1.1.1 The site location

The site is located at the intersection of Taichung Kan and Jian Shin Roads in western Taichung. To the southwest of the building is the 50m wide Taichung Kan Road with Jian Shin Road (20m wide) at the northwestern edge. To the northeast and southeast are 10m and 8m wide roads respectively (Figure 10-1).

The area of the construction site was 6,891m^2. It was situated on 80m away from Taichung Kan Road. This area is the pivotal point for road transportation in Taichung as Jian Shin Road is important in

connecting areas in the north and southwest. This area has become an important commercial and recreational area with features such as the Science Museum being only 200m away, the tranquil Ging-Kuo Park Avenue, together with a large number of office buildings, hotels and large-scale shopping malls.

The building site was the sole auction and fish distribution centre for Taichung City. All the buildings were one-floor awnings or shacks. Nevertheless, with urbanisation this area developed from suburban region in the 1980s to the present day booming commercial centre of Taichung. As the fish market could not keep up with the demands of urbanisation, the area was redeveloped as a commercial access region meeting urban planning goals.

10.1.1.2 Structural system project

As Taiwan is situated in an earthquake zone, and is frequently affected by typhoons in summer, the structure of the building has to carry static and active loads vertically, and withstand winds, earthquakes and other external forces. The structure of the Formosa Building is described as follows:

(a) **number of floors:** six below-ground, 32 above

(b) **building height:** basement storey heights vary from 2.7m to 4.4m. The height of the ground floor is 5m, the 2nd through to the 9th are 4m, the 10th floor is 5m, the 11th through to the 15th are 3.m and the 16th through to the 32nd floor are 3.15m. The total height of the building is, therefore, 117.25m, with an excavation depth of 23.35m below the basement.

(c) **building dimensions:** 68m wide and 63m long in the T-shape plane of the higher floors, and a 65m square plane on the lower floors.

(d) **structural system:** in general, there are three major structural systems for high-rise buildings. These are steel structure (SS), reinforced concrete(RC) and steel reinforced concrete(SRC). In the basement, the 6th up to the 2nd floor are RC constructed whilst the 1st floor has an SRC structure. The ground floor is also an SRC structure, and all floors above the 2nd are all SC built. The column

mainframe and shear wall comprises the main structure underground whereas dimensional flexible structure is used aboveground.

(e) **foundations:** RC floating foundation

(f) **outer wall:** curtain wall

(h) **basement excavation:** support from inside is used in excavation with the soil blocking wall applied manually (Chung-Kan Company, 1993, pp. 2-13).

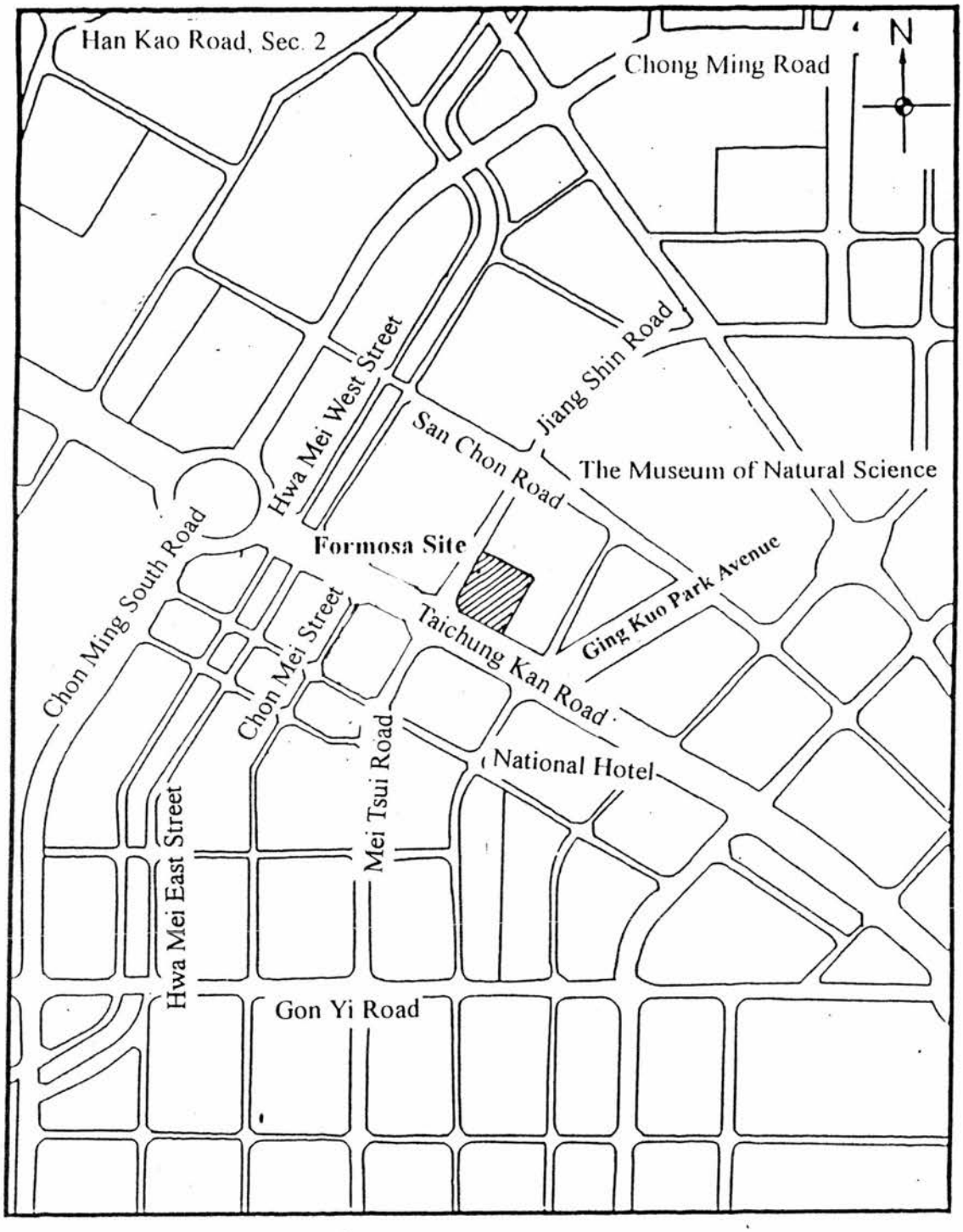
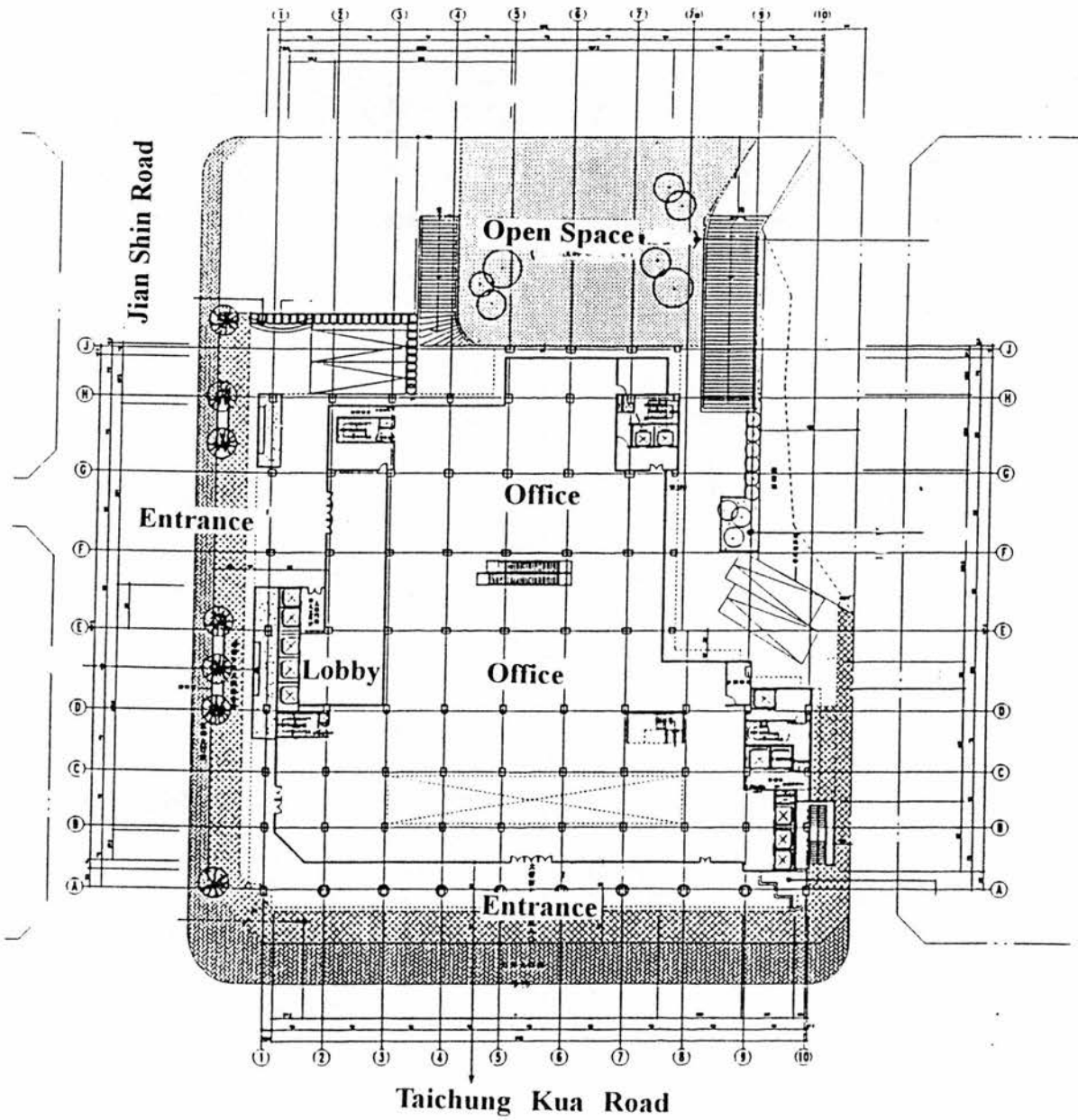
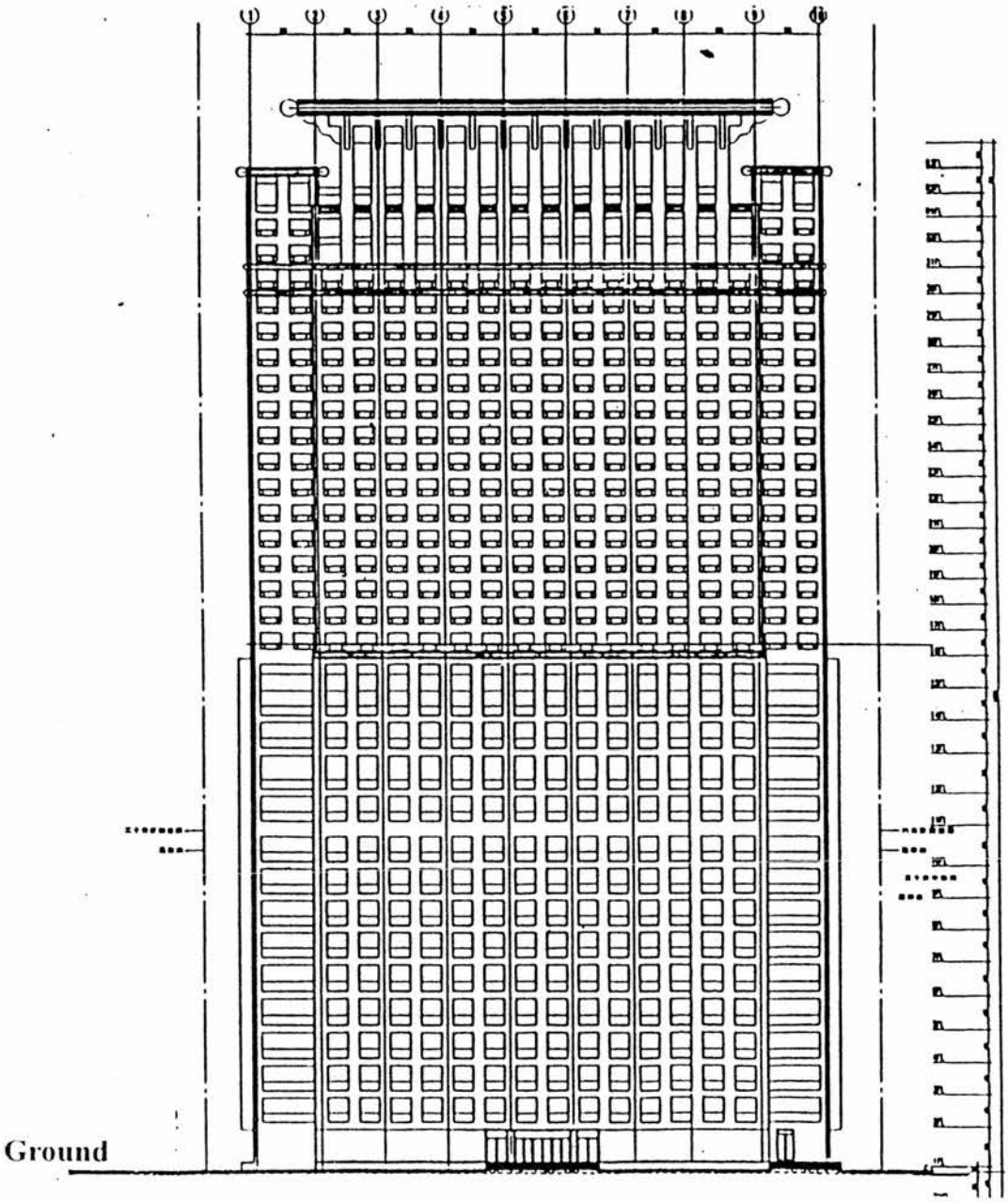


FIG.10-1: Plan of the Construction Site Location



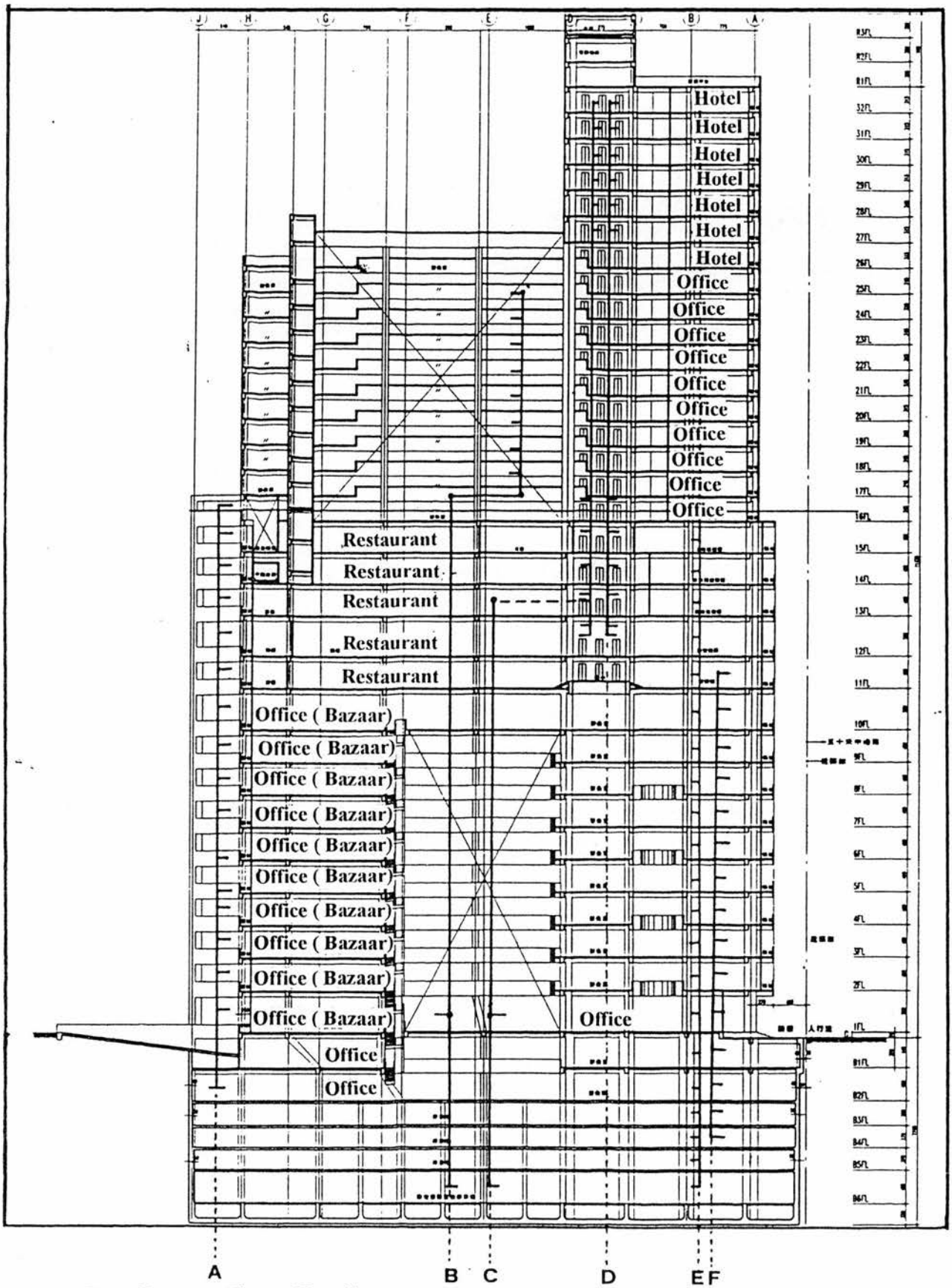
Data Source : Chung Kun Company

FIG.10-2 : Ground Floor Layout



Data Source : Chung Kun Company

FIG.10-3 : Elevation Sketch



Data Source : Chung Kun Company

Plate10-1: Section of Formosa Building

10.2 PREDICTION OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE FORMOSA BUILDING

10.2.1 Physical Environment

10.2.1.1 The Topography and Geology

(a) **terrain and topography:** The building site covers 6,891m^2 with most of the adjacent already developed. As the location is flat the terrain changed during the construction stage. Although the original fishmarket was removed its replacement with a high-rise building will not make a large impact on the terrain and topography as the land was already built on. The skyline varies after construction of the high-rise; some aspects of the site will be restored to serve as open space. This single 117.25m tall high-rise building has a stepped back retreating shape that fits in with neighbouring finished buildings. Positive impacts include the landscaping and redevelopment of an urban site.

(b) **waste soils:** The planned excavation area of this high-rise building is about 6,413m^2 with an excavation depth of 23.35m and an estimated earthwork volume of 150,000m^3. If the coefficient of loose soils is 1.2, then the total earthwork volume will be 180,000m^3. Aside from any earth used for hard landscaping and as fill, the surplus material will be treated as waste soils. To recycle the used earthwork, a sand processing method will be used to produce usable construction materials. As for non-recyclable waste soils, they will be shipped for burial at the soil dump yard.

(c) **settlement and expansion of soils:** When a large-scale foundation is built, a large amount of soil will be excavated and the soil under the base surface will expand. This is especially true for compressible geology. There are two kinds of expansions, water absorbing and elastic. The former only occurs on clay whilst the latter can happen to any kind of soil. At this site there are gravel and pebble soils so its major expansion is elastic. Expansion as a result of excavation may affect buildings and public facilities adjacent to the construction area evidenced as the cracks in houses and breaking pipes. Therefore, the degree of expansion together with the impact on other structures

Plate10-2 : Formosa Building (Courtesy : Chung Kun Company)

should be scrutinised at the beginning of the project.

Expansion figures for the centre of the excavation surface and a corner are 14cm and 7cm respectively (Chung-Kan Company, 1993, pp. 4-5). Land at the corners of the construction site are reserved for open space and a road wider than 10m serves as a buffer zone so reducing the dilatability to a minimum with no significant impact to surrounding buildings, piping or infrastructure.

The maximum settlement range of the 32 floors is 5 to 7cm (Chung-Kun 1993, pp. 4-6). As some empty land is reserved as open space, this settlement will have little impact to surrounding buildings.

10.2.1.2 Hydrology and Water Quality

(a) **hydrological balance:** The level of underground water must be reduced to below the level of excavation in the construction stage. As a result, sectional water withdrawal inside and around the construction site was carried out performed, which changed the underground ecology. Nevertheless, as water withdrawal during the construction stage is only temporary, there will not be any long-lasting effects on underground ecology. The volume of water needed during the construction stage for workers can be calculated when the number of construction labourers is known. In general, the daily water requirement for a worker living on-site is 120 litres; otherwise a worker only needs about 30 litres. There are about 200 construction workers on-site daily, with 50 living there. Therefore, the required water volume will be 10.5CMD. The water will be supplied as tap water rather than from underground water sources so no significant impact will be imposed on the hydrological balance. During the operational stage no underground water will be withdrawn so not affecting the hydrological balance although the daily volume of water required will be 1,993CMD.

(b) **water quality:** The soft loose soils from excavation, together with the dust and mud from the construction vehicles could result in water pollution. A daily average of 10.5CMD of polluted water is produced by construction workers that can contaminate the nearby water sources. However, as construction is temporary there should be no long-term effects. During the operational stage about 1,993CMD of polluted water is produced each day; equivalent to 0.023CMS. This is

first treated at the sewage disposal plant before discharge to meet effluent standards. However, river water quality will be affected.

(c) **water drainage:** As this construction site was once a fish distribution centre, its surface was paved with concrete, thus the flow of rainfall after construction will not increase significantly. Using the rationalised formula, Q = CIA/360 [where the coefficient of run-off (C) is 1.0, the area of water catchment (A) is 6,891 m^2, the maximum rainstorm volume (rainfall intensity) (I) is 343mm hr^{-1} based on an averaged frequency over 25 years] we can calculate that run-off flow (Q) will be 0.66CMS. However, as rain sewers are installed around the construction site, the increasing volume of water drainage can be accommodated.

10.2.1.3 Air quality

(a) **construction stage:** As large-scale excavation is required during earthwork engineering, suspended particulates will be produced. In order to reduce the impact caused by excavation pollutants on the environment, the principle of small-area excavation will be adopted. It is estimated over a period of 18 months, 545 working days will be required to excavate an area of 6,413 m^2. Using emission factors from the EPA, the emission factor of TSP can be found (Table 10-1) ie. there will be 0.4g of particulates produced per second at the building site during the excavation stage. The average volume of dust falling per km^2 in Taichung in 1995 was 15.7tonnes km^{-2} $month^{-1}$[1] (15.7g m^{-2} $month^{-1}$). Together with background and prediction values, the volume of dustfall around the site during the excavation stage is about 16.69 tonnes km^{-2} $month^{-1}$. Although the affected area is limited to the immediate neighbourhood, there is a significant negative impact on air quality that needs mitigation. As 1.02g sec^{-1} of particulates is produced during the operation stage (0.88tonnes m^{-2} $month^{-1}$) which affects local air quality, mitigation measures should be proposed.

(b) **transportation:** Trucks transporting construction materials greatly influence the air quality. Waste air from diesel truck exhausts contain air pollutants (SO_2, NO_2, CO and PM_{10}) affecting air quality.

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[1]Taichung City Government, 1995, p.258

Sources of construction materials (including concrete, steels, and steeled materials) are widespread meaning varied transportation routes are necessary. Nevertheless, as all transportation vehicles enter the construction site via Taichung Kan Road, and as most of the land along Taichung Kan Road is already used for industrial and business purposes, environmental sensitivity is lower. A separate period and area method for site excavation will be implemented for air pollutants produced by transportation vehicles during the construction stage (including waste air and dust). The total earthwork volume was previously stated to be 180,000m^3 achieved in 545 days. The average soil shipping volume is 330m^3 day^{-1}. For an 8m^3 truck, 84 trips will be required each day (ie. 42 round trips). In addition, most transportation vehicles are heavy-duty diesel trucks (HDDT) travelling on the 20m wide road. Estimated emissions can be calculated once the emission factor and number of round trips. Through the application of a formula which uses the local weather conditions and a simulation of the rate of diffusion of each pollutant.

The increase in the concentration of air pollutants during the operation phase is shown in Table 10-2. According to this table, if the distance from the side of the road is more than 20m, the increasing volume of TSP will be less than 9.59 μ g m^{-3}, SO_2 will be 1.22 ppb, NO_2 50.56 ppb and CO 0.77 ppm. After addition to background concentrations, the air quality standard will still be met. Nevertheless, air quality will deteriorate slightly.

Table 10-1 : Dust Emission from the Formosa Building during Construction

Stage			Emission Factor	Construction Duration (Days)	Construction Area (m^2)	Total emissions (kg)	Emission rate of TSP ($g\ m^{-2}\ s^{-1}$)
Excavation Stage	Excavation Procedures		0.1206kg m^{-3}	545	6,413	18,090	5.9905×10^{-5}
	Naked Surface of Construction Site		4.257×10^{-4} kg m^{-2} day^{-1}	545	2,600	603	4.9271×10^{-6}
Construction Stage	Building Procedure	Full period	0.424 kg m^{-2} $month^{-1}$	625	6,250	55,186.95	1.6358×10^{-4}
		Naked Surface of Construction Site	4.257×10^{-4} kg m^{-2} day-1	625	1,567	416.90	4.9268×10^{-6}
	Disposal of Waste Soils and Construction Materials		4.257×10^{-4} kg m^{-2} day-1	625	670	178.67	4.9384×10^{-6}

Notes:

a. Daily working hours are eight

b. Emission factors are in compliance with standards published by EPA, June 1996

10.2.1.4 Micro-Climatic Effects

A number of factors relating to high-rise buildings (such as the large areas of land occupied, the huge, wide dimensions, proximity to hard pavements) will all play a part in the micro-climatic impact on the neighbourhood. In addition, extensively paved roads, dense buildings, waste, polluted air, dust, and car exhaust fumes contribute to the special urban micro-climate phenomena. Further influential elements to the local micro-climate include surface building materials as well as the types and allocation of the buildings. These are described below[2]:

[2] Chung-Kun Company , 1993, pp. 4-13~4-24

Table 10-2 : Concentration of Air Pollutants on Roads Adjacent to the Construction Site during the Operation Phase

Name of Road	Section of Road	Increasing Flow at Peak Hour	TSP ($\mu g\ m^{-3}$)	SO_2 (ppb)	NO_2 (ppb)	CO (ppm)
Taichung Kang Road	Chong Ming Rd. - park path	322	9.59	1.22	16.23	0.77
Jian Shin Road	Taichung Kan Rd. - San Chon Rd.	143	3.08	0.39	16.23	0.26
Chong Ming Road	Taichung Kan Rd. - San Chon Rd.	55	1.19	0.15	6.28	0.14
San Chon Road	Jian Shin Rd. - park path	42	0.91	0.12	4.80	0.10
Background Air Quality			150.11	16.00	33.00	0.84
Standard Air Quality			250.00	250.00	250.00	35.00

Data source: Chung-Kun Company, 1993, pp. 4-30

(a) impact of surface materials: Artificial building materials, roads and paved grounds, etc. affects the neighbourhood micro-climate by changes in radiation and heat. Therefore, the choice of surface materials must be taken into account as to the impact it may impose. Primary factors include surface temperature changes and the reflective value of the material.

The surface material on the lower floors has a high specific heat and large volume to reduce external temperature impacts; stone or metal curtain walls. On the higher floors, curtain walls with low reflective qualities were used; tiles, metal and glass curtain walls. Materials with a high reflective value are not used to reduce changes in the exterior temperature (Chung-Kun Company 1993, pp.4-13).

(b) local wind effects: Wind flows from areas of high to low pressure. The greater the pressure gradient, the higher the wind speed. Wind speed at ground level is slower due to friction and obstruction by various obstacles. The RWDI has to carry out wind tunnel tests to evaluate effects of various wind velocities on the structure, as well as its comfort[3].

'Comfort' is based on a range of all different kinds of activities carried out by pedestrians. The result of the wind tunnel test is a percentage of time for different velocity ranges at each test point, which is then

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[3] For wind tunnel test results refer to Chung-Kun Company, 1993, pp. 4-1~4-23

ranked as a level of comfort. Wind velocity ranges can be classified into five groups in compliance with the principle of the comfort of pedestrians. The velocity range for a comfortable sitting environment is 0-17km hr^{-1}, standing environment is 0-25km hr^{-1}, and walking environment is 0-32km hr^{-1}. If the range at a certain test point is not suitable for sitting, standing and walking, it is termed the range of discomfort, which is 32-95km hr^{-1}. Danger levels are those when the range exceeds 95km hr^{-1}.

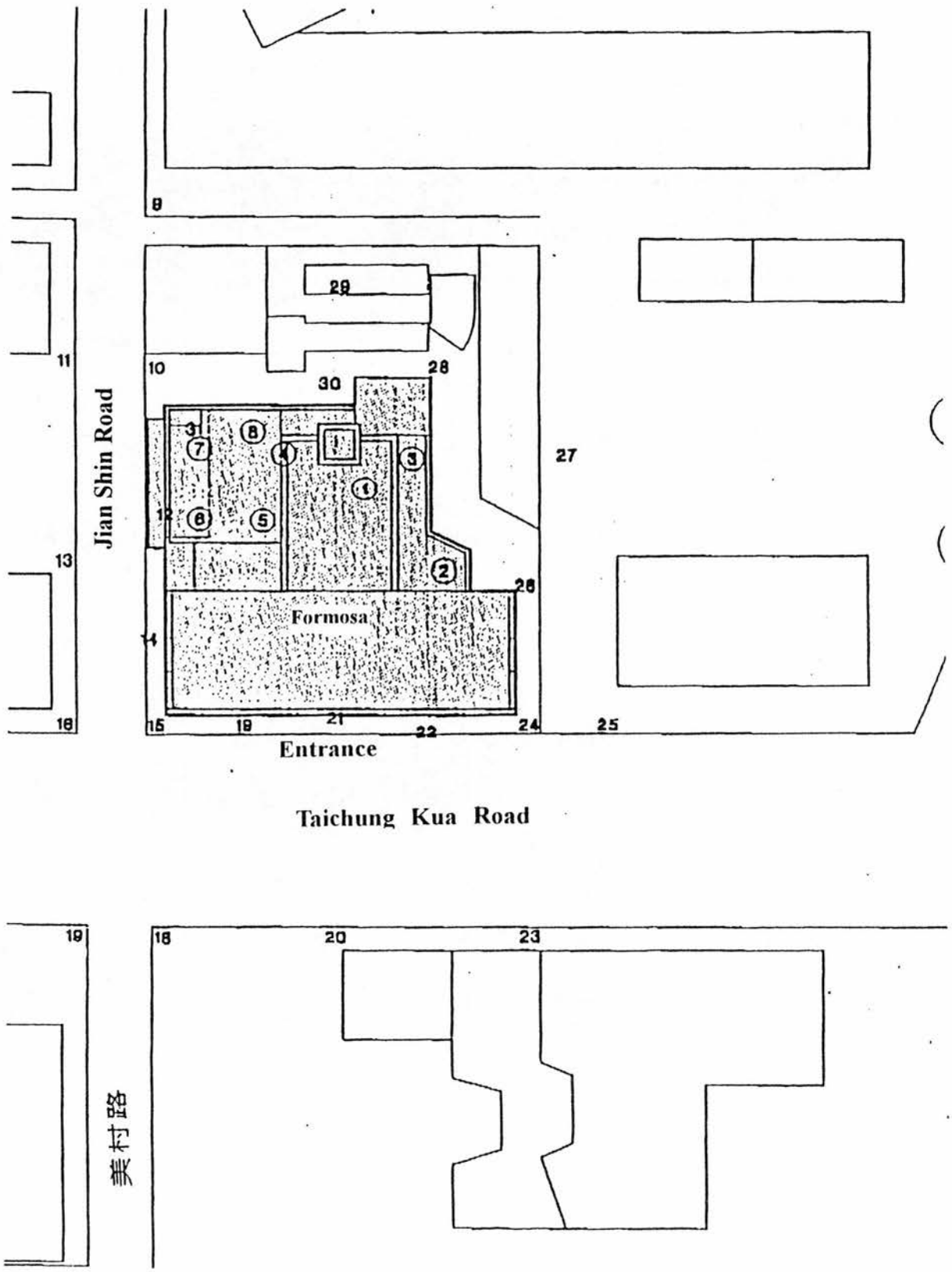
A comfortable zone is when wind velocity is between 0-32km hr^{-1} for over 80% of the time, outside of this it is an uncomfortable zone for pedestrians. If the velocity surpasses 95km hr^{-1} for more than 0.1 % of time it is a dangerous zone (Chung-Kun Company 1993, pp. 4-18).

Figure 10-4 describes the localised wind environment at each test point:

A. **car park entrances and north side of hotel (test points 29 and 30):** The wind environment in the car park (test point 29) satisfies the demand for comfort standing in summer, but only walking comfort in winter. Trees need to be planted. The entrance on the north face of the hotel fulfils sitting comfort demands in both the summer and winter seasons.

B. **wind environment outside the construction site (test point 27):** Areas to the east of the construction site do not meet sitting comfort demands either in summer or winter due to northwesterly winds. Further mitigation measures (eg. multi-storied pot plants and tall evergreen trees) are necessary to reduce wind velocity and impacts in the neighbourhood.

From the above the wind environment at the construction site is appropriate. After modification to the wind environment outwith the site, the integral goal can be achieved. Values for comfort demands at test points in winter and summer seasons are listed in Table 10-2.



Data Source : Chung Kun Company

FIG.10-4 : Chart of Testing Points for the Wind Tunnel

Table 10-3 : Standard Point for Each Comfortable Wind Environment

Season	Sitting	Standing	Walking	Discomfort	Dangerous
Summer	22	8	0	0	0
Winter	11	15	3	0	0

Data source: Chung-Kun Company, 1993, pp. 4-24

10.2.1.5 Noise Impact

The types of noise impact from this building can be split into the construction and operation stages.

(a) construction phase

Most noise produced by construction has a time limit, and is temporary. The human ear cannot detect changes in noise intensity below 3dB(A), so in assessing noise impact if the increased noise level is between 0 and 5dB(A), no mitigation measures are required. However, if the range is between 5 and 10dB(A) moderate impact results so mitigation measures must be considered. When the increased volume is over 10dB(A) mitigation measures, or an alternative, should be taken as it is a major adverse impact.

Noise from construction engineering include surface clearance process, engineering earthworks, foundation piling and concrete engineering. Noise levels measured during day are 66.6 dB(A). An increased noise level of over 10 dB(A) generally comes from concrete and soil blocking engineering.

(b) noise impact from transporting vehicles:

The maximum increase in noise for transporting vehicles is 3.04 dB(A) at Chong Ming primary school, whilst all other areas are below 2 dB(A). The noise caused by construction vehicles has not made a significant impact upon the area as a whole.

(c) operation stage

After development is complete, the major noise source comes from various treatment facilities and vehicles coming and going. Potential noise sources related to treatment facilities include the operation of ventilation equipment and air-conditioning. The operation rooms will therefore be installed either

indoors or on the open balcony with sound-proof boarding to reduce any noise impact.

Noise from vehicles during the operation stage can be estimated using the aforementioned formula. As the number of attracted vehicles are 568PCU, and as the background noise from Taichung Kan Road is around 75dB(A), increases in noise level will be limited to 3dB(A); minor impact.

10.2.1.6 Impact of Vibration

(a) **construction stage :**The source of vibration mainly comes from construction machinery and traffic. There are two primary sources of vibration: mechanical appliances such as bulldozers and compressors; traffic especially from heavy vehicles transporting construction materials or waste earthworks. The most common excavation bulldozer has a noise vibration level from 30m of 65 dB, a minor impact. All other common construction appliances have a vibration level of 60dB (eg. trucks) from a distance of 15m (i.e. the outer edge of the construction site). Taking the distance of 15m as the vibration source, vibration attenuation values for multiple machines operating at the same place simultaneously are listed in Table G-17(Appendix G). Five machines operating together create an estimated vibration level of 67dB; 'slight' vibration.

The movement of transporting vehicles also causes vibration. The vibration level of a transportation truck from distances of 10m and 20m is 56dB and 53dB respectively; 'senseless' vibration.

(b) **operation stage :**Aside from minimal vibration caused by attracted vehicles, there is no significant vibration impact from special machinery during the operation stage.

10.2.1.7 Waste and Waste Soils

(a) waste: During the construction phase, there are about 200 construction workers with 50 actually living at the site. The daily volume of rubbish is low at about 150kg (150 x 0.5 + 1.5 x 50). Daily waste produced during the operation phase is about 0.01kg per person in the car parking area, 0.3kg per person

in the offices[4], 0.1kg per dining person in the restaurant, and 1.5kg per person in the hotel. The daily volume of rubbish is 3.7 tonnes.

10.2.1.8 Insolation and Overshadowing

The shadow formed by the building over the immediate vicinity needs to be included in the EIA process. Insolation is the major heat source at the surface of the ground and ultraviolet light can sterilise. Proper insolation can save energy and help maintain a level of environmental hygiene.

As shown in Figure 10-5, the shadow at the winter solstice is the longest as the sun is at its lowest angle and faces north. Therefore, buildings and land to the north (northwest or northeast) of the building site must meet the insolation and light requirements. According to the analysis of the shadow, the Formosa Building meets these requirements.

Table 10-4 : Analysis of Insolation at the Winter Solstice

Time	Angle of The Sun	Angle of the Height of the Sun	Projected Length of Insolation (m)
07:00, (17:00)	SE (SW) 62°33'	3°05'	2175.76
08:00, (16:00)	SE (SW) 55°16'	14°49'	443.06
09:00, (15:00)	SE (SW) 45°54'	25°24'	246.82
10:00, (14:00)	SE (SW) 33°41'	34°12'	175.84
11:00, (13:00)	SE (SW) 18°07'	40°13'	172.45
12:00	SE (SW) 0°	42°24'	128.35

Note: The height of the building is 117.25 metres.

10.2.1.9 Interference of Electric Waves

The obstruction of electrical waves by high-rise buildings can be caused either by blocking or reflecting obstacles. These, in turn, are affected by the physical presence of the building, allocation direction, height, and materials of the outer walls. A theoretical prediction of the blocking of electrical waves can be calculated using the height and width of the building, the height of the transmission tower, the frequency, projection station and distance to the target building.

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[4] The rubbish factor of office (0.3 kg) is the average of small unit office and general office, which factor is lower than So-Go building (0.7kg per employee per day).

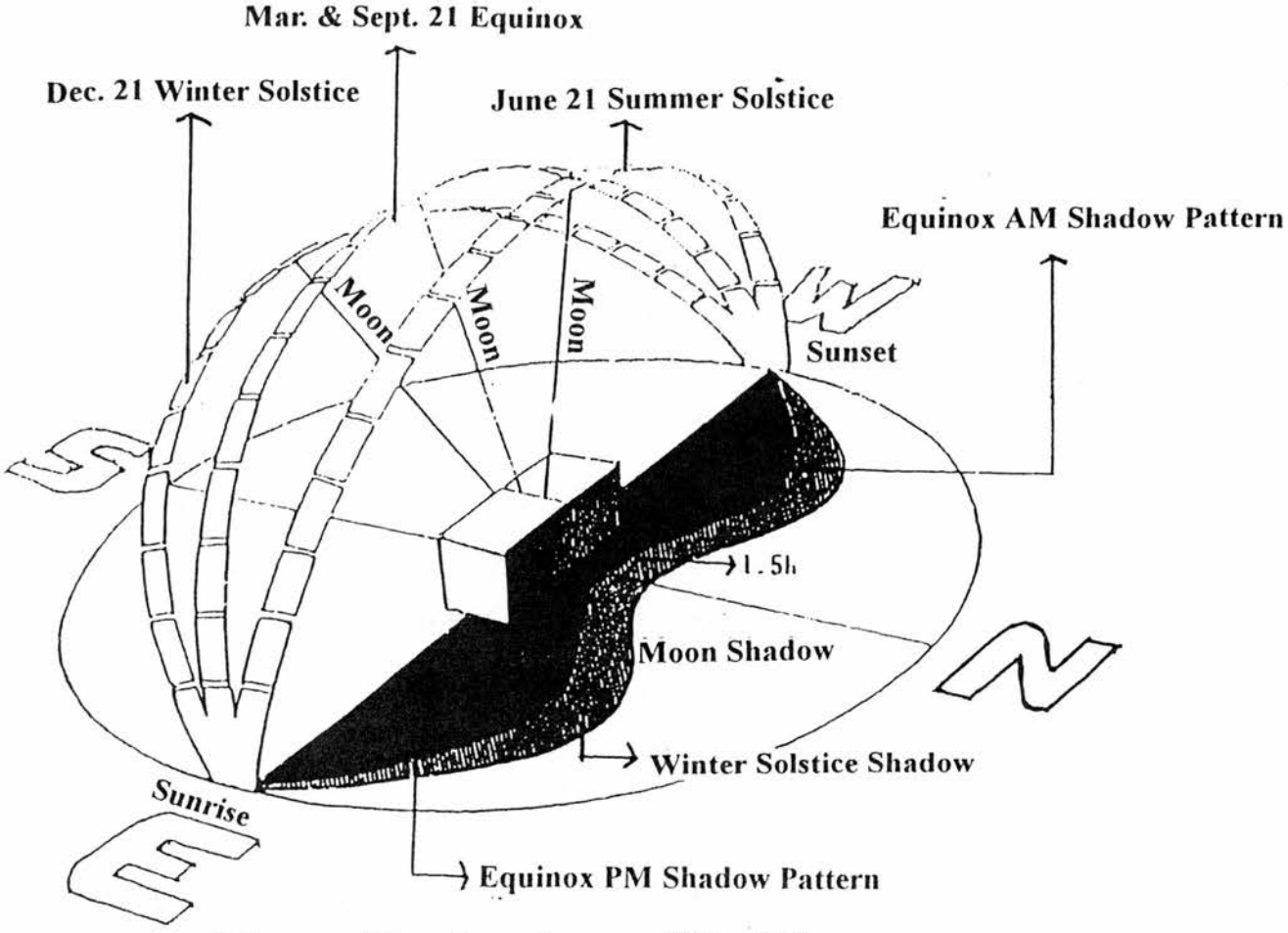
In this instance, the area blocking electrical waves (on the east side of the building) has a length of 327.5m and a width of 83.08m (Figure 10-6). As the blocking area is large, mitigation measures must be taken.

10.2.2 Ecological Environment and Energy Application

10.2.2.1 Fauna Ecological Environment

The site, and adjoining area, is urbanised. The site was once a fishmarket so the land had previously been developed on. The area as a whole is not a good habitat for fauna as residential areas are very dense, population levels are very high. Mammals and reptiles are never seen although there is a limited insects and bird population in the park avenue 200m away. This is, however, far enough away from the site that their habitat will not be disturbed. Nevertheless, birds that use the trees lining the pavements will be influenced by the noise and dust generated by the construction. Therefore, preventative measures against pollution are needed.

After completion of the building indigenous plants will be cultivated in the open spaces together with the restoration of the trees on the pavements providing a habitat for insects and birds. Generally speaking, the development of this building has not had a significant impact on the faunal environment.



Data source: Taiwan Sugar Company, 1997, p.7.20

FIG.10-5 : The Track and Shadow Pattern of the Sun's Movement

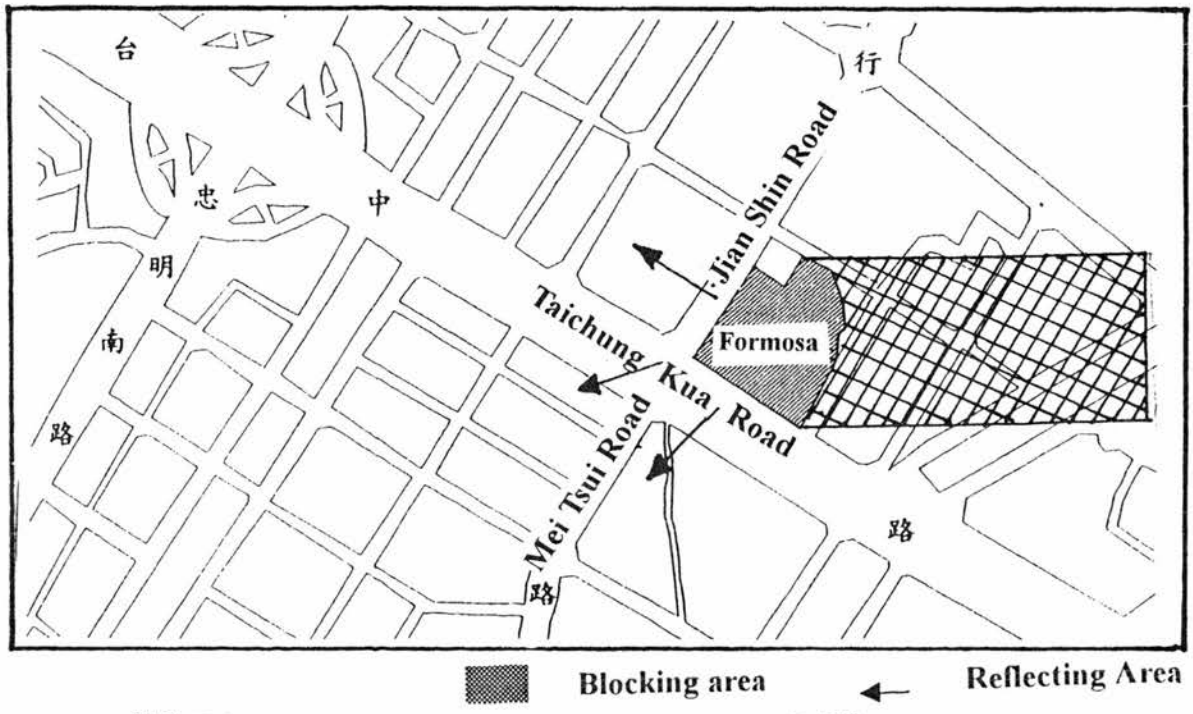


FIG.10-6 : Electric Waves Blocking Range by Formosa Building

10.2.2.2 Flora Ecological Environment

Indigenous plants and grassland on the site prior to construction site should be removed and replanted elsewhere. For example, a Banyan was moved to a local school. Transplantation is unlikely to apply to bushes under 1m in height, and common species. Photosynthesis by the trees lining the pavement around the site will be affected by dust, so endangering growth. To reinforce preventative measures against pollution, these trees must be protected.

During the operation stage, pot plants need to be cultivated in the open spaces to improve the landscape value of the building as well as providing a sound floral environment.

10.2.2.3 Energy depletion and Water Use

Power usage in the building can be classified into three categories; public electricity, power for offices, and power for small-unit offices and restaurants. In addition to the auxiliary generators, the main source of electricity is from the Taiwan Power Company. The capacity of the equipment in the building is 13,320KVA, the contract capacity for public electricity is 550KW, the offices is 3,000KW, small-unit offices and restaurants is 2,600KW, and the integral power requirement is 6,150KW. Two 1,000KW generators are to be installed for temporary use (Chung-Kun Company 1993, pp. 2-19).

The total daily water requirement of the building is 2,374 tonnes. Day to day living consumes 1,648 tonnes whilst air-conditioning requires 726 tonnes (Chung-Kun Company 1993, pp. 4-34). Most of the restaurants are supplied with natural gas (NG). The floor area of the restaurants is 17,351.21m^2 with tables to accommodate 6,590 diners. 16,475 meals can be served daily. As a result, the required consumption of NG is 1,110m^3 day^{-1} (ie. 600Kcal $meal^{-1}$ x 16,475 meals / 8,900Kcal m^{-3} = 1,110m^3 day^{-1}) (Chung-Kun Company 1993, pp. 2-24)

10.2.3 Landscape and Recreation

(a) **construction phase:** As there are no special landscapes or scenic spots near the construction site, there will be no significant impacts. Excavated earthwork temporarily stockpiled at the site will affect the urban landscape. Non-decorated materials on the surface of the structural high-rise frame will impact on the landscape of Taichung Kan Road.

(b) operation phase: There may be a potential impacts on the nearby park avenue and Science Museum that are 200 m from the construction site. These impacts could be:

- The development of a high-rise building may form a disharmonic view against the low buildings around it.
- A sense of pressure will be imposed on the residents living on the north side of the high-rise building as there is only a 10m wide buffer zone.
- The use of stone materials on the lower surface, and glass and metal curtain walls on the higher floors, is very difference when compared with original buildings in the locality.

10.2.4 Traffic Impact

10.2.4.1 Impact of Traffic During Construction phase

(a) construction workers: The impact of the building site on traffic is mainly from the extra volume generated by transportation vehicles. In general, most construction appliances are stored on the construction site reducing any impact. However, 150 construction workers have to commute daily to and from the site, which will affect the traffic flow in the immediate vicinity of the site. Fifty percent of the vehicles are cars, and that the rest are motorbikes (potentially 47 cars, 58 motorbikes[5]), the traffic volume derived by the commuting workers in the construction phase will be 64 PCU each day.

(b) transportation vehicles: The transportation of materials, equipment and earthworks will put

[5] The loading rate for cars is 1.6 people and 1.3 people for motorbikes. Thus, 75 /1.6 = 47 & 75 / 1.3 = 58.

pressure on the traffic. From Table 10-5 42 trucks were needed daily to transport excavated earthwork. About 15 trucks were used to transport concrete, steel, module boards, materials for power and water installation, and equipment during construction stage. This equates to 48 PCU of traffic volume.

(c) **traffic impact during construction phase:** From Table 10-4 there will be 198 PCU increase in the traffic volume during the excavating phase. Aside for the arrival and leaving of construction workers during peak hours, any movement of earthwork should be temporarily stockpiled on the site for transportation during non-rush hour times. There will be 162 PCU of traffic volume daily because of the construction phase. Trucks transporting materials should, therefore, avoid travel during rush hour so reducing the impact.

(d) **impact of occupation or shutting of lanes by construction vehicles:** Construction appliances and vehicles which occupy any area of the road, or even shut the road, obstructs vehicular flow and downgrades the service level of the road. The main routes to the site (Taichung Kan and Jian Shin Roads) are also two major routes in Taichung City. Their traffic is always busy so any disruption should be avoided. Temporary covered pavements should be built to ensure pedestrian and passenger safety.

10.2.4.2 Traffic Impact during the Occupancy Stage

From Table 10-6, the traffic volume associated with the Formosa Building is 568 PCU during peak hours distributed throughout the neighbouring road network.

(a) traffic assignment: Traffic to the site comes from four directions. To determine the traffic volume assignment it is taken that 35% of taxis and 35% private cars travel along Taichung Kan Road in an

Table 10-5 : Prediction of Transportation Attracted during Construction phase of Formosa Building

Construction Item	Content	Quantity	Daily Quantity	Car Trips	P. C. U.
Earthwork Excavation Engineering	Transportation of surplus soils	180000m^3	330m^2	42(x2)	134
	Construction workers	150 people/day	150 people/day	47 (58)	64
	Total				198
Construction Engineering	Concrete Steel Module Board Materials for Painting, Plumbing Total	48455m^3 8722 tonnes 266502m^2 66834m^3	65 12 355 89	15(x2)	48
	Construction worker	150 people/day	150 people/day	47 (58)	64
	Grand Total				162

Notes:

a. ( ) refers to the number of motorbikes.

b. Except for cars belonging to construction workers, the vehicle unit is trucks.

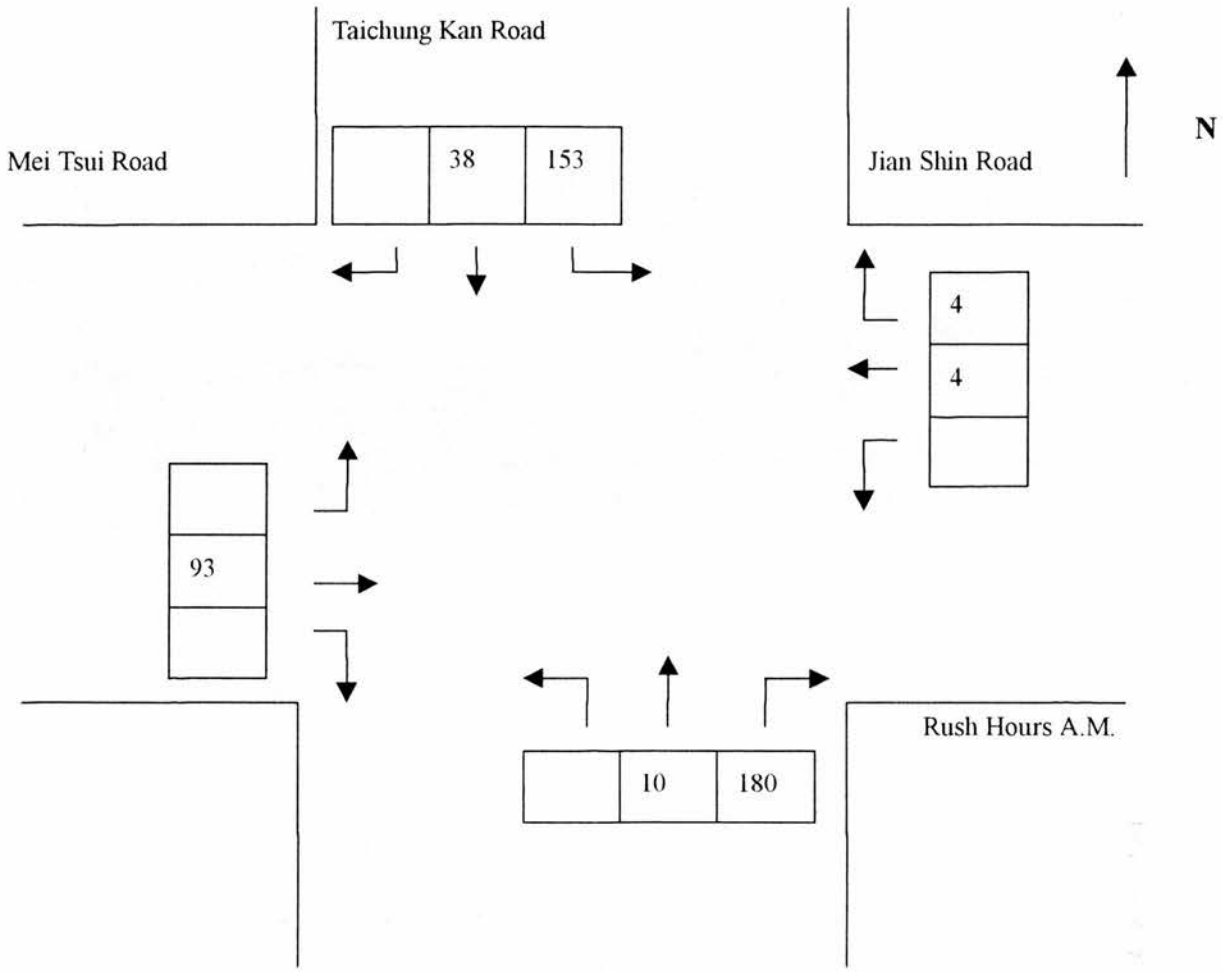
Table 10-6 : Prediction of Traffic Volume during Rush Hour

Application	Hour	Bus	Taxi	Private Car	Motorbike	P. C. U.
Office	Rush Hour am	11	23	285	362	435
Hotel		2	21	108	2	133
Total		13	44	393	364	
P. C. U.		21	44	393	110	568

Data source: Chung-Kun Company, 1993, pp. 4-47, Table 4-3-8

east-west direction and 15% of each along Jian Shin Road. A 25% proportion of motorbikes travel in all four directions. West-bound motorbikes and private cars have to enter the car parks through a 10m wide road before they can get onto Taichung Kan Road and Jian Shin Road. The traffic volume as a result of the construction site during rush hour is shown in Figure 10-7.

(b) **assessment of the level of service (LOS):** After the changes in traffic volume have been assigned, the actual increase in volume on each road is not very great. As a result, the level of service on Taichung Kan Road is maintained at Class F, and that on Jian Shin Road stays a Class C. As for the intersection service level, the level of service east-west on Taichung Kan Road and Jian Shin Road maintains its pre-development Class F status. The south-north bound level of service remains Class E.



Data source: Chung-Kun Company, 1993, pp. 4-51

FIG. 10-7 : Assigned Traffic Flow from the Formosa Building.

10.2.4.3. Prediction of the impact for parking

Parking is currently inadequate. The prediction of parking demand for the building is based on requirement rates during peak hours. Hotels require 0.51 parking spaces per $100m^2$ per hour, and offices need 0.62. Using this model, 425 spaces must be provided for the offices, and 133 for the hotels: totalling 558 parking spaces during the rush hour (Chung-Kun Company, 1993, pp. 4-48).

Underground, the 3rd to the 6th floors are car parks offering 629 spaces for cars and 630 for motorbikes. The entrance to the car parks is situated at the north side of the building. It faces the 10m wide road, and is 60m from Jian Shin Road to the west, which allows for queuing to the car parks without interfering

with traffic flow on Jian Shin Road.

Table 10-7 : Estimated Parking Requirement of Formosa Building

Type	Floor area	Rate of Parking requirement	Demand
Hotel		0.51	133
Office		0.61	425
Total			558

10.2.4.4 Impact assessment of pedestrian traffic

On completion of the development, the original 5m pavement along Taichung Kan Road is reinstated together with a 10m wide stretch of open space set aside for pedestrians. On Jian Shin Road, in addition to the original 2.5m pavement, more than 4m of open space is reserved giving pedestrians at least 6.5m walking space.

According to the estimation of trips to the site during peak hours, there will be 1,765 people in the building. There are 1,379 people/trip for the offices, and 386 people/trip for hotels; a rate of 30 people/trip per minute. If all trips are along the Jian Shin Road and the 4m pavement, then the volume of pedestrians will be 7.5 people/second. metre. According to the assessment principle (Table 10-8), the level of pavement service is Class A, which shows the traffic condition of pedestrians is good. If the trips were all along Taichung Kan Road and the 10m open space, the volume of pedestrians would also be 7.5 people/second. metre, whose level of service is also a Class A (Chung-Kun 1993, pp.4-56).

If trips during the rush hour are kept on the reinstated pavements (with an area about 1100m^2), then an area of 0.61m^2 is available to each pedestrian during the peak hours. According to Table 10-8 this would be a Class E level of service meaning there is enough space for people to assemble in case an emergency in the building.

Table 10-8 : Levels of Service of Transportation Facility for Passengers

Level of service	Area	Areas occupied by pedestrians (m^2/people)	Traffic flow (people /second, metre)	Remarks
A	Business District	≧ 3.13	≦22	Walking rates can be chosen freely. No conflict will occur while passing others. Direction can be changed at will.
	Commuting Area	≧ 3.13	≦23	
B	Business District	2.08 – 3.12	23 – 31	Walking rates can be chosen freely. There is slight conflict while passing other people and interruption may occur.
	Commuting Area	2.08 – 3.12	24 – 33	
C	Business District	1.28 – 2.07	30 – 48	Walking rates are limited. There is a high degree of conflict while passing others and interruption may occur.
	Commuting Area	1.28 – 2.07	34 – 49	
D	Business District	0.85 – 1.27	49 – 59	Normal rates are limited. It is not possible to pass others and difficult to change direction.
	Commuting Area	0.85 – 1.27	50 – 66	
E	Business District	0.48 – 0.84	60 – 72	Walking pace is limited. Difficult to pass others and conflict unavoidable.
	Commuting Area	0.48 – 0.84	67 – 80	
F	Business District	<0.48	>72	Walking pace cannot be decided at will, cannot pass others, or move in adverse direction.
	Commuting Area	<0.48	>80	

Data source: Chung-Kun Company, 1993, pp. 4-57

10.2.5 Social and Economic Impacts

10.2.5.1 Land Use

(a) use of site: This site was classified as a suburb prior to 1970. Neighbouring land is mainly put over to agriculture with a minor portion used for industrial purposes. The population of this district was 71,726 in 1970. The development of the city and the expansion of the business district has resulted in a population increase to 113,049 by 1990; a growth rate of 57% in 20 years. Business is also increasing with the number of shops growing from 623 in 1970 to 4,890 by 1990. The land use of this site has changed from a fishmarket to a residential district with increased urban development.

(b) use of surrounding lands: To the northeast of the site is the Science Museum and park avenue. These are important recreational places in Taiwan with over two million visitors annually. Therefore, this district of Taichung, as well as being a booming business centre, is also an area of scenic beauty. To

the south of the building site is the So-Go Department Store, to the east offices and business buildings with shops and stores to the west. In general, aside from the residential district to the north, the Formosa Building is compatible with other office and business buildings in the vicinity.

10.2.5.2 Social Environment

(a) population: The population in this area has steadily grown (except in 1990 and 1991) as previously mentioned. This trend can be split into two phases: high growth period before 1975, annual growth rates over 4%; after 1975 slower growth period, growth rate between 1-2%. This indicates that urban development in this district has stabilised. In this area the emigration rate is higher than immigration[6]. To reverse this trend, schemes to increase job creation through business activities are major issues in redeveloping this district.

Daily, there are about 200 construction workers coming and going from the site during the construction phase. Fifty live at the site, which is only 0.05% of the population in the district so does not influence population structure. It is estimated that 650 job opportunities will be created during the operation phase of the building (Table 10-9). It is estimated that 60 employees and their families will move into this district. This may amount to 200 people or 0.2% of the district's population, ie. not a significant impact on the populations structure.

Table 10-9: Prediction of Employees in the building

Application	Area (m^2)	Attracting rate of employee (people/m^2. day)	Number of employees (people/day)
Office	68,597.6	0.007	480
Hotel	26,049.0	0.006	156
Total			636

Note: The attracting rate for employees is based on Taiwan Sugar Company,1997, pp. 8-1

From the above, there will be a significant impact on the district population structure on completion of the building. The biggest impact will be the daytime gathering crowds as 20,000 people is about 18% of

[6] Immigration population was 15,106, and emigration was 17,161 people in 1995.

the population in the west. Further incentives and a concentration of economy will encourage the development of surrounding land, which will result in further population and density increases.

(b) public facilities: The sewerage and drainage facility is of the utmost importance. A sewerage facility has not yet been installed in the area so, daily, 1,300 tonnes of waste water have to be treated and drained at the self-made waste water treatment plant. The effluent volume is 0.015 $m^3 sec^{-1}$, which is compatible with the carrying capacity of the drainage and river system. At a recreational level, there are an insufficient number of playgrounds and parks, which will be even more inadequate once the building is fully operational (see Table 10-10). Education facilities will be able to cope as the increase in the permanent population will only be 200.

Table 10-10 public facilities in the western district

Public Facility	Total No.	Area	Area for Each Person (m^2/person)	Minimum Required Area For 1 Person (m^2/person)	Result
Junior High School	5	17.5	1.75	1.3	Sufficient
Elementary School	6	19.3	1.93	1.6	Sufficient
Park	13	22.5	2.25	2.5	Insufficient
Gym/Stadium	1	4.6	0.46	0.7	Insufficient
Parking Lot	10	4.3	0.43	0.5	Insufficient
Children Playground	4	3.8	0.38	0.8	Insufficient

Note: The minimum required area for each person is based on the lowest standard prescribed in the periodic review and performance regulations of the urban project.

(c) public service: As this area is the booming business centre of Taichung City, with the municipal government and city council, public services are well developed eg. the post office headquarters, 242 hospitals (ranked 2nd only to ones in the north), the Cultural Centre, and the Provincial Museum of Arts. Fire-fighting; the height of this high-rise building is beyond the fire-fighting limit so automatic fire-fighting equipment and facilities are installed throughout the building.

10.2.5.3 Economic Environment

(a) job creation: There were 200 construction job opportunities during the construction phase and 636

vacancies during operation stage (Table 10-11), which will help reduce unemployment in Taichung. The shift of the working population to tertiary industry also affects the structure of industry in this area. The employment population in the service industry in this western district has increased from 67.5% to 69.5% with 2% provided by this building.

Table 10-11: Prediction of Employees in the building

Application	Area (m^2)	Attracting rate of employee (people/m^2. day)	Number of employees (people/day)
Office	68,597.6	0.007	480
Hotel	26,049.0	0.006	156
Total			636

Note: The attracting rate for employees is based on Taiwan Sugar Company,1997, pp. 8-1

(b) economic activities: The completion of this high-rise building will promote economic activity in this district, especially in the tertiary industry. The requirements for construction materials and equipment during the construction phase can help in the development of related industries. Since the construction industry has been termed the 'locomotive industry', integral economy will be motivated and developed positively. Local stores and shops will also benefit from the daily presence of construction workers. The local government can impose tax revenues on the building once completed. It is estimated that £50,000 land tax, £240, 000 pounds house tax and £5 million worth of income tax will be collected by the government.

(c) land ownership: The fish company previously owned this building site. The ownership is now split and held by all owners of the building proposal, which may cause problems when a unanimous agreement for re-building or redevelopment is needed in the future.

(d) land prices: Currently, land prices in this district are expensive at £10,000 m^{-2}. As business activities get busier, land prices will increase further.

(e) living standards: As the business and administration centre of Taichung City higher incomes are expected. A daily influx of 20,000 people will cause an impact on the local lifestyle with the old

communities to the north being particularly affected.

10.2.5.4 Social Relationship

The analysis of the impact on social relationships can be divided into three: social system; social psychology; and security hazard.

The construction of the high-rise does not impose a significant impact on the original social structure. The majority of local residents agreed to rebuild the fishmarket into a high-rise building although concerns were expressed at the public briefing about the impact of increased parking impact. They were also concerned about changes in quality to their living environment from large shopping crowds and noise. Nevertheless, when compared with impacts from the fishmarket, most residents still accepted the project[7].

Disaster prevention is a major social issue. The most common catastrophes in the metropolis include fire, earthquakes and wind disasters. As fire is difficult to control and could easily spread to nearby residents, this is taken into consideration at the planning stage. Consequently, open spaces are reserved on the western and northern aspects of the building to serve as buffers against fire spread. In earthquakes, falling materials and debris may affect the safety of neighbouring buildings. An insufficient space between this building and those adjacent to it would result in collision and destruction. In general, a space greater than ($(H)^{1/2}$)/2 is a basic requirement. A space of over 5m is reserved for this purpose to the west and north of the building. Wind disasters generally occur during typhoon season. The position of this building may change or increase the intensity of typhoons damaging neighbouring houses. Wind tunnel tests are carried out to assess the impact of the wind field. Results show that wind disasters will not occur because of this high-rise building.

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[7] Local residents often complained about early morning operations and the stinking smell of the fishmarket. They were happy to have this site used for commercial purposes.

10.3 MITIGATION MEASURES AND ALTERNATIVES

10.3.1 Mitigation Measures

Micro-climate

(a) control of heat environment: The micro-climate of the site changes due to changes in heat capacity. Therefore, surface materials on the lower floors should be of low reflective quality with a high specific heat rate. Aside from areas of greenery, and water landscaping, climbing vines should be arranged and planted to reduce the site temperature through evaporation.

(b) wind hazard: Southerly and northerly winds usually occur in this area. In order to avoid forming a vertical angle between the building and the wind, which might enforce windflow separation at the corners, the location of the building must be arranged and adjusted to form a slanting angle with wind direction. From wind tunnel tests, wind disturbance will be greatest at the northwestern and northern sides of the building. Adopted mitigation measures are:

- installation of a canopy or screen against the wind on the northwestern side to diminish the wind impact on pedestrians to prevent whirlwinds and descending air flows
- facility layer on the medium and higher floors of the building can be used for ventilation so reducing wind hazard impact
- the building is a column style design that can limit the power of the descending wind produced at the higher floors onto the roofs of lower buildings and pedestrians
- according to the wind tunnel test, wind velocity in winter at the north end of the site is strong. This might affect sitting and standing activities of neighbouring buildings. Consequently, evergreen trees should be planted to reduce velocity and wind hazard.

Disturbance of electrical waves

To resolve reception difficulties due to the blocking of electrical waves, community antenna television (CATV) and band increasing facilities will be installed and incorporated into the shared audio-video antenna system

Noise nuisance

To prevent large levels of noise during the construction phase, a manual soil blocking column support will be applied to the base excavation instead of steel pile or steel track piling. This should ensure noise levels do not increase more than 5dB(A). A 3m high fence around the construction site will also reduce noise levels to below 65dB(A).

Land use

The specific use of this site as a hotel and office complex is very different to its former use as a fishmarket. The land will be subjected to three types of impact: insufficient open spaces; traffic congestion problems; and chaos of land use orders. The following mitigation measures will be implemented.

(a) Open space will be reserved for use by people inside the building as well as local residents to compensate for the lack of public parks in the area

(b) Parking spaces must be reserved inside the building to prevent roadside parking and obstruction of traffic flow. Entrance and exit to the car parks will not be directly connected to Taichung Kan Road so preventing disturbance and obstruction of traffic flow by queuing traffic or by changes in direction.

(c) All activities are designed to be held inside the building to prevent any impact on the surrounding land. In addition, the management of the open space will prevent the gathering of temporary vendors.

10.3.2 Alternatives

Development goal alternatives

This alternative is to change the design of the development project and to alter its uses if necessary.

(a) office building: An advantage of this alternative is increased economic activity and job opportunities. However, this use is not beneficial to recreational development in central Taiwan. The traffic volume would also exceed the predicted volume of the original project so imposing greater impact on the local environment. Furthermore, there is an abundance of similar office buildings in the district that might not attract investors.

(b) residential building: The advantage of this alternative is less pollution during the operational stage than the original project. Nevertheless, the construction of a residential building in a booming business centre on the busy Taichung Kan Road does not fit in with the city development and will lead to crowding and pressure on insufficient public facilities.

Intensity alternative (decreasing building coverage ratio)

Advantages of this alternative are the reduction in the size of the excavation area and construction period. This could reduce the range of environmental impacts. A decreased floor area will reduce the number of trips made to the site so alleviating impacts during the operation stage. However, as land costs are fixed, the cost per unit area will be raised lessening the competitive capacity of the industry.

Architecture style alternative (low-level building)

Under the principle of maintaining the total floor area the Formosa Building could be redesigned as a 20 floor building. The advantage of this alternative is a smoother skyline. However, the building coverage over the ground's surface will increase by about 400m^2, which will enlarge the excavation surface and diminish the amount of open space.

No-action alternative

The no-action alternative means that no construction on the site will be carried out. Its purpose is to predict changes and the impact of the development proposal in the application area.

The primary goal of this building project is to provide quality recreation and entertainment, both for

foreign tourists and the general public. It is estimated that the total room requirements for the hotels will be 1,850 in 2001. Nevertheless, international hotels like the Plaza Hotel, Howard Hotel, Evergreen Hotel and International Hotel can only provide 1,469 rooms; 381 rooms short of the target[8]. Therefore, this building can accommodate the shortcomings of these international hotels.

If the project had not been given the go-ahead, the original use of the land as a fishmarket would be incompatible to the services and requirements of the rest of the neighbourhood. The local residents have already experienced foul odours, noise, and a heavy traffic volume in the mornings. The application to change the land use to hotel and office buildings will meet the demands of urban development in this area.

Engineering alternative

This alternative is a change in the construction method, including an alternation of the foundation type used, a change in the structure, and a change in the construction timetable. Any changes in engineering, however, do not significantly reduce impacts on the environment.

10.4 THE EIA ASSESSMENT OF THE FORMOSA BUILDING

The Formosa building is also located in the westside of Taichung, slightly opposite the So-Go Building. The Formosa site originally served as a wholesale fish market, later being rezoned as a residential district. It was purchased by the Tuntex Group at the end of 1991, who aggressively planned to construct a complex high-rise there. The prediction and assessment of environmental impacts was conducted in 1992. After passing the EIA review in 1993, construction commenced in 1994 and finished four years later in 1998. At this point, the Tuntex Group applied to alter the use of the floors below the 10th storey for a new purpose as a department store. Their EIA application triggered a series

[8] If we calculate the lodging rate of international hotels as 70%, then 2,643 rooms will be required in 2001 (Chung-Kun Company, 1993, pp. 2-4).

of arguments but was eventually passed in February 1999.

As the timing of the assessment of the Formosa project fell between the EIA Operational Guidelines for High-Rise Buildings (1992) and the EIA Act (1995), how the legal regulations were applied was an issue for debate in this case.

10.4.1 The EIA Implementation Process in relation to the Formosa Building

There was an eight year interval between the first prediction and assessment of Formosa's environmental impacts and the final approval of its Environmental Impact Differential Analysis Report (EIDAR), i.e., the report concerning its proposed change in use. During this period the Asian financial crisis was brewing, affecting several businesses, not least the Tuntex Group. For instance, the Daimaru department store within the Formosa Building suspended trading in March 1999 which led to a public outcry.

The EIA implementation process on this case can be divided into five stages. The first refers to the planning and approval of Formosa's EIA report, the second to the site's zoning change from residential to commercial status. The third covers the change in the occupancy plan for the building for, as we saw earlier, the Tuntex Group planned to alter the use of the floors below the 10th storey so as to establish a department store - the Daimaru store, mentioned above. The fourth stage refers to the review of the EIDAR while the fifth covers the outcry which ensued when the EIDAR was approved and the Daimaru store temporarily ceased trading, laying off all its employees. As with the So-Go Building analysis of the last section, these stages were not completely discrete but in practice overlapped with each other. Table 10-12 summarises the timing of the main events.

Table 10-12: Summary of Events of Formosa's EIA Implementation Process

Date	Event
1991.12	Tuntex Group purchase site (originally a fish market)
1992.1	Plan to construct a multi-function high-rise is announced
1992.1	EIA assessment commences
1992.4	Zoning change from residential to commercial status received by urban planners
1992.8	EIA assessment is completed and the report submitted to the city government.
1992.9	The competent authority consult with other relevant bodies
1992.12	EIA committee review the case for the 1st time, noting 7 items which need to be re-addressed. The developer responds on Dec. 2nd
1993.1	EIA committee review the case for the 2nd time (Jan 13th) and approve the project with 2 conditions attached
1993.4	Decision-making on EIA report
1993.12	City government issue construction permit
1994.5	Construction commences
1994.6	Waste water treatment plan presented to environmental agency for approval
1995.2	Zoning change passed. The site is now in a commercial zone with feedback conditions attached (Feb. 15)
1997.3	Detailed feedback and approval procedures published
1998.5	Formosa building is completed and issued with an occupancy permit
1998.8	Tuntex Group apply to alter the use of floors below the 10th storey to trade as Daimaru store
1998.9	EPB review procedures of alteration application and agree to substitute EIA report with EIDAR (Sept. 1)
1998.9	EIA committee review EIDAR for the 1st time (Sept. 21) and propose 48 items for the developer to re-address
1998.10	EIA committee review EIDAR for the 2nd time and present 36 items for additional assessment (Oct. 2)
1999.1	EIA committee review EIDAR for the 3rd time and pass with 3 conditions attached (Jan. 26)
1999.2	Taichung city council require the city government to report to them on why the EIDAR was allowed to substitute for a EIA report (March 12)
1999.3	Daimaru announce that they will temporarily suspend trading and lay off all staff because the case has not been approved, costing them £400,000 per month (March 18)
1999.3	Taichung city council suspect that the suspension of Daimaru amounts to blackmail (March 20)
1999.3	Taichung city government ask EPA to explain the legitimacy of displacing the EIA report with the EIDAR
1999.4	EIA committee conduct a review to check whether the attached conditions have been implemented
1999.5	Taichung city council appeal to Control Yuan and ask them to impeach the city government because of illegal interest exchange
1999.9	Taichung City Government approve the variation in Formosa's functions
2000.1	Daimaru Department Store opened (1st January 2000)

10.4.1.1 Phase One (1991-1993): The EIA Review

Having purchased the site (located in a residential zone) in December 1991, the Tuntex Group aimed to construct a multi-function 32-storey high-rise there. The Group hired a noted Taiwanese architect (Lee Zu Ho) to draw up plans and to establish an interdisciplinary team who would analyse the project's environmental impacts. A traffic flow survey was conducted near the site in January 1992. Coupled with a survey of parking space then available around the site, these data formed the baseline information

needed for assessing impacts on traffic. In July, a survey measuring noise near the site was conducted. By August 1992, all the assessments and consultations with other relevant organisations were complete and Formosa's EIA report was submitted for review on August 17th. The city government then began its own round of consultation exercises and, by October, had conducted its own site survey.

In December 1992, the EIA committee reviewed the EIA report for the first time, noting that further work needed to be done on seven items, most importantly on the building's traffic impacts and proposed mitigation measures. As Table 10-13 shows, the developer's EIA team responded to these suggestions and submitted the amended report on December 18th.

Table 10-13: First Review: EIA Committee Comments and Tuntex Group's Responses

Comments	Responses
Traffic plan & mitigation measures during construction	Construction vehicles will avoid Taichung Kang Rd. to lessen traffic impact
Width of lanes should be expanded for cars to pass easily	Entrance/exit changed to 3 lanes to reduce delay-time
Roads on the northside should be built to evacuate crowds	The company will pay for construction and the city government will operate the construction programme
Traffic flow & LOS on the road not accurate. Further investigation needed	Already amended
Applications of the building must match legal regulations	The building to serve as hotels, offices & restaurants, meeting legal regulations. However, basement to 10th floor to be used as dept. mall
Insufficient open space	Section facing Taichung Kan Rd. will be retracted by 10m
The company should plan feed-back in advance of the site changing to a commercial zone	12% of land area on the north side of the site will be provided for feedback

10.4.1.2 Phase Two (1992-1997): The Zoning Change Period

Though the Tuntex Group had planned to construct a multi-purpose high-rise when they purchased the site in 1991, the area was still residential and with that zoning status, the only applications they would be eligible to apply for were hotels, offices and small malls (less than $150m^2$). Thus, while going ahead with these allowable plans, the developers also lobbied for a change in the zoning status of the site so that they could realise their larger ambitions for the building. After receiving the application for a zoning change from Tuntex in April 1992, Taichung city government assessed the goals for urban development in this region and, on that basis, agreed to begin the process of changing the district's

zoning status. This decision made this site, and the So-Go department store slightly opposite it, into a block-shaped business district, which also had the effect of turning Taichung into a multi-core metropolis.

In addition to requiring the approval of the Urban Planning Committee of Taichung, the proposed zoning change also needed to be ratified by Taiwan Province and the Urban Planning Committee of the Ministry of Interior Affairs. This process concluded in February 1995 with the proviso that gains from the zoning change should be returned to the public good in the form of the donation of lands or monies. The following feedback mechanisms were announced and put into effect on March 18 1997:

(a) The owners of the sites altered to the status of business district had to donate 12%-18% of their land to the city government for parking

(b) Feedback land could be substituted by the donation of a car park or of money of equal value, according to the formula:

$$\text{equal value of parking space} = \frac{\text{Area of feedback land x basis floor area ratio parking lot (50\%)}}{\text{area of each parking space (25 m}^2\text{)}}$$

equal value of feedback money = (area of feedback land x published current price of land) x 1.4

(c) If a completed building changes its use, then feedback money of equal value should be paid according to the formula:

Feedback money of equal value = Coefficient of construction cost x published construction cost (NT dollar/m^2) + (published current price of site x area of site x 25 x parking space) /total floor area.

As the building in the Formosa case was almost finished, the third mechanism was the one applied. The feedback money came to a value of £4m which had to be tendered to the local government prior to approval and used as construction funds for public facilities. The entire zoning change process took five years and by its conclusion in March 1997, the Tuntex Group was ready to apply for Formosa's occupancy change permit.

10.4.1.3 Phase Three (1997-1998): Occupancy Change Plan Period

Once the site was designated as belonging within a commercial zone, the Tuntex Group decided they wished to allocate storeys B2 to 10 (12 floors in total) as a department store. The Daimaru department store pushed for this change on the grounds that it could meet the following needs of the city:

a) *Importance:* As the central city of Taiwan with a population of five million, Taichung was booming and diversifying as a consequence of its industrial and commercial development. They argued that the Formosa Building could combine business, industrial and recreational activities in one site whilst also promoting the city's quality of life.

b) *Necessity:* This project, it was argued, could cope with the future development demands of Taichung while retaining consideration for the city's natural environment and the district's needs. A multi-function building combining a hotel, department store, restaurants, car parks and offices would not only boost local development but would also constitute an efficient use of land.

c) *Rationality:* As land in the city is limited and consequently expensive, this building could incorporate entertainment businesses into its functions while simultaneously becoming a recreational and sightseeing focus for the city as a whole (Formosa Company 1998, p.1.5).

Table 10-14 lists the changed uses requested for the Formosa Building. However, as Table 10-15 shows, as occupancy intensifies so too does population density. This population increase generates additional environmental problems and, to assess what these might consist in, the Tuntex Group asked their EIA consultancy firm to quantify the difference the proposed department store would make as compared to the original offices plan.

Table 10-14: Contents of Changed Applications for the Formosa Building

Floor	Original Application	Application after Change
B6-B3	Parking Bays	Unchanged
B2-B1	Hotel, Offices	Department store malls
1F-10F	Offices	Department store malls
11F-15F	Restaurants	Unchanged
16F-23F	Hotel	Unchanged
24F-32F	Offices	Unchanged

Data Source: Formosa Company, 1998, p. 2-5.

Table 10-15: Comparison of Populations between Original and New Plans for the Formosa Building

Application	Population of Original Project	Population of New Project
B2-10F as dept. stores	4,505 people	45045.79 m^2x60% x 0.2 (person/m^2) = 12,000 people
11-15F as restaurants	2,974 people	16524.7 m^2x60% x 0.3 (person/m^2) = 2,974 people
16-23F as hotels	420 people	205 rooms x 2 people = 420 people
24-32F as offices	990 people	508 rooms x 2 people = 1,016 people
Total	8,889 people	16,410 people

Data Source: Formosa Company, 1998, p. 2-5

Table 10-16 outlines the environmental impacts of the change in use of B2 to Floor 10 in the Formosa Building (six changed, nine unchanged). For those items which did change the building's environmental impact, all except one - the emission volume of waste water - were changes for the worst. The most pressing item to emerge was the increased demand for parking - up by 26%. Thus, ensuring an adequate supply of parking space became the most important issue to tackle if the building's environmental impacts were to be ameliorated.

Table 10-16: Environmental Impact Differential Analysis (EIDAR) of the Formosa Building (B2-10F):

Unchanged:

Item	Content of Original Plan	Content after Change	Description
1. Location	Westside District, Taichung	As per original plan	------
2. Area of site	6,972 m^2	As per original plan	------
3. Zoning	Commercial zone	As per original plan	------
4. Building type	32 floors above ground level steel-frame structure	As per original plan	Design of appearance not involved in this case.
5. Noise & vibration	noise increase vol. of construction vehicles is 5 dBA – 11 dBA. * vibration value of construction machinery at residences 15m from the site is 64.8 dB.	------	Noise & vibration impacts mainly appear during the construction stage, now finished.
6. Obstructed electric waves	Installation of public antenna	As per original plan	Design of appearance not involved in this case.
7. Overshadowing of other buildings and land	The projected areas at Winter Solstice located inside the site.	As per original plan	Design of appearance not involved in this case.
8. Local wind effects	Wind tunnel tests show the wind field for walking at every test point meet comfort demands	As per original plan	Design of appearance not involved in this case.
9.Ecological environment	No precious or preserved wild animals	As per original plan	The area is a developed district

Changed:

Item	Content of Original Plan	Content after Change	Description
1. Building use (B2 – 10F)	Hotel & Office	Department Store	
2. Population	8,889 people	16,410 people	7,512 increase
3. Volume of waste water	1,318 CMD	1,250 CMD	68 CMD decrease. Capacity of 1,500 CMD at waste water treatment plant.
4. Air quality	------	Emission volume of traffic pollutants once building is operational: NO_x = 59.23 ppb SO_x = 3.15 PM_{10}=66.96 ug/m^3 emission concentration of pollutants at under-ground parking bay CO = 5.63 ppb NO_x = 0.27 ppb SO_x = 0.016 ppb	
5. Solid wastes	5.67 tonnes/day	9.37 tonnes/day	3.7 tonne increase cleaning by a collective
6. Car parking	616 spaces	776 parking spaces	160 increase

Data Source: Chung Kang Formosa, 1998, pp. 1-2

The Tuntex Group applied for an occupancy change for B2 to the 10th floor, presenting an Environmental Impact Differential Analysis Report(EIDAR) to the city government in August 1998. As the Formosa's EIA report had been approved prior to the EIA Act of December 1994 coming into force, a heated debate arose as to whether the Formosa's EIDAR should now be assessed according to the old guidelines or the new law. The issue caught the public's attention and triggered a series of arguments within the city council, resulting finally in an ad hoc project meeting being called.

10.4.1.4 Phase Four (1998-1999): Review of the EIDA Report

The city government now had to decide whether the Formosa building could go ahead on the basis of an approved EIDAR or whether the whole EIA process needed to be re-started. According to Article 38 of the Detailed Implementation Principles of the EIA, an EIA has to be re-done if the following situations occur:

a) planned output capacity, scale or route increases by more than 10%;

b) the change of land application involves protected areas or green belts within the original plan or

otherwise threatens vulnerable areas;

c) the change diminishes the level or efficiency of environmental protection facilities;

d) the change aggravates the impacts on living, natural & social environments or on protected targets; and

e) the change worsens the maintenance of environmental quality.

As the city government did not spot any significantly disadvantageous impacts upon environmental quality after conducting its research, it was judged that Formosa's EIDAR was in fact an acceptable substitute for an entire EIA Report. The EIA committee convened its first review of the case on September 21 1998. Forty-eight items emerged as requiring significant amendment, complete with mitigation measures. As Table 10-17 shows, 10 of these items referred to parking; seven to traffic; and six to the treatment of waste.

Table 10-17: EIA Committee First Review Responses to Formosa's Proposed Change in Use

Category	No. of Comments
Parking	10
Traffic	7
Assessment methodology	6
Treatment of wastes	6
Landscape	4
Water pollution	3
Noise	2
Air pollution	2
Open space	1
Socio-economic issues	1
Construction plans	1
Evacuation/emergency facilities	1
Environmental management	1
Wind hazard (micro-climate)	1
Total	48

Responding to the issues which emerged from the first review, the Tuntex Group submitted a revised document at the end of September. The second review of Formosa's EIDAR was held on October 2 1998. Committee members still could not agree on the traffic and parking implications of the change in use. As for the assessment methodology, most thought that the crowds the new Formosa was likely to attract were deliberately underestimated so as to minimalise environmental concerns. As a result of the

controversy within the committee, three members deemed that it should be returned and re-assessed.

Table 10-18 shows that traffic remained the major concern of the second review; 10 comments referred to traffic, eight to parking and four to the assessment methodology. It was clear after the second review that the committee felt that the environmental impact was still unacceptable and that the developer's mitigation measures were not sufficient. Therefore a third review was called for which was eventually held on January 26 1999.

Table 10-18: EIA Committee Second Review Responses to Formosa's Proposed Change in Use

Category	No. of Comments
Traffic	10
Parking	8
Assessment methodology	4
Returned for supplementary assessment	3
Air pollution	2
Water pollution	2
Landscape	2
Open space	1
Socio-economic issues	1
Evacuation/emergency facilities	1
Total	36

To address the parking issue, the Tuntex Group now proposed to construct a parking tower at the back of the site and to provide temporary parking lanes for buses and taxies along the retracted frontage facing Taichung Kan Road. By now, it had taken five months from the first EIDAR submission to the third review meeting and the opening of the department store had been postponed three times. Thus, by the time of the third review, both the committee and the developer had had enough; if the mitigation measures were not deemed to be sufficient this time round, the application would be returned and the case closed.

After long discussion, the third review meeting passed the project with two conditions attached. If the developer failed to accept these conditions, then approval would be withdrawn. These two requirements were, firstly, that B1 to 9F could be used as department store space only if two underground floors were solely reserved for parking and, secondly, that a parking space must be

provided for every 75m^2 of floor area with 850 spaces provided in total.

From this contentious case, we can see that mitigation measures relating to the impacts which stem from changes in the use of a building cannot easily be implemented. Once a building is finished, there is not much room for manoeuvre. This was especially true in the case of the Formosa Building for its very location ensured that there was little lee-way for enhancing its parking capacity.

10.4.1.5 Phase Five (1999) : The Controversial Aftermath

Since the EIA committee passed the Formosa application on January 26, public criticism has not abated. By February, Miss Zu, a member of Taichung City Council, asked the city government to present an ad hoc report of the contents of the change process which could then be evaluated by representative agencies and the general public.

The council's ad hoc report meeting was held on March 19th, with many participants querying why the city government had agreed to accept an EIDAR from the Tuntex Group instead of insisting on a new EIA. Some were suspicious of the government's motives[9], while others viewed the EIDAR as being so deliberately partial and evasive that insisting on a second EIA process was the only appropriate response the government should have made to it. The meeting's Chair concluded that the city government should review this case in terms of the criteria of local prosperity, civic rights, law and justice.

One week after this special meeting, the Tuntex Group held a news conference and formally announced the suspension of its department store operations and the laying off of all its employees from March 18. Preparation work for the store had commenced in the spring of 1998. They were now carrying 120 employees and had spent £500,000 on personnel and management consultant fees. More than £4m had

[9] During the ad hoc project meeting, councillor Hsiao questioned the integrity of the city government and councillor Hsieh Ming Yuan considered that the development company was using its wealth as a lever. See Chinatimes, March 13, 1996 p.16, Taipei, Taiwan.

been lost over the year so their only option was to suspend operations. In the course of this announcement, the Tuntex Group criticised the two conditions which had been attached to the approval granted in January by the third review committee. They claimed the terms were too harsh; that the enforced allocation of two underground floors to parking cut too deeply into their projected profits. At this news conference, they claimed that they were willing to re-negotiate these conditions with the city government.

Meanwhile, the city government indicated that the project had been passed on condition that the two parking items were dealt with and that they had made no special or shady deal with the Tuntex Group. Some city councillors thought that the suspension of Daimaru's trading was a blackmailing tactic designed to put pressure on the government to drop the attached conditions. Others argued that it was obvious that the company was simply refusing to put traffic mitigation measures in place and, for this reason, it was necessary that a new EIA review be conducted. Caught in the vice of pressure from the public, the suspicion of the city council and the impeachment appeal to the control Yuan, the city government decided to ask the EPA for its advice concerning the legitimacy of this case.

The EPA replied in April 1999, endorsing the city government's authority to deal with the case as it saw fit. The EPA's view was that if the city government could not identify significant negative environmental impacts in this case, then it was entitled to accept the EIDAR as an adequate substitute for a full re-enactment of the EIA process. With this endorsement supporting them, the city government formally announced at the end of April that its approval of Formosa's EIDAR would stand. The application change in favour of the Daimaru Won department store was approved in September 1999 and the developer proceeded with interior design work anticipating an opening date in January 2000.

This case took eight years to assess, the same length as the So-Go Building took. Though it was much more fraught than the So-Go assessment, the bottom line for both cases was the same. Both high-rises

were finally built with permission to use part of their space as department stores, though the Formosa Building has approval for a much more complex range of activities than does the So-Go Building. However, as both are close to each other on Taichung Kan Road, competition between them can be expected. Looking at the detailed history of these two cases, we can see that there is still a long way to go before the credibility of the EIA process becomes firmly established.

10.4.2 The Decision-Making Process

There were two stages to the decision-making process in this case. The first refers to the original EIA review of 1992/93 and the second to the later EIDAR. The first process followed very similar lines to the So-Go case; both took roughly the same length of time and both were regulated according to the same kinds of criteria. Thus, we will just deal here with the control mechanisms which were pertinent in the second stage of the decision-making process on the Formosa Building. In addition to the three control mechanisms cited in the previous section on the So-Go Building, this case also features a judicial control mechanism.

10.4.2.1 Professional Control

Professional control refers to the influential role that professionals can play throughout the EIA process. In this case, it was already evident in the first stage of the EIA process. Expert and scholarly opinion was instrumental in inducing changes to the developer's early plans (e.g., retracting the building, increasing Formosa's open space, expanding the width of car lanes, etc.). However, the professional control mechanism was even more apparent in the second stage. The EIA committee, with two-thirds of its members being specialists, proposed 48 amendments at the first EIDA review (45 or 94% of them voiced by experts) and 36 (all voiced by experts) at the second.

At the EIDA Report's third review, the specialists imposed two conditions on their conditional approval which, if not met, would result in the case being dismissed. This demonstration of the power of the

professional control mechanism led to the Tuntex Group holding a press conference in which it loudly criticised the over-exacting standards of the EIA committee which was directly costing them a great deal (too much) time and money. Though the developer was clearly unhappy with the stringency of the review process, the fact that the company was obliged to accept its conditions clearly indicates the power of the professionals to crucially shape an outcome.

Furthermore, the importance of professional opinion is revealed through the attitude the city government took to the controversial decision taken. In the midst of the quarrels amongst the general public, the city council, the developer and the city government, the mayor announced that professional expert opinion should be respected as the ultimate measure against which the case's outcome should be judged (China Times, 1999). Table 10-19 outlines how the professional control mechanism operated at each stage.

Table 10-19: The Operation of the Professional Control Mechanism during the Decision Process on the Formosa Building

Stage	Instances of Professional Control
1st stage EIA review	Professional committee members present practical suggestions which influence the decision
Decision of the mayor	Implemented in compliance with the review conclusions of the committee
1st EIDAR Review	Professional members voice 45 out of the 48 review comments, indicating their dominance of the committee's decision-making
2nd EIDA Review	36 amendment comments are proposed (all voiced by experts)
3rd EIDA Review	Two conditions are attached to the approval which the developer must implement if permission is to be granted
Decision of the mayor	Said on 18/3/99 that expert opinion would be totally respected

10.4.2.2 Direct Control by the Public and Outside Agencies

This form of control imposed tremendous pressure on the government in the latter assessment stages of this case, though there was a noticeable difference in public attitudes towards the project between the first and second decision-making phases. During the original review process (1992-1993), most public opinion tended to support the project as it was seen to boost local prosperity and increase job opportunities. Since it was not facing significant public objections, the city government granted

permission to build in compliance with the resolutions of the EIA committee.

As we have seen, public opinion later turned as the new proposed use of the Formosa Building introduced the issues of serious traffic congestion and further environmental decay. In addition to hostile public opinion, the city council also played a critical role during this stage especially when it asked the city government to present an ad hoc report which would have the effect of making the entire decision-making process transparent and therefore directly amenable to comment by outsiders.

The various non-governmental organisations (NGOs) (which might otherwise be considered under the heading of outside agencies) did not form a distinct voice in this case, as the EIA committee had incorporated their views by including NGO participants in the committee's membership, e.g., the directors of the New Environmental Promotion Institute and the Guild of Environmental Engineering Technicians were on the EIA committee. Table 10-20 outlines the forms of control exerted by the general public and by external agencies, and this case illustrates well the extent to which the city government is sensitive to that form of control.

Table 10-20: Controls exerted by the Public and Outside Agencies in Decision-Making on the Formosa Building

Stage	Public Opinion	Decision of City Government
First stage EIA approval	Supportive	Development approved
Second Stage (EIDAR)	More wary; keen to ensure environmental quality is not disregarded	3 conventions, review & one time of approval meeting
Ad hoc meeting of city council	Questioning the justice of replacing the entire EIA process with EIDAR	Decide to accept the EIDAR as a substitute
Final decision on altering Formosa's use	Lobbying for environmental impacts to be reduced to acceptable level for approval	Insist on implementation of mitigation measures
NGOs	No comments	Incorporate some NGO members to EIA committee

10.4.2.3 Procedural Control

In this case, the procedural control mechanism only partially came into play. The decision-making process governing the original approval for building Formosa was subject to older and simpler

procedures than those made mandatory by the EIA Act. Nevertheless, these older procedures were adhered to illustrating that this control mechanism did, indeed, fulfill its function of improving the quality of decision-making.

By the time the Formosa Building came to be reviewed again in terms of its planned changed in use, the EIA Act had come into law. Thus Formosa's EIDAR was subject to the procedures laid down by the Act including consultation with relevant agencies, a site survey, review meetings, planning approval, etc. Table 10-21 outlines how certain parts of the plan were criticised as a result of consultation.

Table 10-21: Consultation Responses to the Alteration of Building Use Proposal for the Formosa Building

Consultees	Comments
Urban Planning Division	Area has been changed to commercial zone (category 3) and £4m due in feedback prior to approval
Business & Industry Division	No comments
Air Quality Control Division	Too few noise-measuring posts. The noise of air conditioning equipment exceeds the norm and requires immediate improvement
Water Pollution Prevention Division	Waste water volume estimates should be based on rush hours & safety coefficient added; COD & E-coli need to be added to drainage standards
Solid Waste Treatment Division	Daily rubbish volume per person hugely underestimated and needs amendment; needs a recycling programme

As there were no specific regulations on whether an EIDAR is an acceptable substitute for re-processing an EIA, the city government made an intuitive decision to accept the former. As they were later hugely criticised for this decision by the city council, we find evidence here that there is a lacuna in procedural controls governing this kind of situation (see Table 10-22). Except for the choice of the EIDA option, other procedures played a positive role in enhancing the quality of decision-making at each stage.

Table 10-22: Differences between re-processing an EIA and presenting an EIDA Report

Item	Re-processing EIA	Impact Difference Report
Review procedures	Need to be sent to the EIA committee	Only need approval from environmental protection authority & competent authority
Title of report	EIS & EIR	EIDAR
Content of report	10 items	4 items
Review period	50 days; overruled beyond 50 days	No limitations
Public participation	Explanatory conference, public exhibition & hearings	None
Punishment for Record-keeping Infractions	Max 3 years imprisonment	None
Punishment for violations	£6,000-£30,000 fine	None

10.4.2.4 Judicial Control

In Taiwan, judicial organisations cannot interfere with the policies of administrative organisations except for dealing with legal violations. Consequently, people cannot pursue litigation when they are dissatisfied with EIA decisions. As no specific targets for set for defining deterioration in environmental quality, the general public cannot file a suit on that basis. Nevertheless, there is a quasi-judicial organisation - the Control Yuan - which can accept petitions from the general public; investigate reports of illegal behaviour or of inappropriate decisions made by administrative organisations; ask the organisation in question to withdraw or re-process a contested decision; and impeach or punish policy-makers if appropriate. As a result, the Control Yuan plays a quasi-judicial role in the governmental system of Taiwan.

The city council announced at one point in the Formosa Building controversy that it would appeal to the Control Yuan to revoke the city government's policy and to identify who within the city government was responsible for failing to insist on a full re-processing of the EIA system. This threat forced the city government to appeal to the EPA for a verdict on their actions. Though the final decision on the Formosa Building remained the same, the city government slowed their pace while considering procedures and making policies. Therefore, the judicial control mechanism influenced decision-making in this case.

10.4.3 Key Issues to Emerge from the Formosa Building Case

In assessing the environmental impact of the Formosa Building, the issues of greatest concern to the EIA committee and the public were traffic, parking, wind hazard, the feedback fund from the zoning change, the adequacy of accepting an EIDAR in the second assessment period, and the effect this controversial case had on the government's image. The first three items refer to physical environmental impacts, while the latter three can be categorised as procedural arguments. We will look at each in turn.

10.4.3.1 Traffic

The Formosa Building is located on the main route connecting outer districts with Taichung city, a route which is clogged with traffic especially during rush hours. As a result, the EIA committee and the public are highly sensitive to the traffic implications of new high-rise building projects along this route. Tables 10-23, 24 and 25 list the EIA committee's comments on this issue at different points in the assessment process.

Table 10-23: Comments of the EIA Committee on the Traffic Impacts of Building the Formosa High-Rise

Comments	Responses
Transportation plan during construction, exit/entrance & transportation period amendment	Amended
Roads along both sides of the site to be developed to ease traffic flow	City government in charge of development using donated money
Reassess impact on the level of service	Amended

Table 10-24: Comments of the EIA Committee on Traffic Impacts of the Formosa Building with Altered Function (1st Review)

Comments	Responses
Impact of increased lane traffic on neighbours should be assessed	Re-survey the LOS on lanes
Evaluation of the LOS on the nearby roads is incorrect; why is it cited as being better than it was in 1992?	Re-assessment done
Data quoted in the traffic analysis are the same as in the EIA report of 1992; current data should be adopted	Amended
Two lanes facing Taichung Kan Road should be retracted to provide temporary parking	Parking space for buses is installed on Taichung Kan Road
Schedule the mobile traffic lines	The traffic maintenance programme should be presented to the city government for approval prior to anniversary activities
Arrange an area for taxis	Radio to be used to hail taxis to prevent traffic jams
Travel rate decreased, but the report does not cover the impact on LOS which requires an explanation	Though the rate is reduced, it remains within the same LOS category

Table 10-25: Comments of the EIA Committee on Traffic Impacts of the Formosa Building with Altered Function (2nd Review)

Comments	Responses
Car lanes facing Taichung Kan Rd need to be retracted to prevent traffic jams	A bay-shaped space for buses is installed along the side of Taichung Kan Road
Promotions should not be held at times when the store opposite is open to avoid traffic build-up	Promotion activities to be coordinated so that this situation is avoided
Basic information on Taichung Kan Road is incorrect	Amended
Re-assess traffic impacts	Detailed re-assessment done
Total floor area of the department store should take the traffic capacity and environmental carrying capacity of the neighbourhood into consideration	In-depth assessment done. Changed portion still within environmental carrying capacity
Can the open space along Taichung Kan Road take the crowd?	Every m^2 of open space in front of the building can carry 1.06 pedestrians. The LOS is D class, which is still acceptable
Conduct an actual survey on the trip every m^2 in adjacent department stores	Trip attraction rate of So-Go department store has been surveyed
Can the load capacity of buses accommodate passengers in this building?	The mass transportation system can meet trip demands to this site
Explore the possibility of a connecting system in this case	A flexible connecting system between nearby car parks and this building to be established at holiday times
Suggest reserved taxi lanes to prevent traffic impacts	Taxi lanes cannot be added due to the limitations of the site

The comments of the EIA committee can be divided into two main concerns. One was to consider whether the surrounding traffic system could bear the traffic volume derived from this building. The other was to consider whether temporary parking or waiting time would affect the traffic flow on Taichung Kan Road. In assessing the former issue, the consultancy firm which undertook the work found that the LOS on roads at three sections near the site would worsen - though only one location would deteriorate to a point where it could be categorised as an unacceptable "Class E" LOS rather than an acceptable "Class D". What this reveals is that development of the site indeed imposes negative impacts on adjacent traffic. It was this very issue which prompted the greatest criticism by outside agencies.

While reviewing the Formosa's later EIDAR, the EIA committee deemed that the traffic volume attracted by the change in use would cause the LOS on some sections of roads in the neighbourhood to decline to "Class E" (i.e. unacceptably stagnant traffic) (see Table 10-26). Thus, the committee concluded that the proposed area of the department store would need to be reduced in order to lessen the

building's impact on traffic. It was decided at the final review that two underground floors could not be designated as store space but would remain as parking bays, while the 10th floor would remain as office space.

Table 10-26: Level of Service Before and After Change in Use of the Formosa Building during Rush Hour (Late Afternoon on Week Days)

Road Name	Road Section	Direction	Before Change			After Change		
			Traffic Volume	Travel Rate	Level of Service	Traffic Volume	Travel Rate	Level of Service
Taichung Kan Road	Chong Ming S. Rd. - Jiang Hsin Rd.	West	2,935	24.5	D	3,085	21.3	D
		East	2,726	5.6	F	2,976	4.5	F
	Jiang Hsin Rd.– In Tsai Rd.	West	2,058	13.7	E	2,384	15.3	E
		East	2,292	25.7	C	2,442	17.8	D
Jiang Hsin Rd.	Taichung Kan Rd - Hsi Tun Rd.	South	744	16.7	D	1,044	14.5	E
		North	720	22.1	C	871	17.8	D
Mei Tsui Road	Taichung Kan Rd.- Gon Yi Rd.	South	954	15.1	E	987	14.7	E
		North	516	16.5	D	776	16.1	D

Data Source: Chung Kang Formosa, pp. 4-24, 1998

10.4.3.2 Parking

Parking was always an issue for the EIA committee and the general public and concerns about it surfaced in both assessment stages. In the first review of the original EIA report (December 2 1992) one of the seven resolutions made was about parking. In the EIDAR of September 21 1998, 10 comments out of 48 concerned parking. In the next EIDAR of October 2 1998, eight of the 36 comments also referred to parking issues (see Table 10-27). During the conventions convened by Taichung city council, questions about parking were also much in evidence.

Table 10-27: Comments of the EIA Committee on Parking Impacts of the Formosa Building after Alteration in Use (2nd Review, Oct. 2, 1998)

Comments	Responses
Parking for motorbikes should not be installed under the 3rd floor of the basement	Parking for motorbikes on the ground; floors under B3 only to be used by employees
Parking for motorbikes should be placed on B1 or the 1st floor.	Parking for motorbikes on the ground; floors under B3 only to be used by employees
Number of car spaces and how to improve mobile lines	Increased parking demands after change of application to be located in the parking tower on empty land behind
Using other buildings to meet the parking requirements of this building not pragmatic; parking demands should be resolved within the site	A parking tower to be built on empty land behind
Parking for motorbikes should not be located on the 3rd to 6th floors underground	The same as for comments 1
The land for a car park shall be rented. Can property ownership be obtained for a permanent parking application?	The rental plan has been cancelled and substituted with building a parking tower
Attached parking space should be located within the site, on the same street or block or on adjacent streets or blocks	The parking lot project at other places has been cancelled
Number of spaces needing to be added need further discussion and measures should be presented	222 additional spaces for motorbikes installed on the 1st floor and 160 extra spaces to be located in the parking tower

Table 10-27 demonstrates the two major concerns about parking: an insufficiency of spaces and where motorbikes should be parked. In relation to the first problem, the original application reserved 616 spaces. According to the building technique regulations a minimum of 620 are needed for Formosa's change in use. However, the committee considered that demands for spaces should be evaluated to meet rush hour demand rather than relying on meeting the minimum legal requirement. On this basis, the consultancy firm doing the analysis predicted that 1,033 spaces would be required. However, the peak parking demands of offices, hotels and the department store do not arise at the same times of day so it was suggested that a parking tower be built at the back of the site which would create an extra 776 spaces.

The committee asked that a parking space be provided for every 75m^2 floor area of the department store - 850 in total. Thus, the plan to use two of the underground floors as department store space was scratched in favour in turning those floors into parking bays and the allocation of the 10th floor was also re-negotiated. As we saw earlier, this new requirement led the Tuntex Group to announce a temporary

suspension of the store. The committee, however, declared that their decision was based on expert professional opinion.

As for the appropriateness of parking space for motorbikes, most committee members regarded it as improper to locate motorbike parking at B3 to 6F since few motorcyclists are willing to ride their bikes above B3; thus, this parking issue still remains. At the last review, although the developer was willing to build a parking tower with 222 spaces on the ground floor, 929 motorbike spaces were still located below B3. Finally, the committee decided that all motorbike space should be located on the ground floor and on B2, which was the issue which was most heavily criticised by the Tuntex Group.

As we have seen, the committee was consistently concerned about parking. Past experience demonstrates that large-scale development projects usually generate significant levels of illegal parking because parking problems have been underestimated. This is the reason why Taichung city council, the EIA committee and the public were so rigorous about parking allocation in the Formosa Building case.

10.4.3.3 Wind Hazard

The Formosa Building is 120 metres tall and 70 metres wide, a structure which is certainly large enough to affect the locale's micro-climate especially in terms of wind hazard. Taichung city government asked the developer to conduct wind tunnel tests to establish the wind environment at pedestrian height around the building. After assessment, it was found that this environment on Jiang Hsin Road and Taichung Kan Road could only meet the demand for comfort while standing but not while sitting. In addition, there was the possibility that wind speed would increase on the southwestern corner of the Formosa Building (i.e., the intersection of Jiang Hsin Road and Taichung Kan Road) in winter. As the wind changes direction here and blows downwardly, wind speeds at this corner are much faster than at other areas. Though the requirement that pedestrians can comfortably stand can be met, there are bus stops in this area which may mean that people waiting for their buses feel uncomfortable.

This building also adversely affects the wind environment on its eastern and northern sides; though the comfort demand for walking here can be met, comfort levels for sitting or standing cannot. As the wind blows north or northwest in winter, existing buildings on the northeastern side of the site shorten the wind path in winter, increasing wind velocity as a consequence, which adversely affects residents in the vicinity. It was required of the developer that tall evergreen trees be planted here to help reduce wind speed.

10.4.3.4 The Feedback Fund v. a Development Impact Fee

Zoning changes alter the kinds and intensity of usage to which buildings can be put. A zoning change necessarily has economic implications since different categories of land use command different land prices, and land values can vary enormously before and after a change. As we have already discussed, the Formosa Building is located on a site which successfully achieved a change in zoning status from residential to commercial. This change allowed the developer to increase the total floor area ratio devoted to profitable business. As the Tuntex Group was a major beneficiary of the zoning change, Taiwanese laws regulate how some of its windfall must be returned to the public purse. In general, methods of extracting this public benefit include land profit tax, development charges, development impact fees, transfer development rights (TDR), etc., though in Taiwan not all of these methods are legally available.

During the zoning change process which accompanied negotiations on the Formosa Building project, a feedback fund was levied on the development. This meant that the developer was obliged to pay a sum (or some equivalent) prior to being entitled to use the property as a bona fide commercial district enterprise. The feedback fund in the Formosa case was based on parking space, where the developer had to meet the costs of building a car park which it then rented back from the government. Although this feedback method is simple to administer, it does not necessarily reflect the profits gained by the developer from the zoning change. Nevertheless, the very existence of the feedback fund idea is an attempt to ensure that urban planning decisions can benefit everyone.

However, some experts who dealt with the Formosa Building case hold that the levying of a development impact fee would have been a more equitable mechanism for achieving this theoretical principle. Most of the EIA committee members who support this view come from an urban planning background. In the Formosa case, they argued that the proposal to change the function of the lower 10 floors to a department store would undoubtedly have adverse environmental effects. Though some of these can be (and were) lessened through mitigation measures (e.g., providing additional parking within the site) others simply cannot be directly addressed by the development company itself (e.g., ensuring that the LOS on roads nearby does not deteriorate further). It was argued that this latter type of problem can best be addressed by imposing a development impact fee. This method of sharing the cost of public facilities and infrastructure is based on the cost of the development. For example, in Florida USA, the formula for calculating the water drainage impact fee and road impact fee is as follows (Chen 1989, pp.152-8):

$$\text{Waste Water Impact Fee} = \text{ERU} \times C - \text{Credits } i_i$$

ERU: equal value based on residence unit (300 gallons of waste water per day as a unit)

C: construction cost for each ERU

Credit i: annual payment of investment cost in the beginning

The ERU of houses is 1, hotels (each room) 0.36, restaurants (each seat) 0.14, department malls (each 100 m^2) 0.35 and offices (each 100 m^2) 0.05.

$$\text{Road Impact Fee i} = \frac{\text{ADTi} \times \text{Tli}}{2 \times \text{CAP}} \times C - \text{Credits}_i$$

ADTi: average daily trip for each unit $_i$

TLi: average trip distance for each unit i (km)

CAP: trips capacity of each lane as LOS is 4 (class D)

C: land acquisition fee & construction cost for each lane every kilometre

Credits $_i$: current value of annual payment for initial construction costs

Some committee members held that waste water impact fees and road impact fees should have been imposed on the revised use of the Formosa Building in order to meet the "Polluters Pay Principle" and

to reach towards the goals of justice and fairness.

Feedback funds and development impact fees are just two expressions of the same principle, i.e., some equitable return to serve the public good. However, there is no legal framework in Taiwan for levying development impact fees so the imposition of the feedback fund is the only option available. The sum finally agreed on for the Formosa Building was £4m. However, the contentious history of the Formosa Building's development highlights that it is time that some serious consideration was given to enacting different kinds of mechanism for ensuring equitable payback.

10.4.3.5 EIDAR or EIA Reports

Table 10-19 lists the different requirements made of the EIDA Report and the EIA Report. The contents of the former only include items which will be changed; the differences to the environment those changes are estimated to make; and an environmental management plan. The purpose of the report is to alert the agency in charge rather than being to assess and lessen any environmental impacts. Consequently, mitigation measures or alternatives are not a mandatory component of the report, though the presentation of an environmental management plan is.

As we have seen, whether an EIDAR is an acceptable alternative to the entire EIA process depends on whether the assessors believe that the change of the building's function will have a critically adverse effect on the environment. In the Formosa case, the city government did not consider the alteration to be that environmentally contentious, while the city council came to an opposite conclusion. Thus, the history of the Formosa Building highlights difficulties over the definition of "negative impacts". The definitional problem in the Formosa case was not resolved until the EPA arbitrated on it and the city council threatened to petition the Control Yuan. What this reveals is the ambiguities within the EIA Act and the level of administrative discretion the EIA process allows.

10.4.3.6 Effects on the Government's Image

The Tuntex Group invested £200m in this project. The building, with its hotels, offices, restaurants and department store, certainly increased job opportunities and boosted local prosperity though it also engendered environmental problems. For local government, this case represented a difficult balancing act. On the one hand, the government has a duty to nurture prosperity by attracting outside investors. On the other hand, it has an equal duty to ensure that development does not stretch the environment beyond its ability to recover. One argument which surfaced in the Formosa case was that local government was afraid to appear "anti-business" and so acted less strictly than they should have done in the EIA assessment process so as to benefit the developer.

The Tuntex Group was not slow to exploit this government dilemma. As we saw earlier, the Daimaru department store held a press conference in March 1999 where they announced that they were temporarily suspending trading. They blamed this on the EIA committee who, by being too harsh, had forced the company to postpone the opening date several times. They argued that the treatment meted out to them would deter other investors from launching new wealth-creating projects. After the news conference, the city government expressed its dissatisfaction with Daimaru's comments, stating that the company was mischievous in suggesting that it was anti-business and that the public also misunderstood its administrative procedures. Undoubtedly, Taichung city government's image was damaged by the Formosa case. Critiques based on the two polar extremes of anti-business tendencies and lax supervision damage the credibility of the EIA system.

Of the six issues raised about the implementation of the EIA system in this section, some are systemic and others derive from the particulars of the Formosa case. The former group of problems need to be overcome gradually, drawing on the accumulated expertise and credibility of the EIA system. The latter group of problems are best solved by improving the professionally objective assessment capabilities of EIA consultancy firms.

10.5 SUMMARY

Formosa building is located opposite to So-Go building. The site was originally served as the auction center for fish. As the city develops in compliance with nuclei development mode, this area becomes a booming business district gradually. Thus, the Tuntex Group conceived to construct a compound high-rise building, which mainly serves as offices, hotels and restaurants. A portion of floors was applied for change to become Daimaru department store in 1998.

Formosa building has a height of 117.25 metres with 32 floors above the ground and 6 stories under the ground and the total floor area is 118,437 m^2. The review was approved by the EIA Committee for High-rise Buildings in 1993, construction began in 1994 and completed in 1998. It is mainly appealed by a five-star resort hotel, with the combination of recreation, shopping and working.

As this site is located on the artery saturated with traffic flow, the level of service falls to level F (traffic jam) and the level of service at the intersection mainly falls between level D (delayed; bearable) and level E (delayed; unbearable). Thus, the traffic impact is the most concerned issue. 22,500 trips are required for trucks to transport waste soils during constructing phase, which worsens the deteriorating traffic situation. 568 PCU (passenger car unit) are attracted at peak hours during the occupancy phase. As a result, the level of service on Taichung Kan Road falls on level F (traffic jam) either on constructing stage or occupancy phase. Besides, 558 parking spaces are required at peak hours during the occupancy phase and this building supplies 629 parking spaces.

Rebounding and settlement of soils at this site during the constructing phase not only imposes impact on the living pipe system and infrastructure, but also threatens the safety of the neighborhoods. During the excavation period, the soil rebounding volume is 14 cm; however, 7-cm of soils were sunk due to increased weight upon the completion of the building. Open space needs to be reserved to buffer the difference and reduce the impact. Noise impact is more significant during constructing phase with the

noise increased volume of 11.6 dB(A), which requires mitigation measures. Furthermore, piling procedure will produce 74 dB of vibration volume upon the neighbours, but still belongs to minor impact.

As for the impact of micro-climate, as this building reflects heat, but imposes limited impact upon local increased temperature, it is classified as a minor impact. However, the local wind it forms will influence human activities in the neighbourhood as well as inside the site. According to the result of the wind tunnel test, three places on the northern side of the site can't meet the comfort demands of sitting and standing in winter. Though they do not belong to the levels of uncomfortable and danger, they do impose significant impact. Besides, for overshadowing of other buildings and land, there are at least two hours of insolation in the neighbourhood on winter solstice day, whose impact is minor. However, electric wave interference influences a wider range of 2.8 hectares with 300 buildings affected and belongs to severe impact.

As for socio-economic environment, construction of this building is bound to promote the change of land use in the neighbourhoods, which not only can reinforce local business performance, but also influence population flow due to the movement of employed population.

Various mitigation measures for Formosa building project have been proposed, including geology & soil, micro-climate, interference of electric waves, noise, water quality, land use, landscape and traffic, etc. For alternatives, they consist of development project alternative, development intensity alternative, architecture style alternative, no-action alternative and technical alternative, etc.

The development process of Formosa building adopts an adverse approach, which means to have a development idea first, then planning and EIA process and then detailed design and construction. The zoning change of the urban plan is not implemented until during construction and the use change plan for the building is not proceeded, either upon completion of the building. Therefore, the decision-

making process of EIA is full of disputes.

For the cost of preparing EIA reports, the EIA cost for Formosa building is 0.095%. Both rates are lower than 0.5% among general countries (Wood 1995, p.254) and lower than 0.6% in the UK (Commission for EIA 1998a, p.249). As for the content of EIA reports, the length of the EIA report for Formosa building is 215 pages, which are longer than 21-100 pages in the UK (80%) and 51-150 pages in Germany (65%). For the structure proportion, prediction of environmental impacts, mitigation measures and alternatives account 41.5% of the total length of the EIA report for Formosa building project accounts 46%, which indicates that the most critical part of the EIA report only takes less than half of the length of the report.

The EIA Committee for High-rise Buildings reviewed EIA reports for Formosa building. However, the competent authority is responsible for administering EIA procedure during EIA report preparation phase. Nevertheless, the environmental authority takes charge during EIDAR phase for Formosa building project in compliance with the regulations of the EIA Act of 1994. For public participation, only public briefings were held prior to reviewing the EIA report.

As for EIA report review, the EIA report meetings as well as EIDAR for Formosa building project were held twice and thrice respectively.. From the aspect of decision-making process, it takes 3 months and 8 months for EIA report and EIDAR for Formosa building project respectively. Integrally speaking, the government takes 8 months (32 weeks) and 13 months (52 weeks) to deal with EIA report and EIDAR for Formosa building project, which are longer than 23 weeks in the UK, but shorter than 60 weeks in Germany (Marr 1997, PP.223-33).

As the development formula of Formosa building project is adverse, key issues and arguments are more, which mainly concentrate on traffic impact after implementation of the use change plan, parking impact and feedback money from changed use of land, etc. Issues for So-Go building project primarily focus on traffic impact and landscape impact.

A great deal of modifications were made against the EIDAR review of the use change plan for Formosa building project, including reduction of 8,974 m^2 floor area (2 floors) designed for shopping malls, and change of the allocation of parking spaces. These modifications belong to moderate modification level.

The control mechanisms during the decision-making process for So-Go building project consist of professional control and procedural control mechanisms. Whereas, Formosa building is added with public and outside agency control mechanism, which reveals that the decision-making process of the use change plan for Formosa building as well as the pressures from the general public already play an influential role against policymakers.

CHAPTER ELEVEN: REVIEW OF THE IMPLEMENTATION OF THE EIA SYSTEM ON TWO CASE STUDIES

We have already analysed the environmental impacts of the So-Go Building and the Formosa Building. In this chapter, we will use those case studies to examine the characteristics of the EIA system in Taiwan and compare the characteristics and process of EIA for So-Go and Formosa buildings.

The So-Go and Formosa Buildings were the first two high-rises to be built in Taichung after the EIA system began to become mandatory for projects of this kind. As pilots for testing the implementation of the EIA scheme, they yield interesting insights into the EPA's learning curve in its attempts to meet the objectives and procedures set out by the EIA Act of December 1994.

11.1 RESULTS AND IMPLICATIONS

The EIA process played an important role in decision-making in both the So-Go and the Formosa cases. Our exploration of the EIA implementation process in relation to these cases reveals the limits and opportunities of the EIA system in Taiwan.

11.1.1 The Influence of the EIA on Decision-Making

When the So-Go Building was being assessed, the EIA Act had not yet come into law. While this meant that So-Go was reviewed using less authoritative regulations than those provided by the EIA Act, nevertheless decision-making in this case was coherent as the agency implementing the EIA process was the same one which later issued the construction permit. The tone of the decision-making on So-Go was negotiation and compromise. This active search for compromise between the EIA committee and the developer reinforced the importance of environmental protection measures and alleviated most of the adverse environmental impacts of this project.

After the EIA review, the policy-maker of the city government - the mayor - confirmed his respect for the professionalism of the EIA committee and judged that the final decision should comply with its resolutions. Whether decisions are influenced by committees' resolutions or not depends entirely on the attitude of policy-makers. The So-Go case illustrates that the EIA system can not only wield this kind of influence but can also ensure that issues of environmental quality do not fall off the policy-making agenda.

The review process of the Formosa Building was identical to So-Go's in so far as both were characterised by negotiation and by expert professional involvement. Though the Formosa case spanned the transition into the full powers of the EIA Act, this did not greatly affect the mode by which decisions were arrived at by the committee though it did ensure that their findings carried more formal authority with the policy-makers. As with the So-Go Building case, the mayor based his first approval decision (i.e., to build Formosa) on his respect for the professionalism of the committee. By the time the second decision was due to be made (i.e., to alter the use of Formosa), the EIA Act was law and the governmental policy-makers were not empowered to make a decision until the resolutions of the EIA committee were available.

A peculiarity of Taiwan's EIA Act is that while the committee do not have policy-making power, they do have the right of veto. As two-thirds of EIA committee members are expert specialists, the EIA system is not only effective but also carries the legitimacy of professional independence. It is clear from the two cases we have examined that the EIA system in Taiwan is elitist in that most of the power to influence outcomes belongs to those with specialist or expert knowledge. The general public cannot easily participate in - or, more especially, genuinely shape - the EIA's decision-making process. However, this elitism also suggests that Taiwan's EIA system possesses sufficient knowledge-based credibility to provide policy-makers with the robust information base they need to make environmentally-sustainable decisions.

11.1.2 Constraints and Opportunities of the EIA System

Taiwan's EIA system draws, of course, on other countries' experience of implementing various environmental protection regulations. However, the country is also gradually establishing its own ways of improving the EIA process. These indigenous refinements are opportunities for making the EIA system within Taiwan more effective. We will use the So-Go and Formosa cases to summarise the elements and properties of EIA constraints and opportunities.

11.1.2.1 Constraints

The So-Go and Formosa cases reveal some of the limitations of the EIA system in Taiwan. For one thing, it is clear that the assessment skills of EIA consultancy firms are not always up to scratch. The spirit of the EIA system is first to assess the environmental impact of a project and then to adopt necessary mitigation measures or alternatives. The assessment task, therefore, is a highly technical one. Yet in both of our case studies, the EIA committee was obliged to question consultancy firms' estimates, sometimes requiring supplementary information from them and sometimes that the work be redone more accurately. Not only do many consultancy firms lack credibility with the EIA committee, but the general public is also not impressed.

In addition, the EIA assessment process requires more than expertise in environmental protection (important though that is). The interactive relationship between economic development and environmental protection also needs to be thoroughly understood. This need, however, remains unclarified. Indeed, some agencies even conduct EIA studies up to the point where policies are made: the 4th nuclear power station and the Taichung regional shopping mall of the Taiwan Sugar Company provide two examples. As a result, a systematic review of alternatives cannot be practiced. As we saw in an earlier chapter, discussion of alternatives in EIA reports is typically cursory and short (only taking up about 1.5 pages out of 162). What this shows is that alternatives are mere window-dressing in the EIA system rather than being the genuine

options they should be.

Another limitation of the EIA system in Taiwan is our immature technical conception of assessment models. As many of the predictive models currently in use in Taiwan are borrowed from those practiced in other countries with our own indigenous margin limits, environmental parameters and application conditions only grafted on later, the assessment results can often be misleading. Furthermore, the way assessment reports are written remains a problem. Most are presented in highly technical terms without any attempt to provide an accessible executive summary (unlike many EIA reports emanating from other countries where such summaries are mandatory). What this means is that the contents of Taiwanese EIA reports are not easily communicable to the interested public nor even to other relevant agencies whose primary expertise is not in the EIA technical realm. This, in itself, constitutes a barrier to the emergence of a shared understanding of the assessment process and its findings.

An extremely important pillar of the EIA system is public participation, for this reinforces the roundedness and the acceptability of EIA findings. Yet the So-Go and Formosa cases show that public participation mechanisms leave a lot to be desired; the targeting, approach and timing of public interventions all carry flaws. The fact that this issue is not governed by specific regulations in the EIA Act not only possibly distorts review procedures but also limits democratic participation in, and communication about, the EIA system. That said, this issue cannot be easily solved regardless of whether specific regulations exist or not. The general public and relevant other organisations do not possess sufficient professional knowledge to participate fully in EIA debates. In addition, as those outsiders who do participate come with their own agendas (e.g., specific and localised concerns about traffic disruption, opportunities for business etc.) genuine and objective two-way communication is hard to achieve even in the best of circumstances.

Finally, an effective and efficient EIA system requires an experienced multi-disciplinary professional team

who will dedicate their skills to the review of EIA reports. Thus, the single most important element in creating a successful EIA system is cultivating sufficient independent expertise to administer it.

11.1.2.2 Opportunities

Taiwan's current EIA system was not invented from scratch. A system for implementing its core aims and for gradually enhancing its procedures through specific case studies has been in motion since 1980. This system is not only becoming increasingly geared towards addressing Taiwan's environmental problems but it also provides an excellent base for sustaining EIA efforts.

Taiwan's EIA system is constructed around the granting of consecutive concessions. First of all, the competent authority is not allowed to issue a development permit before the environmental agencies has reviewed the project. Second, documents like the EIS and EIR have the status of written promises tendered by the development company and infractions of those promises incur penalties. Administrative laws term this process the "Additional Article": when a development permit is issued, it is attached to other articled items (i.e., the contents of the EIA report) to become the "Additional Article."

Another feature of the EIA system in Taiwan is that the EIA committee possesses the right of veto. If assessment findings suggest a serious or malign impact, then the EPA or the EIA committee can declare that the project proposal should be turned down. The policy-makers cannot ignore this verdict and just issue an approval regardless. This right of veto guarantees that the EIA system has teeth in determining which developments actually go ahead.

The right to back-date the terms of the EIA Act is quite a rare legal permission. The EIA Act demands that projects which are unfinished at the time the Act came into law must nevertheless submit to an EIA analysis, complete with a requirement on the developer to present countermeasures if the EIA committee

Plate 11-2 : Situation of So-Go and Formosa

Formosa Building

So-Go building

Plate11-1 : Traffic Situation of So-Go and Formosa Building

finds it necessary. This requirement ensures that all developments under construction during the cross-over period cannot evade meeting the terms of the Act.

Although the EIA system has been emerging over the last 20 years, it has only had a comprehensive legal status since 1995. However, over this whole 25-year period, Taiwan has been accumulating experience in using it effectively to ensure that development projects shoulder their environmental responsibilities. In this respect, it is likely that the EIA system will play an increasingly important role in Taiwan's future development.

11.2 COMPARISON OF ENVIRONMENTAL IMPACTS OF SO-GO AND FORMOSA BUILDINGS

The So-Go and Formosa Building projects were proposed by the private development sector. The So-Go Building is a single-function department store while the Formosa Building is a combination of offices, restaurants and hotels. The So-Go building has 21 floors aboveground, and 4 floors underground level. The Formosa has 32 floors aboveground with 6 underground. At a socio-economic level, the So-Go Building was built during a period of booming economy. However, the Formosa Building began operating as the Asian economy went from prosperity to crisis. An earthquake (7.3 on the Richter scale), the largest recorded this century, struck on 21 September 1999 bringing down a huge number of buildings making many people homeless. This shakes the confidence of the citizens, and influences economic growth (Table 11-1). From a political perspective, the situation was stable and the decision-making process was smooth during the preparation phase of the So-Go Building. The political situation during the Formosa Building preparation phase was less stable as parties transferred, central and local governments belonged to different sects, and local municipal government and the city council were diverse factions. This unstable political environment did not make for good decision-making practices.

In the environmental impact assessment, severe impacts were detected for both buildings. These included interference with radio waves, traffic and parking impacts, waste soils, economic structure, and local finance (Table 11-2). Taking the interference of radio waves, the Formosa Building has a greater impact as its influence extends over 2.8ha and 300 households. Although the So-Go Building imposes a lighter impact, 200 buildings are affected. With respect to traffic and parking implications the greatest impact on the local environment is from the So-Go Building as it attracts 1,244 passenger car units (PCU) demanding 633 parking spaces during peak hours; the Formosa Building also has a high traffic and parking impact in peak hours. Both buildings produced large volumes of waste soil as they both required deep excavations; delivery trucks took 14,188 and 22,500 trips respectively. As a whole, severe environmental impacts were imposed on traffic, transportation and disposal processes. With respect to local finance, the Formosa and So-Go Buildings are liable for £6 million and £5 million of value-added taxes (respectively) during the operational stage. This accounts for 1.5% and 1.3% of the local government budget: a great impact on the local finance.

Noise impact during construction: the Formosa Building is close to neighbouring buildings (east side), any increased noise from piling was categorised as severe as the noise increment exceeded 10dB(A). However, as So-Go Building is some distance from its nearest buildings, the noise level increment was only 9dB(A), which is still a significant impact.

Further significant environmental impacts from both buildings include air quality, use and quality of water resources, solid waste and landscape impact. The So-Go Building produced 25.2 tonnes of TSP during the construction stage whilst the Formosa Building produced 74.5 tonnes; annual emissions of 22.9 and 23.2 tonnes respectively. During the occupancy phase, increases in the volume of NO_x produced (from emissions of waste air from traffic) in the So-Go Building car park is 59.33 ppb, and that for Formosa Building is 50.56 ppb. On a daily basis, the So-Go Building requires 336 CMD of water, and the Formosa Building requires 1,110 CMD. From a landscape impact perspective, both buildings, being located on the traffic artery of

Taichung City, are landmarks so have a significant impact on the urban landscape. These modern high-rises contrast strongly, and cause an imbalance, with adjacent two-storied terraced houses and street stores with a traditional architectural style. Both buildings during the operational phase produce huge volumes of waste water, which in turn influences the water quality. The Formosa Building yields 1993 CMD of waste water daily, the So-Go Building 400 CMD.

The So-Go Building produces 7.5 tonnes of solid waste every day during the occupancy phase. This accounts for 0.63% of the total daily volume of rubbish produced in Taichung. The Formosa Building yields 3.7 tonnes, accounting for 0.31% of the daily total.

Localised wind effects generated by high-rise buildings affects local residents and pedestrians, especially during the winter monsoon season. As the height of the So-Go Building does not exceed 100m wind tunnel tests are not required so its impact is unknown. Wind tunnel tests on the Formosa Building, indicated wind speeds on the north side exceed comfort levels for sitting and standing. Although walking comfort standards are reached, a significant impact on human activities is imposed in that area.

In addition to the environmental impacts above, there are other minor impacts associated with the So-Go and Formosa Buildings. For example terrain, geology, vibration insolation, ecology, public facilities, safety hazards, land use, land prices, population structure, living standards, and social relationship (Figure 11-1).

Both projects drew up mitigation measures. The So-Go Building presented measures against the geology, water, noise, traffic, landscape and interference wave impacts. The Formosa Building proposed measures against the geology, soil, micro-climate, interference wave, noise, quality of water, land use, landscape and traffic impacts. The Formosa Building also presented five alternatives: development project alternative; development intensity alternative; architecture style alternative; no-action alternative; and technical alternative.

Although when taken together, the So -Go and Formosa Buildings do cover most major environmental issues. However, in both cases emphasis is on the physical environment. When looking at natural resource depletion, only the volume of water use and natural gas is evaluated. Items such as energy use, the use of non-renewable and renewable resources, abiotic resource use, the use of recycled materials (e.g. demolition materials, waste materials, re-use of bricks and stone) are not assessed. Both projects also concentrate on local issues with national, regional and global issues seldom being considered e.g. global warming (emission of greenhouse gases), depletion of the ozone layer (emission of ozone depleting substances), acid rain (emission of acidifying pollutants), photochemical oxidant formation, eutrophication, human toxicity, and ecotoxicity are not included in the scope of an EIA. This is a result of the background of members of the EIA Committee for High-Rise Buildings as more emphasis was placed on construction and urban planning. The competent authority also lacked the experience in implementing an EIA.

Furthermore, it is clear that the assessment of these two projects focuses mainly on the occupancy phase with some assessment of the construction phase (Figure 11-2). However, there is no assessment of the manufacture of construction materials, the transportation of such materials, or the demolition phase. This both underestimates and reduces the reliability of the EIA results.

To compensate for this shortcoming, this thesis presents the concept of life-cycle environmental impact assessment (LEIA) in next Chapter. It is presented with a view to integrating life cycle assessment (LCA) and environmental impact assessment (EIA) to LEIA, and to then apply each environmental theme to the assessment of high-rise buildings.

Results of the EIA process indicated that the cumulative impact of these two projects has not been assessed. Although the So-Go and Formosa Buildings are opposite each other, the traffic and parking impacts, local

wind effects, overshadowing, and socio-economic impacts have only been evaluated individually. The total impact of both projects cannot be obtained by merely assessing individual impacts and linearly accumulating them. For instance, some cumulative impacts show up in various ways e.g. synergistic impacts, threshold and saturation impact, induced and secondary impact, time-crowded or space-crowded impacts (i.e. no time or space to recover from one impact before it is subjected to the next) (Therivel *et al.*, 1992, pp. 9). These cumulative impacts impose a greater influence on the environment than additive impacts. As a result, an EIA based purely at the project level is not effective from the cumulative impact assessment perspective. Therefore, it is necessary to promote the EIA from project assessment to that of policy, plan and programme (3Ps).

It is also noted that EIAs for these projects do not function well with mitigation measures as they do not include severe and significant impacts. In the same way, alternatives are also not effectively assessed. The So-Go Building project never presented alternatives, and the Formosa Building project only proposed routine alternatives with no further assessment.

In summary, the shortcomings of the EIA process for these two projects (insufficient assessment, exclusion of important environmental themes, absence of phases in the life-cycle) might lead to an under-assessment of the impacts. In addition, cumulative impacts are not revealed in the project EIA, which means real impacts cannot be evaluated. Furthermore, mitigation measures and alternatives cannot be fully assessed and considered. All of the above greatly reduce the effectiveness of the EIA system.

Table 11-1:Comparison of EIA Contents for So-Go and Formosa Buildings

Item	So-Go Building	Formosa Building
Developer's Characteristic	Private Sector	Private Sector
Project Characteristic	Department Store	Office, Restaurant, Hotel
Number of Floors	21 floors, 4 underground	32 floors, 6 underground
Height	91m	117.25m
Floor Area	79,523m^2	118,437m^2
Competent Authority Characteristic	No experience with EIA for high-rise buildings	No experience with EIA for high-rise buildings
Location Characteristic	Downtown Artery	Downtown Artery
Application Year	1992	1992
Approval Year	1993	1993
Completion Year	1995	1998
Occupancy Date	Nov 1995	Aug1998 (restaurant, hotel, office);some parts of offices applied for the change into Daimaru Dept. Store
Economic Circumstance	Booming economy	From booming economy to financial crisis in Asia
Political Circumstance	Stable political situation	Transference of parties
Social Circumstance	Energetic & stabilised	Energetic & stabilised but the earthquake happened on Sept. 21, 1999 shaking the confidence of people and tearing down many houses.
EIA Review	EIA Committee for high-rise Building	EIA Committee for high-rise Building
EIA Committee Characteristics	* newly established * background mostly based on construction & urban plan professionals	* newly established *background mostly based on construction & urban plan professionals * members with environ-mental background added
Nature of Affected Environment	Terraced houses on the north terraced shops on the east tend to be affected.	Terraced houses on the east tend to be affected.
Decision-making Circumstance Characteristic	* chairman (monistic) * policy of economic development priority	* chairman (monistic) * policy of economic development & environ-mental protection

Note: Circumstances and characteristics in this chart refer to the preparation phase of the building, ie. from planning, permit application, construction to before occupancy.

Table 11-2:Comparison of Environmental Impact Assessment of So-Go and Formosa Buildings

Environmental Impact Assessment Item	So-Go Building		Formosa Building	
	Results of Prediction	**Level of Impact**	**Results of Prediction**	**Level of Impact**
Terrain & Geology	Maximum soil sunk is 2.9cm.	Minor impact	Re-bloated volume of excavated soil is 14cm. Soil sinking volume after completion is 7cm.	Minor impact
Disposal of Waste Soils	113,500m^3 of waste soils need 141,88 truck trips.	Severe impact	180,000m^3 of waste soils need 22,500 truck trips.	Severe impact
Volume of Waste Water	Construction phase: 22CM	Minor impact	Construction phase: 10.5CMD	Minor impact
	Occupancy phase: 400CMD	Significant Impact	Occupancy phase: 1,993CMD	Significant impact
Air Quality	Constructing phase: 25.2 tonnes of TSP	Significant impact	Constructing phase: 74.5 tonnes of TSP	Significant impact
	Occupancy phase: NO_x increased to 59.33 ppb		Occupancy phase: NO_x increased to 50.56 ppb	
Local Wind Effects	Not assessed (height below 100 m)	Uncertain impact	3 spots do not meet requirements for comfortable sitting and standing.	Significant impact
Micro-climate Effec	Not assessed	Uncertain impact	Slight increased temperature	Minor impact
Noise Effects	Maximum noise increased volume is 9dB(A) (construction phase).	Significant impact	Maximum noise increased volume is 11.6dB(A) (construction phase).	Severe impact
Vibration Effects	Maximum vibration volume is 60dB (constructing phase)	Minor impact	Maximum vibration volume is 74 dB (constructing phase)	Minor impact
Overshadowing	At least 4 hours of insolation on Winter Solstice Day	Minor impact	At least 2 hours of insolation on Winter Solstice Day	Minor impact
Solid Wastes	7.5 tonnes daily	Significant impact	3.7 tonnes daily	Minor impact
Interfere Wave	1.6 hectares of over-shadowed areas 200 affected houses	Severe impact	2.8 hectares of over-shadowed areas 300 affected houses	Severe impact
Fauna Ecology	slight	Minor impact	slight	Minor impact
Flora Ecology	slight	Minor impact	slight	Minor impact
Vol. of Water Consumption	336 CMD required daily (occupancy phase)	Significant impact	1993 CMD required daily	Significant impact
Landscape Impact	Out of balanced adjacent buildings	Significant impact	A great contrast of height with adjacent terraced houses	Significant impact
Traffic Impact	1244 PCU during rush hour	Severe impact	568 PCU during rush hours	Severe impact
Parking Impact	633 parking spaces required during rush hour	Severe impact	558 parking spaces required during rush hour	Severe impact
Economic Structure	500 job opportunities increased (1.6% of total)	Severe impact	636 job opportunities increased (2.1% of total)	Severe impact

Environmental Impact Assessment Item	So-Go Building		Formosa Building	
	Results of Prediction	**Level of Impact**	**Results of Prediction**	**Level of Impact**
Public Facilities	Insufficient sports facilities and playgrounds for children	Minor impact	Insufficient parks and sports facilities	Minor impact
Safety Hazards	Not assessed	Uncertain impact	low	Minor impact
Consumption Natural Gas	150m^3 required daily	Minor impact	1,110m^3 required daily	Significant impact
Local Finance	£6 million of income tax increased annually	Severe impact	£5 million of income tax increased annually	Severe impact
Land Use	Promotion of lands in the neighbourhood for business usage	Minor impact	Promotion of lands in the neighbourhood for business usage	Minor impact
Land Price	Price of the adjacent areas is raised.	Minor impact	Price of the adjacent areas is raised.	Minor impact
Structure Population	Regional population increased	Minor impact	Regional population increased	Minor impact
Living quality	Not assessed	Minor impact	Slightly promoted	Minor impact
Social Relationship	Not assessed	Minor impact	Lowly affected	Minor impact
Mitigation Measures	Geology, hydrology, noise, traffic, landscape and interfere wave	Mitigate impact	Geology & soil, micro-climate, interfere wave, noise, quality of water, land application, landscape and traffic	Mitigate impact
Alternatives	Not assessed		Alternative of development plan, alternative of development intensity alternative of architectural style, no-action, alternative of technique	Without significant function

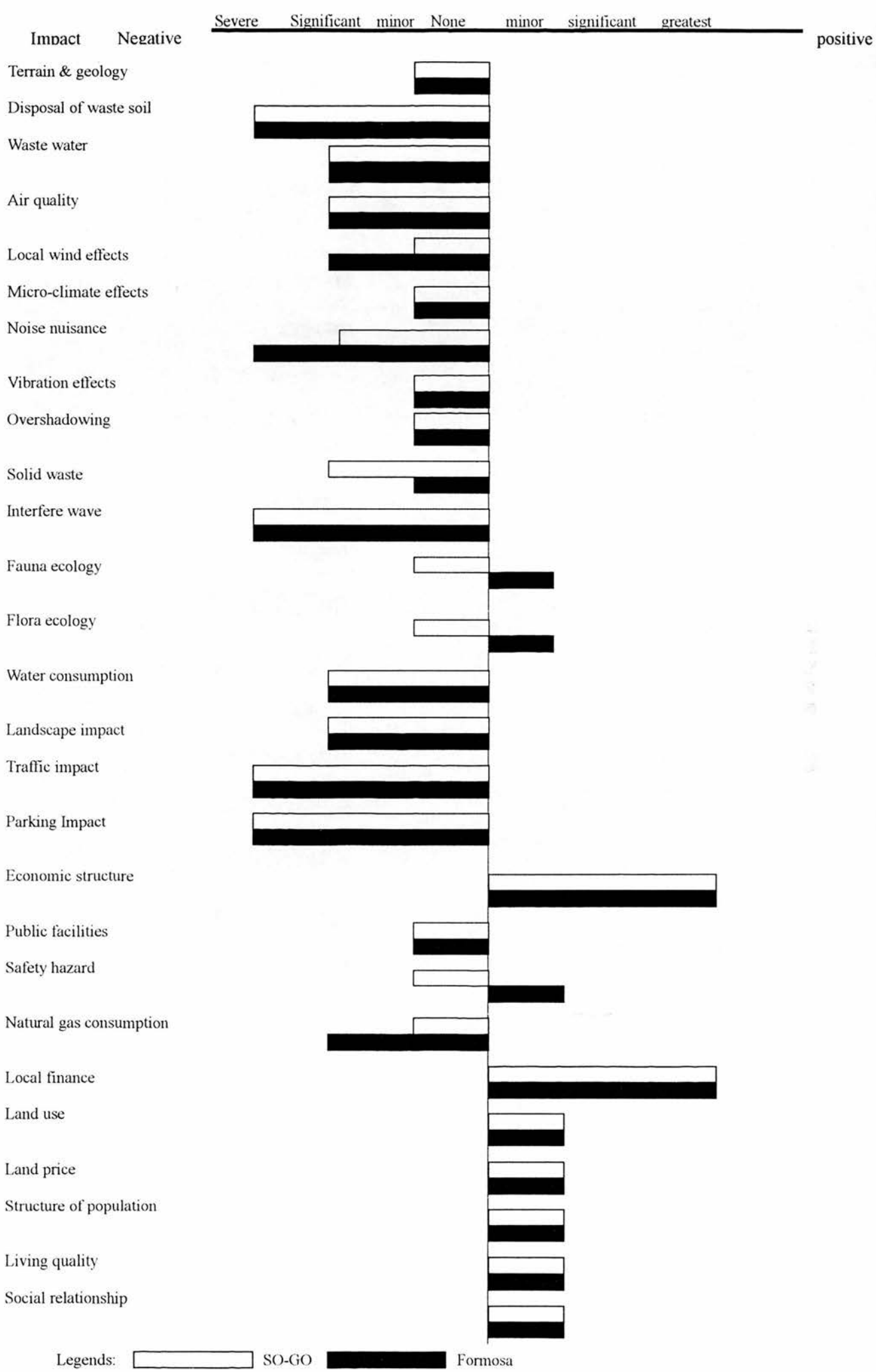

Figure 11-1 Relative importance of the various impacts of SO-GO and Formosa building

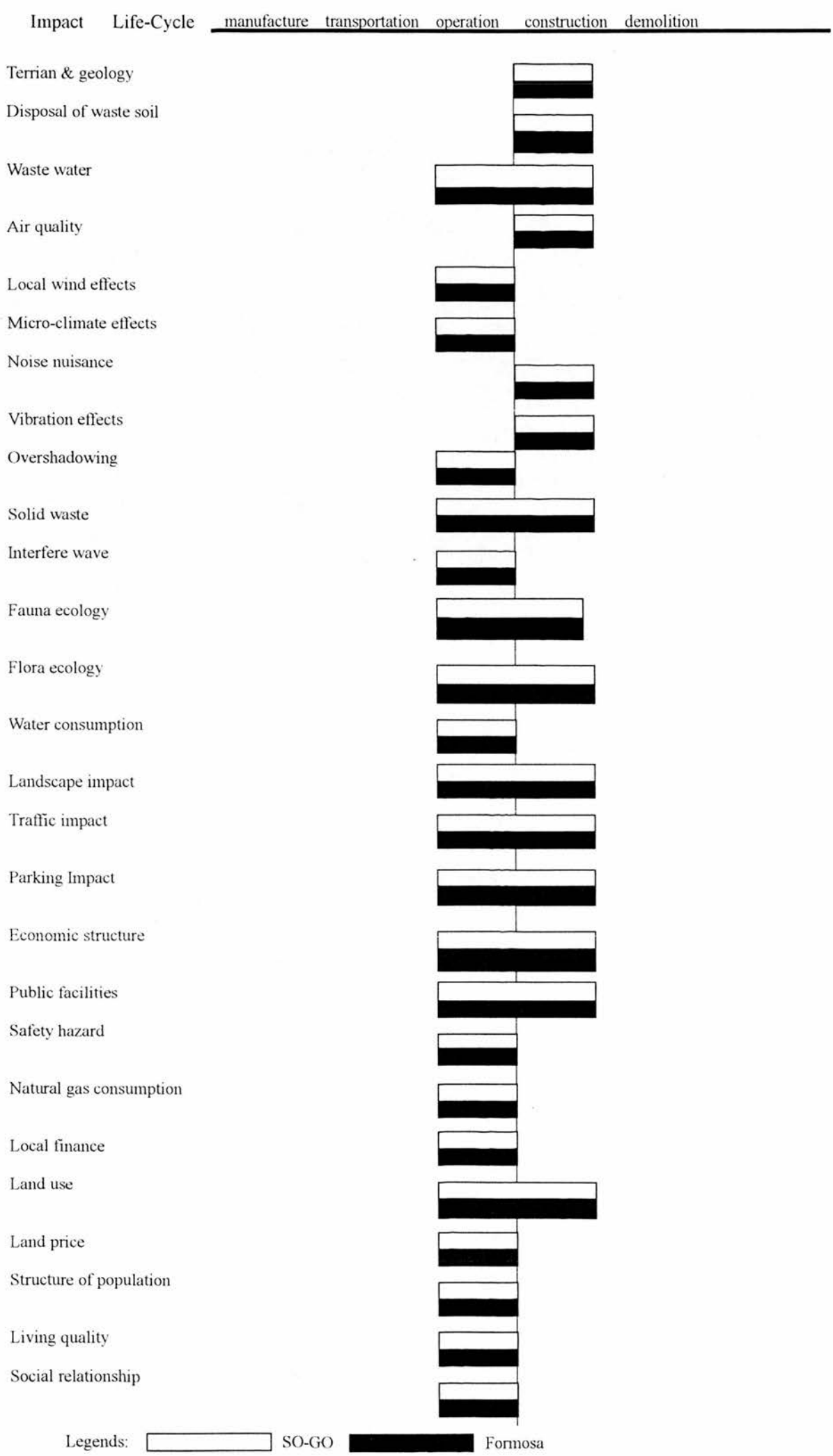

FIG. 11-2 Coverage of Assessment of SO-GO and Formosa building

11.3 CROSS-CASE COMPARISON OF EIA PRACTICE

The EIA implementation process for case study has already been analyzed in chapters 9 and 10. The empirical part of this research has not only revealed some similarities, but also considerable differences in So-Go and Formosa building practice of EIA process, which will be compared in three parts.

11.3.1 Cross-case Comparison of EIA Report

For EIA report, it can be compared through development characteristics, development process, preparation of EIA report, content of EIA report, alternatives and environmental impact items.

From the perspective of development characteristics, So-Go building is a high-rise building with one single usage. As its operator is an exclusive private development sector, planning and management are more convenient and effective. Whereas, Formosa building is a high-rise building with multiple usage since its office, hotel, restaurant, and department store are run by different private companies. Consequently, the management system is complicated (as Table 11-3).

For the aspect of development process, So-Go building adopts an up-down procedure. Zoning change for urban plan is firstly scheduled and then land reclamation and public facilities are completed. Last, construction development and EIA process are conducted. However, Formosa building adopts a dual-track procedure. On one hand, construction development and EIA process are implemented; on the other hand, zoning change for urban plan is conducted simultaneously. Its advantage is time saving though construction duration takes three more years than So-Go building. As a whole; nevertheless, development duration of Formosa building only takes seven years, one year less than that of So-Go building. As So-Go building adopts an up-down incremental procedure, no disputes occur during the process; but, arguments arise frequently during the process because Formosa building applies the dual-track model, which results in the

loss of the operator since this adverse approach has not finished upon the completion of the building. Besides, as construction precedes the application change building use, satisfactory mitigation measures are hard to present.

For the preparation of EIA report, Formosa building is more adequate as its assessment duration (from initial consultation to EIA report submission) takes double time than that of So-Go building and manpower for assessment is 160% of that for So-Go building. As for cost, the EIA cost of Formosa building accounts for 0.095% of the project costs, higher than 0.083% for So-Go building. As a result, the former does a better job of preparing the EIA report, which is related to its large scale, great height and multiple applications.

As for the content of the EIA report, So-Go building focuses on impact items of the physical environment and includes landscape impact. These coverage of assessment items cover land application, architectural project, environmental impact, mitigation measures and construction plan, etc. Whereas, the EIA report of Formosa building emphasizes environmental impacts, including environmental setting, environmental impacts, mitigation measures and alternative, etc. In addition, the environmental impact differential analysis report (EIDAR) of the application of change use for Formosa building aims at comparing the differences between environmental protection measures and environmental impacts. Consequently, Formosa building has quality content for an EIA report.

Speaking of alternatives of an EIA report, So-Go building presented no alternatives; however, Formosa building proposes five alternatives, including development project alternative, development intensity alternative, architectural style alternative, no-action and technical alternative. From the standpoint of its substantial content, these alternatives are not specific enough; nevertheless, it has more sufficient alternatives than So-Go building.

Last, for environmental impact assessment items, both buildings are similar because they stress physical environmental impacts. So-Go building has additional assessment items of overshadowing of other buildings and land, interfere wave, public utility and energy; whereas, Formosa building adds in geology and soil and population structure. As a result, So-Go building has more integral assessment items.

Overall, Formosa building prepares the EIA report more adequately and takes more advantages on assessment duration, assessment manpower and the content structure of an EIA report. However, as Formosa building adopts an adverse procedure for development, EIA process does not proceed smoothly. Besides, waiting for the results of the EIA review wastes more than a year without utilizing one third of the building and suffers a tremendous loss.

Table 11-3:Comparison of EIA Reports for So-Go and Formosa Buildings

Category	Item	So-Go Building	Formosa Building
Project Description	No. of floors	21 floors above the ground (4 floors under the ground)	32 floors above the ground (6 floors under the ground)
	Height of floors	91 metres	117.25 metres
	Usage	Department store	Office, hotel, restaurant, Department store
	Floor area	79523 m^2	118437 m^2
	Location Characteristics	A burgeoning business Centre on the artery	A burgeoning business Centre on the artery
	Project Characteristics	Department store Building	A multiple-application Building
	Developer Characteristics	Private development Company	Private development Company
Development Process	Development Duration (from Acquisition of land to operation)	8 years	7 years (8 years for the department store)
	Main Process	Urban zoning change Preparing EIA report EIA report review EIA follow-up	EIA conducted Urban zoning change Building usage change EIDAR review Decision making & Dispute
Preparation of EIA Report	Assessment period	4 months	EIA report: 8 months ,EIDAR: 1 month
	Date of EIA report Submission	Oct., 1992	Aug., 1992
	Manpower of assessment	20 people-months	32 people-months
	Rate of EIA cost Against project cost	0.083%	095% (not including EIDAR)
Major Content Of EIA Report	Main content	* project description * land use description * traffic impact * public utility facilities & disaster prevention plan * landscape project & image design * prediction of environmental impact & mitigation measures * construction structure plan * development construction plan * impact during construction & mitigation measures	EIA report * project description * environmental setting * mitigation measures * alternatives * environmental management plan * conclusion EIDAR * project description * development activities & changed content of environmental protection measures * environmental setting * EIDAR * discussion & amendment of environmental protection measures
Alternatives	Main content	None	EIA report: *development plan alternative *development intensity alternative *architectural style alternative * (no action) *technical alternative EIDAR: none

Category	Item	So-Go Building	Formosa Building
Prediction of environmental impact	Impact item	Land use, industry activities, traffic impact, wastes, public facilities, energy, landscape, micro-climate, over-shadowing (insolation), interfere wave, noise, vibration, air pollution, water pollution	EIA report: geology & soil, micro-climate, local wind, air pollution, noise, vibration, water pollution, land use, population structure, industry activities, traffic impact, landscape EIDAR: geology, hydrology, quality of water, air quality, wastes, level of service on the road (LOS) impact, parking service level impact

11.3.2 Cross-case Comparison of EIA Practice

EIA practice can be compared and divided into final responsibility authority, public participation, proportion of each part in the EIA report and EIA review.

For final responsibility authority, administering EIA procedures for these two buildings are conducted by a competent authority, that is the Bureau of Public Works. However, as the application change usage of Formosa building during EIDAR is after promulgation of the EIA Act, the final responsibility for administering EIA procedure is transferred to the environmental authority. Both initiators are in charge of EIA task. But, the EIA Committee for High-rise Buildings is responsible for EIA report review. Whereas, the EIA Committee takes full responsibility for Formosa building during EIDAR phase. One thing in common for these two buildings is that scoping process is absent. By 1995, there is no scoping process for the EIA system in Taiwan. For decision-making and monitoring, these two cases are identical (as Table 11-4). As a whole, the EIA system in Taiwan has been adjusted after the EIA Act of 1994 was promulgated. For examples, the EIA Committee is integrated, responsible sector of administering EIA procedure is transferred from competent authority to environmental authority and the initiator is still in charge of initiating EIA to meet the "user pays principle"

As for public participation, only public briefings are held for both buildings during EIA report stage. There

is not any public participation procedure during EIDAR process for Formosa building. Besides, public briefing of both cases are held after submitting EIA reports (prior to EIA review) and only local officials and related agencies are invited. As a result, participants are always less than 10 people, which reveals that the general public is not so concerned about development of these two projects. Public comments never show up during the process of public participation. Overall, public participation in these two cases is quite insufficient and participants are relatively few, which is related to less argumentation against development of high-rise buildings. However, public representatives are concerned about no adequate public participation during EIDAR phase for Formosa building.

For the quality of EIA report, EIA reports for So-Go and Formosa buildings are over 200 pages, which is longer by far than most countries. For instance, 80% of EIA reports in the UK is within 100 pages, Germany 65%, 95% of EIA reports within 50 pages in Sweden and 99% in Canada (Commission for EIA 1998a). However, for the content of mitigation measures, the EIA report for So-Go building accounts for 8.2% of total length and Formosa building 15.8%. It takes 6.7% during EIDAR phase for Formosa building. It reveals that the EIA report for Formosa building pays more attention to research and draw-up of mitigation measures. Besides, no alternatives are presented for So-Go building; however, there are five alternatives in the EIA report for Formosa building, whose content accounts for 2.8% of the EIA report. As for prediction and analysis of environmental impacts, it takes 33.3% of the length of the EIA report for So-Go building and 27.4% for Formosa building, which shows that So-Go building emphasizes more on environmental impact analysis instead of alternatives and mitigation measures seem insufficient as well. Therefore, from the perspective of the integral structure and content of EIA report, Formosa building does a better job. But, as a whole, mitigation measures, alternatives and environmental impact analysis account for 41.5% of the EIA report for So-Go building and 46% for Formosa building (34.1% of EIDAR). This indicates that more than half of the EIA reports for these two buildings describe its project and environmental setting, which decreases the function of an EIA report. Consequently, from the standpoint of

the content structure of an EIA report, quality of these two projects is not good but quantity of both EIA reports is too much..

Finally for EIA report review, the EIA report for So-Go building is reviewed twice by the EIA Committee for high-rise building, which takes three months and although that for Formosa building is also passed through twice reviews (three times for EIDAR), it takes five months. As we discussed previously that Formosa building excels in EIA report preparation, manpower, cost and the quality of content structure of the EIA report; whereas, its review period takes longer time, which is mainly because Formosa building has a greater size (height & area) and complicated applications (four major usages) and it also attracts more population and imposes more extensive and greater environmental impacts.

For the integral implementation process of case study, it reveals that effective public participation is void and the initiator is in charge of initiating the EIA report, which satisfies the rule of "Users pay principle." The Exert Committee conducts the EIA review task for these two projects, which helps promote the quality of the EIA report. As for the content structure of the EIA report, mitigation measures and prediction of environmental impact only account for 41.5% (So-Go building) and 46% (Formosa building), which shows that not only EIA reports of these two projects do not hold master the major points completely, but also no scoping process is conducted in these two cases.

Table 11-4:Comparison of EIA Implementation Process for So-Go and Formosa Buildings

Category	Item	So-Go Building	Formosa Building
Final Responsibility Authority (Party)	Administering EIA procedure	Competent Authority	EIA report: competent authority EIDAR: environmental authority
	Initiating EIA	Initiator	Initiator
	Reviewing EIA	EIA Committee for High-rise Building	EIA report: EIA Committee For High-rise Building EIDAR: EIA Committee
	Scoping EIA	None	None
	Final decision-making	Competent Authority	Competent Authority
	Monitoring	Competent & environmental authority	Competent & environmental authority
Public Participation	Participation Method	Public briefing	EIA report: public briefing EIDAR: none
	Participation Time	Prior to EIA report review	Prior to EIA report review
	Participant	Local people	Local people
	No. of participant	5 people	8 people
	Public comments	None	None
Proportion of Each Section In EIA Report	Total length	255 pages	EIA report: 215 pages EIDAR: 135 pages
	Length of mitigation measures	8.2% (21 pages out of 255 pages)	EIA report: 15.8% (34 pages out of 215 pages) EIDAR: 6.7% (9 pages out of 135 pages)
	Length of alternatives	0%	EIA report: 2.8% (6 pages out of 215 pages) EIDAR: 0%
	Length of environmental impact analysis	33.3% (85 pages out of 255 pages)	EIA report: 27.4% (59 pages out of 215 pages) EIDAR: 27.4% (37 pages out of 135 pages)
EIA Report Review	Review duration	3 months	EIA report: 5 months EIDAR: 5 months
	Review frequency	2 times	EIA report: 2 times EIDAR: 3 times
	Review conclusion	Passed with 2 attached conditions	EIA report: passed with 2 attached conditions EIDAR: passed with 4 attached conditions

11.3.3 Comparison of Cross-case EIA Decision-making Process

Comparison of the decision making process can be divided into the following categories: context of decision-making, decision making, key issue during EIA process, modifications to the project, post-decision, total spent time of EIA process and environmental quality of decision (as Table 11-5).

For the context of decision-making, public and outside agencies all tend to pro-development of So-Go and Formosa buildings while making the decisions in the EIA reports. However, opinions oppose to the department store in Formosa building during EIDAR phase for the application change building usage as long as traffic impact problem can't be resolved. Policymakers of these two projects incline to professional opinions (i.e. expert committee & competent authority). The difference of decision-making environment between So-Go and Formosa buildings is that the former is in an opportune and booming economic environment and a number of great investments are thrown into Taichung city one after another, which promotes prosperity and the general public support the development project naturally. However, the latter faces Asian financial crisis during EIDAR phase for the application change plan and it worsens the problem of deteriorating traffic as its location on the main artery. Consequently, the general public considers investment on the Daimaru Department Store of Japan as a non-productive disbursement, which wouldn't help much for the economic recovery[1]. Besides, three downtown department stores were closed because operation of So-Go department store; as a result, Daimaru department store will bring nothing but more negative environmental impacts. These two construction projects taste different fates due to economic and traffic environments at that time.

Context of decision-making under such circumstances shows different time schedules for making decisions.

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[1] Personel interview with Miss Jou, who is chief of EIA section of EPB, 25th of April 1999, and the same point of view had revealed on major newspaper. See, for example, Chinatimes news, 19th of March, 1999 P.8, Taipei, Taiwan and Taiwan Daily news, 13th of March, 1999, p.6, Taipei, Taiwan.

It only takes four months for So-Go building and although the construction plan of Formosa building merely takes 3 months, decision-making of the application change plan (to be Daimaru department store) requires 8 months. During this period, as the concern expressed by Taichung City Council, a special case meeting is convened. Thus, the control mechanism during decision-making process for So-Go building is professional control and procedural control mechanisms; however, that for Formosa building remains on the public and outside agency control mechanism. The major disputes of EIA process during the application change plan phase for Formosa building include traffic impact, parking impact, alteration of land use and the choice of re-conducting the EIA process or substitution with EIDAR.

The importance of the outcome of the decision during EIA process can be told through required modifications to the original proposal. These two construction projects during the phase of EIA report review are demanded to make amendments to certain items, which are minor modifications. However, greater modifications are required while reviewing the application change plan for Formosa building, including 2 floors are deducted for the department store and a parking tower is added on the empty land at the back of the building. It can be inferred that modifications at this phase should be moderate ones to the original proposal. As a whole, EIA process implementation of these two cases already develops it expected performance.

As for post-decision, the effect of implementing EIA can be analyzed through surveillance, effect monitoring, impact management, environmental management audit and process audit and evaluation. Although mitigation measures of these two cases are only practiced partly, conclusions of EIA reviews are performed accordingly, which is because review conclusions are mandatory. During surveillance process, we can discover that noise of Formosa building is beyond noise control level, which is resulted from incomplete implementation of mitigation measures.

Lastly, from the aspect of time, it takes 11 months for So-Go building to implement the EIA process, including 4 months of assessment, 3 months of reviewing and 4 months of decision-making. On the contrary, as Formosa building adopts a two-phase review, it takes 30 months (120 weeks), which is longer than 45 weeks in the UK, but shorter than 71 months in Germany by far (Marr 1997, pp.216-233). If we calculate time of EIA process for the EIA report of the construction plan and EIDAR of the application change plan for Formosa building separately, they require 16 months (64 weeks) and 14 months (56 weeks) respectively, which is long as well.

The environmental quality of decision for these two cases performs better. Despite a great amount of money and time are required for the EIA process, EIA does profit to improve the quality of decisions from an sustainability point of view positively.

Table 11-5:Comparison of EIA Decision-making Process for So-Go & Formosa Buildings

Category	Item	So-Go Building	Formosa Building
Decision-making	Decision-making time	4 months	EIA report: 3 months EIDAR: 8 months
	Decision-making control mechanisms	Professional control, Procedural control	Professional control Procedural control Public & outside agency control
Key Issues during EIA Process	Key issues	* local prosperity or negative impact * making a new landmark or becoming a contrast & isolated building * traffic impact * balancing regional development or accelerating down- town declination	* traffic impact * parking impact * local wind impact * feedback money of application change plan or development impact fee * re-conducting EIA or EIDAR
Modifications To the Project	Necessary modifications	yes	EIA report: yes EIDAR: yes
	Major modification content	Change of appearance, increasing open space, adding parking spaces, change of traffic routes	EIA report: increasing open space, adding parking spaces, change of traffic routes, change of style EIDAR: increasing parking spaces, deduction of 2 floors for dept. store, change of noise control
	Level of modification	Minor modification	EIA report: minor EIDAR: moderate
Post-Decision	Practice of mitigation measures	Implemented partly	Implemented partly
	Practice of review conclusions	Implemented completely	Implemented completely
	Violation of environ-mental protection law	None	Yes (noise)
Context Of Decision-Making	Public opinions and outside agency	Tended for support	EIA report: tend to support EIDAR: against traffic impact
	Tendency of policymakers	Respect of professional review opinions	Respect of professional review opinions
	Economic environment	Booming economy	EIA report: booming economy EIDAR: Asia financial crisis
Total EIA Process Duration	Including assessment review & decision-making	11 months (4+3+4 months)	30 months (9+10+11 months)
Environmental Quality of Decision	From sustainability point of view	Better decision	Better decision

11.4 SUMMARY

The development process of So-Go building project adopts incremental approach, which means to have a development idea first, zoning change of the urban plan next, then EIA process and then detailed design, construction and occupancy. This approach is from the top to the bottom. Thus, it takes longer time (8 years) without much argument. Nevertheless, Formosa building adopts an adverse approach, which means to have a development idea first, then planning and EIA process and then detailed design and construction. The zoning change of the urban plan is not implemented until during construction and the use change plan for the building is not proceeded, either upon completion of the building. Therefore, the decision-making process of EIA is full of disputes.

For EIA duration, it takes 4 months for So-Go building and 8 months for Formosa building. As for the environmental impact differential analysis report (EIDAR) for the use change plan, it takes one month. Consequently, overall, preparation of EIA report and EIDAR for Formosa building takes 9 months (36 weeks).

For the cost of preparing EIA reports, the EIA cost for So-Go building accounts 0.083% of the total project cost and that for Formosa building is 0.095%. Both rates are lower than 0.5% among general countries (Wood 1995, p.254) and lower than 0.6% in the UK (Commission for EIA 1998a, p.249). As for the content of EIA reports, the length of the EIA report for So-Go building project is 255 pages and that for Formosa building is 215 pages, which are longer than 21-100 pages in the UK (80%) and 51-150 pages in Germany (65%). For the structure proportion, prediction of environmental impacts, mitigation measures and alternatives account 41.5% of the total length of the EIA report for So-Go building project; whereas, Formosa building project accounts 46%, which indicates that the most critical part of the EIA report only takes less than half of the length of the report. Thus, project description and environmental setting account

for more than half of the length of the report. It shows that EIA costs for both EIA cases are too low and the structure of the EIA report is not proper, either.

The EIA Committee for High-rise Buildings reviewed EIA reports for So-Go building and Formosa building. However, the competent authority is responsible for administering EIA procedure during EIA report preparation phase. Nevertheless, the environmental authority takes charge during EIDAR phase for Formosa building project in compliance with the regulations of the EIA Act of 1994. For public participation, only public briefings were held prior to reviewing the EIA report for both cases. Besides, participants are under 10 people and there are no comments from public. Compared with Germany, 64% of cases have 1 to 50 petitions of public comments and 16% of the cases have more than 100 petitions of public comments (Marr 1997, P.241). It reveals that timing for public participation is too late and channels for participation are too few.

As for EIA report review, two review meetings for So-Go building project were held and EIA report meetings as well as EIDAR for Formosa building project were held twice and thrice respectively. So-Go building project only takes 3 months for reviewing and 5 months for Formosa building. From the aspect of decision-making process, it takes four months for So-Go building project and 3 months and 8 months for EIA report and EIDAR for Formosa building project respectively. Integrally speaking, the government takes 7 months (28 weeks) to deal with EIA for So-Go building project (including EIA report review & time for decision-making) and 8 months (32 weeks) and 13 months (52 weeks) to deal with EIA report and EIDAR for Formosa building project, which are longer than 23 weeks in the UK, but shorter than 60 weeks in Germany (Marr 1997, PP.223-33).

Both original proposals were modified more or less during EIA report review process, belonging to minor modifications. However, a great deal of modifications were made against the EIDAR review of the use

change plan for Formosa building project, including reduction of 8,974 m^2 floor area (2 floors) designed for shopping malls, and change of the allocation of parking spaces. These modifications belong to moderate modification level.

The control mechanisms during the decision-making process for So-Go building project consist of professional control and procedural control mechanisms. Whereas, Formosa building is added with public and outside agency control mechanism, which reveals that the decision-making process of the use change plan for Formosa building as well as the pressures from the general public already play an influential role against policymakers.

As we look back the definition of EIA effectiveness given in chapter 3 as "to improve the quality of decisions from an sustainability point of view" we might say that decisions derived from EIA practice for both projects are better made. Though effectiveness has not been accomplished in many aspects; however, positive function is already achieved. Analysis of the integral effectiveness evaluation of the EIA system will be conducted in chapter 13.

CHAPTER TWELVE: THE APPLICATION OF LEIA TO HIGH-RISE BUILDINGS - CASE STUDIES OF THE SO-GO AND FORMOSA BUILDINGS

In Chapters Nine and Ten, we discussed the environmental impacts of the So-Go and Formosa Buildings, though the analysis was largely limited to their construction and occupancy stages. This chapter uses the LEIA concept and method to evaluate their environmental effects at other stages of the building life-cycle. As Chapter Eleven discussed, the life-cycle is divided into five stages: the manufacture of raw materials, the transportation of those materials, construction, occupancy and demolition.

The environmental themes to be explored, which derive from a concern with sustainable development, include: depletion of natural resources (i.e., water consumption, abiotic resource depletion, use of recycled materials, solid waste disposal and land use); the buildings' impact on the environment's carrying capacity (i.e., global warming, acid rain, ozone depletion, photochemical oxidant formation, nitrification, human toxicity, atmospheric pollution, waterborne pollution and aquatic and terrestrial ecotoxicity); their impact on the local physical environment (i.e., noise and vibration, geology and soil, overshadowing of other buildings and land, local wind effects and wave interference) and their effect on the socio-economic environment (i.e., local population structure, economic environment, public facilities, traffic, community culture and landscape). As can be seen, the scope of the evaluation encompasses global, national and local issues. The evaluation method for all the stressors and environmental themes is listed in Table 4-9 of Chapter Four.

To estimate air pollution, predictions of the level of every stressor are calculated in terms of the consumption of fossil energy, times its thermal value and emission factor, giving an emission volume = emission factor (EF) * activity intensity. In addition, the pollutants emitted from the burning of natural gas are calculated in terms of natural gas consumption, times emission and control factors, giving an

emission volume = consumption * emission factor (EF) * control factor (C). The level of pollutants generated from the use of construction machinery is calculated in terms of hours of usage, times emission factors. The level of waterborne pollutants is calculated in terms of the volume of waste water, times emission concentration of each pollutant as shown in Table 12-1 in relation to the So-Go Building.

12.1 ENVIRONMENTAL IMPACTS AT THE MANUFACTURING STAGE

12.1.1 Depletion of Materials

Though the So-Go Building (a department store) and the Formosa Building (mixed-use) are both high-rises, their height, structure and number of storeys differ so the materials needed for their construction also differed.

The lower floors and basements of So-Go have a steel-reinforced concrete (SRC) structure; Formosa, on the other hand, is a steel frame structure except for its SRC basements. Therefore, So-Go's consumption of concrete is much higher than Formosa's, as Tables 12-1 and 12-2 illustrate. So-Go needed 81,234 m^3 of gravel and Formosa 57,246 m^3. Compared on the basis of gravel consumed per unit floor area, So-Go needed twice as much as Formosa.

Table 12-1: Energy Consumed and Air Pollutants Emitted by the So-Go Building at the Manufacture Stage

Construction Material	Amount	Energy consumption (million kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	Tsp (kg)	Sox (kg)	CO (kg)	Pb (kg)	HC (kg)
Cement and Mortar	895m^3	497	173630	1	7	716	1754	72	18	0.003	1
Premixed Concrete	58400m^3	22872	7884000	41	350	35040	116800	2920	876	0.140	40
Moulding Board	331500m^2	355	99450	1	4	332	3315	16	12	0.005	2
Steel Bar	4930T	10390	2854470	11	113	11240	3747	740	394	0.130	38
Steel Frame	12677T	26715	7339983	28	292	28904	9635	1902	1014	0.330	97
Timber	3976m^3	181	45287	1	2	199	2505	8	8	0.001	1
Plywood	3550m^2	11	2485	1	1	12	21	1	1	0.001	1
Glass	3976m^2	64	19085	1	1	40	4	8	4	0.001	1
Curtain wall	20020m^2	2378	586586	2	20	2402	40	100	80	0.004	1
Paint	73850m^2	70	15509	1	1	74	1	1	2	0.002	1
1/2 B brick	7950m^2	364	116865	1	4	398	1670	40	16	0.002	1
1 B brick	4770m^2	437	140238	1	5	477	2003	48	19	0.002	1
Marble on exterior wall	2200m^2	102	35420	1	1	15	44	13	4	0.001	1
Interior marble	2730m^2	127	43953	1	1	19	55	16	5	0.004	1
Interior wall tile	14329m^2	436	98870	1	2	287	1290	1	29	0.002	1
Floor tile	54923m^2	1673	378969	1	8	1098	4943	4	110	0.020	3
Total		66672	19834800	94	812	81253	147827	5890	2592	0.648	191
average of unit floor area(/m^2)		0.838	249	0.001	0.01	1.02	1.86	0.074	0.033	8.2E-06	0.003

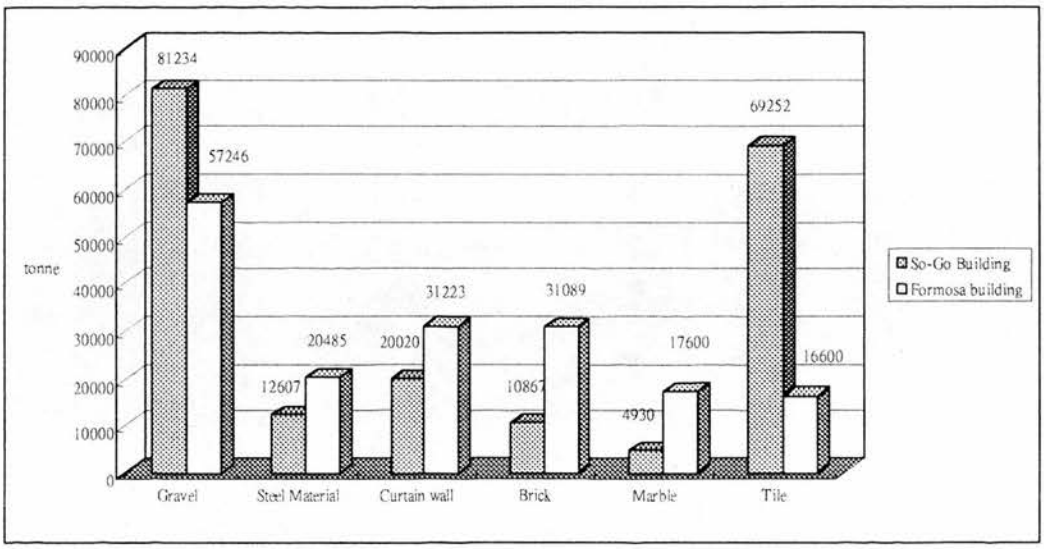
Note: Average for unit floor area is million kcal/m^2 or kg/m^2

Table 12-2: Energy Consumed and Air Pollutants Emitted by the Formosa Building at the Manufacture Stage

Main construction material	amount	Energy consumption (Million Kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	Tsp (kg)	Sox (kg)	CO (kg)	Pb (kg)	HC (kg)
Cement	1185m^3	658	229890	1	10	948	2,323	95	24	0.004	1
Premixed concrete	40600m^3	15,900	5481000	28	244	24360	81200	2,030	609	0.090	28
Moulding board	119622m^2	128	35886	1	1	120	1,196	6	5	0.002	1
Steel bar	3800T	8,008	2200200	9	87	8664	2888	570	304	0.099	29
Steel frame	16685T	35,162	9660615	37	384	38042	12681	2,502	1,335	0.434	127
Wood material	1777m^3	81	20240	1	1	89	1120	4	4	0.001	1
Plywood	10500m^2	327	73500	1	4	368	630	3	6	0.007	2
Glass	5922m^2	95	28426	1	1	59	6	12	6	0.001	1
Curtain wall	31223m^2	3709	914834	3	31	3747	63	156	125	0.004	1
Paint	100672m^2	95	21141	1	1	101	2	2	2	0.002	1
1/2 B brick	15397m^2	705	226336	1	8	770	3233	77	31	0.004	1
1 B brick	13028m^2	1193	383023	1	13	1303	5472	130	52	0.006	2
Marble on the exterior wall	11300m^2	525	181930	1	1	79	226	68	23	0.004	1
Interior Marble	630m^2	293	101430	1	1	44	126	38	13	0.002	1
Floor tile	16600m^2	506	114540	1	3	332	1494	1	33	0.003	2
Total		67385	19672991	88	790	79026	112660	5694	2572	0.663	199
average of unit floor area		0.569	166	0.0007	0.007	0.667	0.951	0.951	0.022	56E-06	0.002

Note: Average for unit floor area is million kcal/m^2 or kg/m^2

The difference in steel materials used for both buildings is minimal; So-Go took 17,607 tonnes and Formosa 20,485 tonnes. Per unit of floor area, however, So-Go's steel usage was 29% higher than Formosa's as the former's SRC structure required more gravel and steel. In addition, So-Go's use as a department store demanded a higher safety factor on its construction materials since it would have to accommodate greater crowds and so had a higher unit weight loading imposed. (See Fig. 12-1).



Note: unit m^3(gravel), tonne(steel), m^2(curtain wall, tile) 100 pieces(brick)

FIG.12-1: A Comparison of So-Go's and Formosa's Main Construction Materials

12.1.2 Energy Consumed and Air Pollutants Emitted

With respect to the energy consumed at the materials manufacture stage, premixed concrete, steel bars, and metal curtain walls use the highest proportion. For the So-Go Building, the energy needed to manufacture its steel materials came to 55.6% of the total energy used to meet this building's material requirements, while the manufacture of Formosa's steel materials used 64% of the energy its manufacturing stage consumed. The energy needed to provide the buildings' premixed concrete took 34.3% of the total needed for manufacturing So-Go's materials requirements and 24% of Formosa's.

Between them, the manufacture of these two building materials consumed 90% of the total energy used at the first stage of these buildings' life-cycle. Furthermore, as Fig. 12-2 shows, most of the energy consumed at this first stage was to serve the buildings' structural materials requirements. Per unit of floor area, So-Go's first stage energy consumption was highest (at 838,000 kcal/ m^2) as compared with Formosa's 569,000 kcal/ m^2 (see Fig. 12-3).

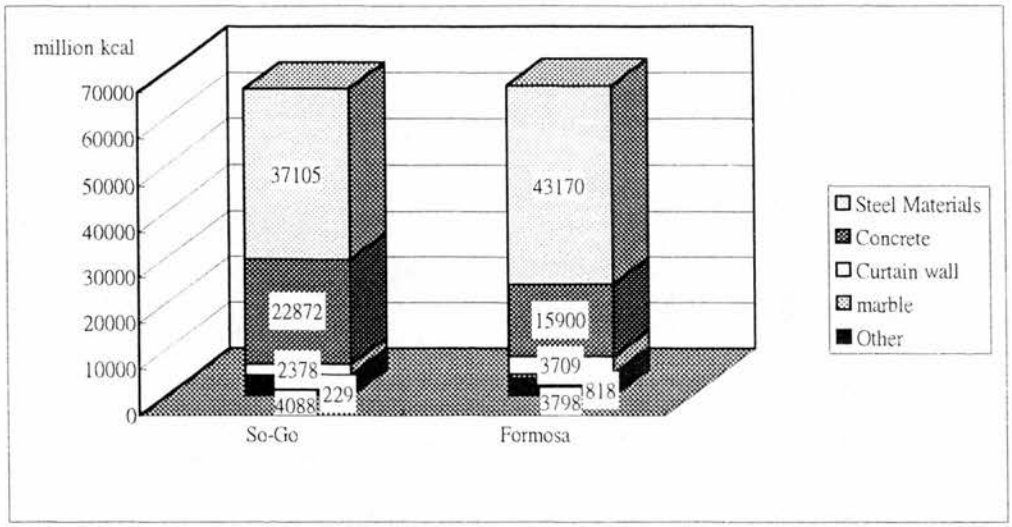
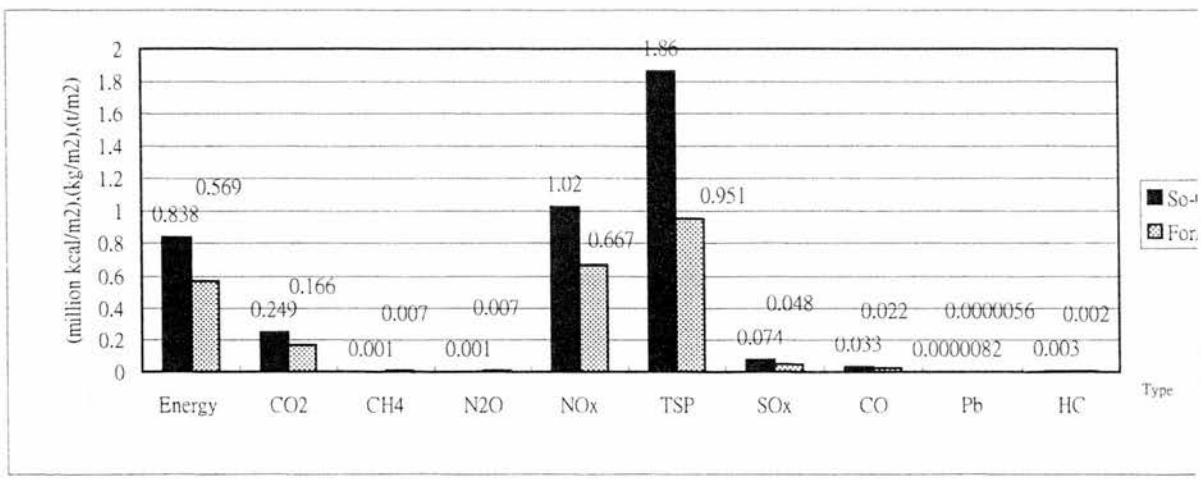


FIG. 12-2: Comparison of Energy Consumed by So-Go and Formosa to Meet their Materials Requirements



Note: unit of energy consumption is million kcal/ m^2; unit of CO_2 is T/ m^2; units of others are kg/ m^2

FIG. 12-3: Pollutants Emitted per Unit Floor Area by So-Go and Formosa at the Stage of Manufacturing their Construction Materials

At its materials manufacture stage, So-Go, per unit floor area, generated 249 kg of CO_2 while Formosa emitted only 64% of that, at 166 kg. The reason for Formosa's lower emissions lies in the fact that it is largely SS structured, reducing the amount of concrete needed for its construction and hence reducing the

CO_2 emissions associated with concrete manufacture. From these figures, we see that SRC structures tend to generate more CO_2 than do SS structures at the first stage of the building life-cycle.

Fig. 12-3 above shows the air pollutants emitted at the materials manufacture stage of So-Go and Formosa. Because So-Go's construction required more materials per unit floor area than did Formosa's, So-Go also tended to cause more pollutants to be emitted at its first stage. Amongst these pollutants, we find the biggest difference between them in the level of total suspended particles (TSP) emitted. So-Go's first stage volume was 1.95 times greater than Formosa's, largely as a consequence of So-Go's heavier requirement for premixed concrete materials. Nevertheless, the TSPs emissions from manufacturing steel and bricks are not negligible.

As CO_2 is a dominant greenhouse gas, and both So-Go's and Formosa's first stages caused the emission of great amounts of it, we can see that these types of building do contribute to global warming. Similarly, their first stage emissions of SOx and Nox (the main acidifying substances) were large, suggesting that these types of building also contribute to the formation of acid rain.

12.1.3 Waterborne Pollution

The volume of polluted effluent produced from the materials manufacture stage was obtained by multiplying the amount of materials required by the buildings with their related industrial emission factor, as investigated by the Industrial Bureau at the Ministry of Economics (Ministry of Economic 1995, pp. 5-16-18) .

So-Go's first stage produced c. 250,000 m^3 of waste water and Formosa's c. 340,000 m^3, as we see from Tables 12-3 and 12-4. Per unit floor area, So-Go's volume of waste water was slightly higher than Formosa's (see Fig. 12-4); 3.06 m^3/ m^2 and 2.87 m^3/ m^2 respectively. Again, the main reason for So-Go's

larger volume was its greater use of concrete; the tasks which go into the production of concrete (shifting gravel, and then washing, smashing and mixing it) all tend to produce large amounts of waste water.

Table 12-3: Volume of Polluted Effluent from So-Go's Materials Manufacture Stage

Construction Material	Amount	Waste water generated (M^3)	COD produced (kg)	COD effluent volume(kg)	BOD produced (kg)	BOD effluent volume(kg)	SS produced (kg)	SS effluent volume (kg)
Cement mortar	895m^3	2275	1177	117	*	*	137963	939
Premixed concrete	58400m^3	148434	76808	7601	*	*	9002340	61286
Steel bar	4930T	8529	4388	725	656	138	10121	109
Steel frame	12677T	21931	11283	1864	1686	355	26026	279
Glass	3976m^2	1890	667	69	168	21	123	16
Curtain wall	20020m^2	3703	2202	600	67	14	3630	312
Paint	73850m^2	2341	4347	761	849	253	620	372
1/2 B brick	7950m^2	310	72	16	*	*	2401	103
1 B brick	4770m^2	372	86	19	*	*	2881	124
Marble on exterior wall	2200m^2	22800	6915	1794	670	268	189936	2851
Interior Marble	2730m^2	28293	8581	2226	832	333	235694	3537
Interior wall tile	14329m^2	559	129	29	*	*	4327	186
Floor tile	54923m^2	2142	494	110	*	*	16587	714
Total		243579	117149	15931	4928	1382	632649	70828
The average of unit floor area	(m^3/m^2 or kg/m^2)	3.06	1.47	0.20	0.06	0.02	121.13	0.89

Notes:

a) This estimation of the volume of effluent produced from materials manufacture assumes that 1 m3 of cement mortar takes 0.5 tonnes of cement and 1.37 m^3 of gravel; that 1 m^3 of premixed concrete takes 0.34 tonnes of cement and 1.37 m^3 of gravel; that a metal curtain wall (210 kg/cm2, 3000 psi) takes 25 kg/ m^2 of metal and 6.5 kg/ m^2 of glass; and that paint is based on 0.45 kg/ m^2 and marble 260 kg/ m^2.

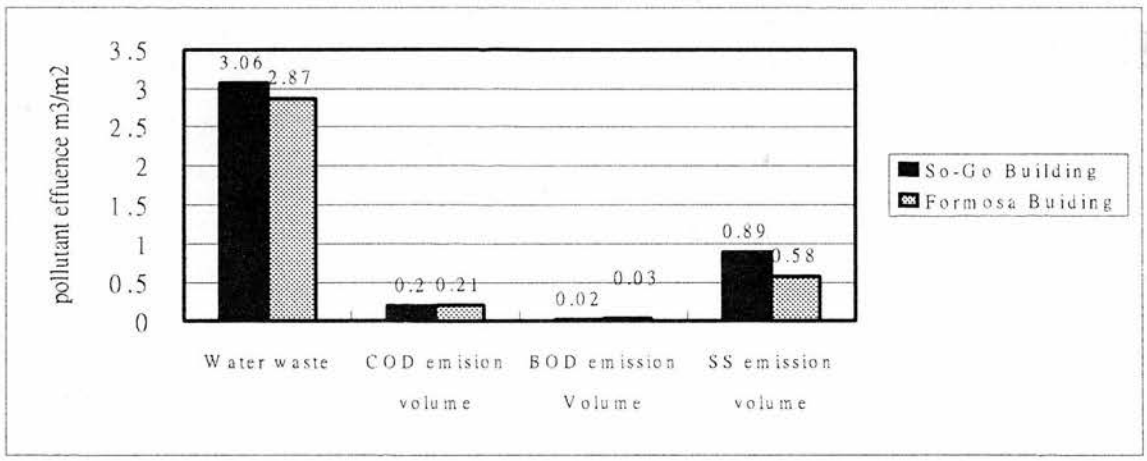
b) The per unit volumes of pollutants and effluent accord with the figures provided by the Industrial Bureau of the Ministry of Economics: *The Current Situation in Preventing Industrial Waste Water and Pollutants in Taiwan* (Taipei, 1995), pp.5-16-18.

c) * represents a minimal or non-existent amount or that the volume has not been calculated.

Table 12-4: Volume of Polluted Effluent from Formosa's Materials Manufacture Stage

Main construction material	amount	Waste water generated (M^3)	COD produced (kg)	COD emission volume(kg)	BOD produced (kg)	BOD emission volume (kg)	SS produced (kg)	SS emission volume (kg)
Cement mortar	1185m^3	3012	1559	154	*	*	182667	1244
Premixed concrete	40600m^3	103192	53397	5284	*	*	6258476	42606
Steel bar	3800T	6574	3382	559	505	106	7801	84
Steel frame	16685T	28865	14850	2453	2219	467	34254	367
Glass	5922m^2	2815	994	102	250	32	184	23
Curtain wall	31223m^2	7172	4129	1051	104	22	5662	485
Paint	100672m^2	3191	5927	1038	1158	344	845	507
1/2 B brick	15397m^2	601	139	31	*	*	4650	200
1 B brick	13028m^2	1016	235	52	*	*	3935	339
Marble on exterior wall	11300m^2	117108	35518	9215	3443	1378	975581	14639
Interior Marble	6300m^2	65290	19802	5138	1920	768	543908	8162
Floor tile	16600m^2	647	149	33	*	*	5013	216
Total		339438	140081	25110	9599	3117	8022976	68872
average of unit floor area	(m^3/m^2 or kg/m^2)	2.87	1.18	0.21	0.08	0.03	67.74	0.58

Note: the same as table 12-3



Note: unit : m^3/m^2 (waste water), kg/m^3(COD,BOD, SS)

FIG. 12-4: Volumes of Polluted Effluent per Unit Floor Area from So-Go's and Formosa's Materials Manufacture Stage

Per unit floor area, the COD emitted from Formosa's materials manufacture stage was higher than So-Go's, at 0.21 kg/ m^2 and 0.20 kg/ m^2 respectively. Analysing the pollution sources, we see that 57% of the COD from Formosa's first stage stemmed from Formosa's higher requirement for marble; So-Go's first stage COD emissions relating to marble came to only 25% of its total, as Fig. 12-5 shows. This shows that Formosa's higher consumption of marble accounted for its higher level of COD effluent at its materials manufacture stage.

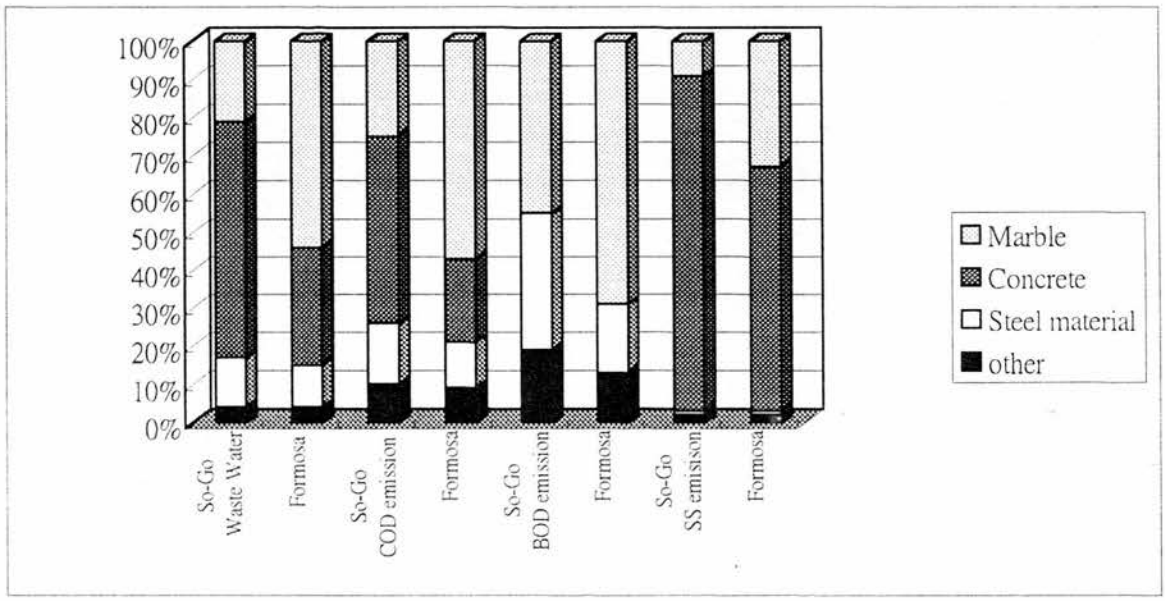


FIG. 12-5: A Comparison of So-Go's and Formosa's Volumes of Polluted Effluent at the Materials Manufacture Stage

Note: the unit for waste water generated is m^3/m^2 while units for the other items are kg/m^2

Formosa's level of BOD effluent was also higher at this first stage (see Fig. 12-4 above), because of its greater requirement for marble, resulting in marble manufacture accounting for 69% of its total BOD volume. So-Go's volume of BOD from its use of marble also accounted for almost half of its first stage total, as Fig. 12-5 above shows.

The situation was reversed for the volumes of suspended solids (SS) each building caused to be emitted at the materials manufacture stage; So-Go's effluent was 53% higher than Formosa's, at 0.89 kg/ m^2 and 0.58 kg/ m^2 respectively. So-Go's higher SS effluent was mainly down to its greater need for concrete, which accounted for about 88% of its total. About half of Formosa's SS effluent came from concrete production and 33% from marble production. Between them, concrete and marble manufacturing accounted for 96% of both buildings' SS effluent at the first stage. The manufacture of the other materials used by the buildings accounted for the remaining 4%.

In sum, when we look at the environmental impact of So-Go's and Formosa's first life-cycle stage, we see that the building sector is a industry which depletes rather a lot of natural resources, e.g., So-Go required over 80,000 m^3 of gravel and 17,600 tonnes of steel. Acquiring the raw materials of concrete and steel has a huge ecological impact and large amounts of energy are consumed and pollutants emitted as a consequence of manufacturing these products for use by the building trade. Emitted pollutants, aside from immediately affecting air and water quality, can contribute to global warming, acid rain, photochemical oxidant formation and eutrophication. Furthermore, some of these pollutants may be toxic, affecting human health or damaging particular ecological niches.

12.2 ENVIRONMENTAL IMPACTS AT THE TRANSPORTATION STAGE OF THE BUILDING LIFE-CYCLE

12.2.1 Energy Consumed from Transporting Building Materials

The materials transportation, or second, stage carries environmental repercussions in the form of traffic and air pollution problems as energy consumed in this stage is from petrol and diesel energy sources. If we assume that each truck in this stage carries 10 tonnes per journey, then constructing So-Go needed

11,912 truck loads and Formosa 9,084. These laden vehicles not only affected local traffic conditions but also consumed fuel and emitted exhausts.

Tables 21-5 and 12-6 outline the energy consumption and pollutant emissions of the So-Go and Formosa Buildings at the transportation phase. So-Go consumed 1,320 million kcal of energy (0.15 MTOE) and Formosa 977 million kcal (0.109 MTOE). Per unit floor area, So-Go's energy use at the transportation stage was 1.8 times more than Formosa's. The main reason for this higher consumption was So-Go's need for large quantities of concrete and moulding boards; these materials are bulky and so more trucks were needed to carry them to the site. These two materials alone accounted for 83% of the energy used at So-Go's second stage, as Fig. 12-6 shows. Per unit of floor area, So-Go's transportation stage used around 17,000 kcal (c. 1.89 litres of oil equivalent) while Formosa's used 9,000 kcal (c. 1 litre of oil equivalent).

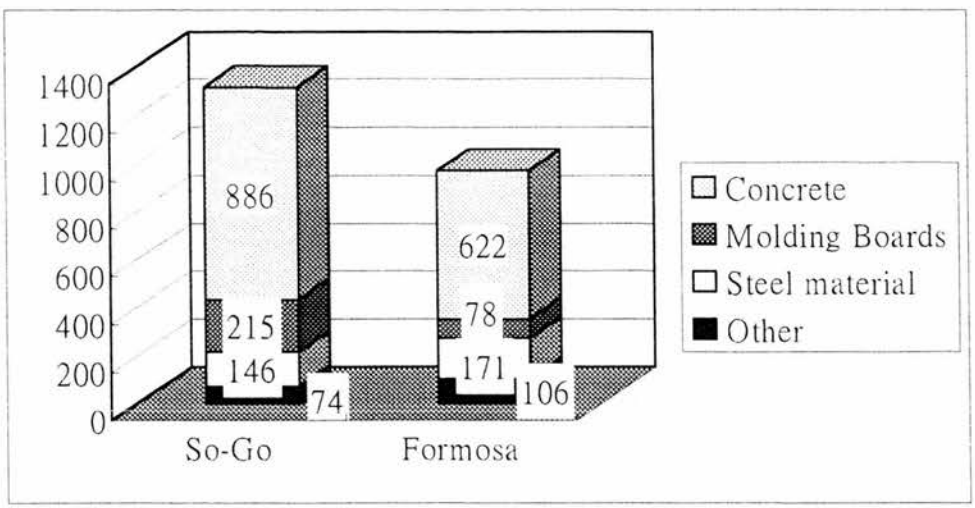


FIG. 12-6: Comparison of Energy Consumed by So-Go and Formosa at the Materials Transportation Stage

Table 12-5: Energy Consumed and Pollutants Emitted at So-Go's Transportation Stage

Construction Material	Amount	Energy depletion (Million kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	Tsp (kg)	Sox (kg)	CO (kg)	Pb (kg)	HC (kg)
Cement and mortar	895m^2	10	3034	3	1	116	53	15	66	2.9E-03	18
Premixed concrete	58400m^3	876	269224	234	117	14425	19272	1986	7650	3.5E-01	2336
Molding boards	331500m^2	215	66300	60	37	3315	1326	332	1989	8.3E-02	663
Steel bar	4930T	41	15	1	1	1	1	1	1	1.6E-05	1
Steel frame	12677T	105	38	1	1	2	1	1	1	4.1E-05	1
Wood	3976m^3	25	7634	7	4	398	199	48	219	9.5E-03	68
Plywood	3550m^2	1	1	1	1	1	1	1	1	2.4E-07	1
Glass	3976m^2	1	159	1	1	8	3	1	4	1.9E-04	1
Curtain wall	20020m^2	10	3203	3	2	162	60	20	90	4.0E-03	28
Paint	73850m^2	1	222	1	1	12	4	2	7	3.0E-04	2
1/2 B brick	7950m^2	7	2226	2	1	119	103	15	65	2.9E-03	24
1 B brick	4770m^2	9	2671	3	1	143	124	18	95	3.4E-03	29
Marble on exterior wall	2200m^2	2	528	1	1	22	37	4	15	6.8E-04	5
Interior Marble	2730m^2	2	655	1	1	27	46	4	19	8.5E-04	6
Floor tile	54923m^2	15	4394	4	2	236	110	30	132	6.0E-03	41
Total		1320	360304	323	172	18987	21340	2478	10354	0.464	3224
average of unit floor area		0.017	4.53	0.004	0.002	0.239	0.268	0.031	0.130	5.8E-06	0.041

Table 12-6: Energy Consumed and Pollutants Emitted at Formosa's Transportation Stage

Construction Material	Amount	Energy Use (Million kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	Tsp (kg)	Sox (kg)	CO (kg)	Pb (kg)	HC (kg)
Cement mortar	1185m^3	13	4017	4	2	154	70	20	88	3.8E-03	24
Premixed concrete	40600m^3	609	187166	162	81	10028	13398	1380	5319	2.4E-01	1624
Moulding boards	119622m^2	78	23924	22	13	1196	479	120	718	3.0E-02	239
Steel bar	3800T	32	12	1	1	1	1	1	1	1.2E-05	1
Steel frame	16685T	139	50	1	1	2	2	1	1	5.3E-05	1
Wood	1777m^3	11	3412	3	2	178	89	21	98	4.3E-03	30
Plywood	105000m^2	20	6	1	1	1	1	1	1	7.1E-06	1
Glass	5922m^2	1	237	1	1	12	5	2	7	2.8E-04	1
Curtain wall	31223m^2	16	4996	4	3	253	94	31	141	6.3E-03	44
Paint	100672m^2	1	302	1	1	16	5	2	9	4.0E-04	3
1/2 B brick	15397m^2	14	4311	4	2	231	200	29	126	5.5E-03	46
1 B brick	13028m^2	24	7296	7	4	391	339	50	261	9.4E-03	78
Marble on exterior wall	11300m^2	9	2712	3	2	113	192	18	79	3.5E-03	25
Interior Marble	6300m^2	5	1512	1	1	63	107	10	44	2.0E-03	14
Floor tile	16600m^2	5	1328	1	1	71	33	9	40	1.8E-03	13
Total		977	238592	216	116	12710	15015	1695	6933	0.307	2144
average of unit floor area	(/m^2)	0.009	2	0.002	0.001	0.107	0.127	0.014	0.059	2.6E-06	0.018

12.2.2 Emissions of Various Pollutants

The pollutants associated with the transportation phase are caused by vehicles' exhausts and by the dust and suspended solids they raise as they move. Based on the emission factors previously calculated, Tables 12-5 and 12-6 (above) show the volumes generated by each building at the second stage.

Looking at the greenhouse gases associated with this stage, transporting materials to the So-Go site produced 360 tonnes of CO_2; per unit of floor area, it averaged 4.53 kg/ m^2 of CO_2. Its CH_4 and N_2O emissions were lower per unit of floor area, at 0.004 kg/ m^2 and 0.002 kg/ m^2 respectively. By the same measure, Formosa's emissions were similar; 2 kg/ m^2 of CO_2, 0.002 kg/ m^2 of CH_4 and 0.001 kg/ m^2 of N_20. CO_2 emissions stemmed largely from the need to transport concrete - 76% of So-Go's CO_2 emissions were accounted for by the transportation of concrete, followed by the transportation of moulding boards. In Formosa's case, 80% of its CO_2 emissions were accounted for by the transportation of concrete to the site (see Fig. 12-7).

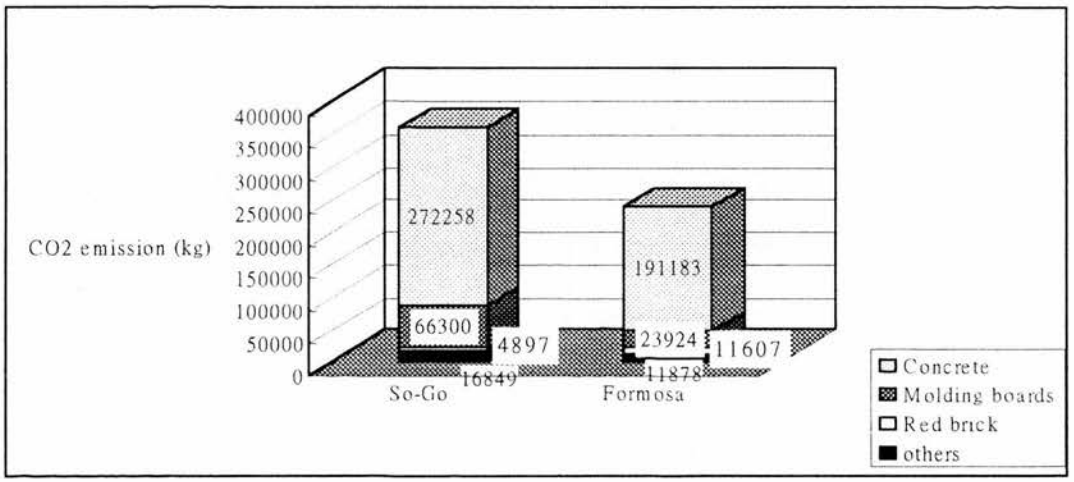


FIG. 12-7: Comparative CO_2 Emissions of So-Go and Formosa at the Materials Transportation Stage

Per unit of floor area, the most voluminous pollutant emitted at this stage was TSP, followed by NO_X (see Fig. 12-8). Of the two high-rises, So-Go's per unit emissions were roughly twice as high as Formosa's. So-Go's steel-reinforced concrete structure required more steel and concrete material than did Formosa's steel structure, thus using more energy and generating more atmospheric pollutants at the transportation stage.

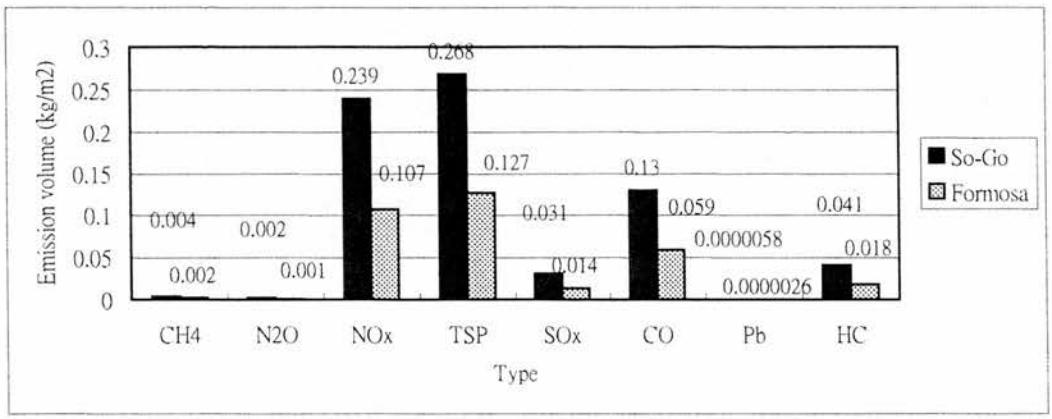


FIG. 12-8: Comparison of So-Go and Formosa's Polluting Emissions per Unit of Floor Area at the Transportation Stage

12.2.3 Socio-Economic Impacts

The main environmental issue to consider here is the impact of the buildings' transportation stage on traffic and LOS on the roads, including the alteration of land use to construct a temporary access route for the construction trucks. Other issues which arise at this stage are local job opportunities and traffic safety problems.

It took 11,912 truck loads to transport So-Go's materials to the site and 9,084 to transport Formosa's. To accommodate these trucks, temporary access roads (to the west of the So-Go site and to the north of the Formosa site) were opened on land that was originally used for farming. The trucks also used normal traffic routes for parts of their journey but as these trips were concentrated at specific points in the

construction process, their impact on local traffic conditions was time-related. For example, trucks delivering concrete came most frequently at the phase when the cast-in concrete of the basements and floors was being laid. During this particular phase in So-Go's construction, about 130 trucks carrying premixed concrete were in and out of the site, causing serious - if short-lived - traffic congestion.

In addition, these heavy trucks can be a hazard or a nuisance to those living nearby. For example, of Taiwan's traffic accidents in 1996, a full 23% involved transport trucks (MOTC 1996, pp. 212-3).

The second stage of the building life-cycle generates job opportunities for truck drivers. In 1996, 221,313 people were employed in the transportation industry (MOTC 1996, pp. 14-15) - an important sector in Taiwan's labour market - and some of this number is linked with the transportation needs of the building trade.

12.3ENVIRONMENTAL IMPACTS AT THE CONSTRUCTION STAGE

During the construction stage, both buildings generated air and water pollutants and affected the local socio-economic environment. The sources of the pollution were the operation of construction machinery, the movement of construction vehicles and the waste water of the builders.

12.3.1 The Emission of Air Pollutants

The air pollutants of the construction stage came from four main sources: construction machinery, painting work, particulate pollutants raised by the building process, and dust raised by construction vehicles. The emissions of fuel-driven construction machinery are related to the number of hours the different kinds of machine are in use. As Tables 12-7 and 12-8 show, of the five major pollutants emitted, NO_X volumes were the highest; So-Go generated 0.042 kg/ m^2 per unit of floor area and Formosa 0.085

kg/ m^2. The Formosa Building's emissions were 2.02 times that of So-Go's because it took longer to build which, in turn, increased the accumulated work hours of its construction machinery. In addition, its greater height and basement depth meant that the construction work was both more difficult and more dependent on the use of heavy construction machinery than was the case with So-Go's construction.

Table 12-7: Air Pollutants Emitted by the So-Go Building at the Construction Stage

Pollutants Construction machinery and engineering items		CO (g/hr)	HC (g/hr)	NO_X (g/hr)	SO_X (g/hr)	TSP (g/hr)	Vehicle number for construction items				
							Excav-ation	casting concrete	Structure assembling	Exterior wall operation	Interior operation
Construction machinery	Excavator	568.19	128.15	1740.14	210	184	2	0	0	0	0
	Bulldozer	816.81	86.84	1889.16	158	75	1	0	0	0	0
	Dump Truck	816.81	86.84	1889.16	206	116	3	5	2	2	2
	Others	306.37	69.35	767.3	64.7	63.2	2	4	3	3	2
Emission of various items (tonnes)	Excavation (100days)	0.50	0.08	1.26	0.14	0.10					
	Casting concrete (50days)	0.27	0.04	0.63	0.07	0.05					
	Structure assembling (120days)	0.31	0.05	0.72	0.08	0.05					
	Exterior wall operation (80days)	0.21	0.03	0.48	0.05	0.14					
	Interior operation(50days)	0.11	0.02	0.26	0.03	0.02					
Total (tonnes)		1.40	0.22	3.35	0.37	0.26					
Per-floor-area average (kg/m^2)		0.018	0.003	0.042	0.005	0.004					

Note:

a. The emission factors for all construction machinery were in accordance to You-jiuh company , 1997 p.7-12,table 7.1-4.

b. The duration and quantity of construction machinery for different operation was in accordance to the project's construction plan.

Table 12-8: Air Pollutants Emitted by the Formosa Building at the Construction Stage

Pollutants Construction machinery and engineering items		**CO (g/hr)**	**HC (g/hr)**	**NO_X (g/hr)**	**SO_X (g/hr)**	**TSP (g/hr)**	**Vehicle number for construction items**				
							Excavation operation	**Casting concrete**	**Structure assembling**	**Exterior wall operation**	**Interior operation**
Construction machinery	Excavator	568.19	128.15	1740.74	210.00	184.00	1	0	0	0	0
	Bulldozer	816.81	86.84	1889.16	158.00	75.00	1	0	0	0	0
	Loading trucks	816.81	86.84	1889.16	206.00	116.00	3	6	3	2	1
	Others	306.37	69.35	767.30	64.70	63.20	1	6	3	3	2
emission of various items (tonnes)	Excavation (545days)	2.25	0.29	5.48	0.57	0.37					
	Casting operation (75days)	0.50	0.07	1.19	0.12	0.08					
	Structure assembling (220days)	0.74	0.10	1.75	0.18	0.12					
	Exterior wall operation (200days)	0.51	0.07	1.21	0.12	0.08					
	Interior operation (130days)	0.18	0.03	0.44	0.04	0.03					
Total (tonnes)		4.18	0.56	10.07	1.03	0.68					
Per-floor-area average (kg/m^2)		0.035	0.005	0.085	0.009	0.006					

Note: The same as in table 12-7.

Another major source of pollution at the construction stage was the volatile organic contaminants from the coating process. To estimate the HC emissions from coating the building we multiply the amount of paint used with the EPA's suggested emission factor (375 kg/tonnes) (EPA 1999, p.3-79). The HC emissions from coating the Formosa Building came to 16.99 tonnes and the So-Go Building 12.46 tonnes.

TSP emissions at the construction stage relate to the area of the site and the length of time the building is under construction. Formosa's site was bigger than So-Go's and it also took longer to build so its TSP

emissions were higher. In both cases, the dust raised by construction vehicles was mainly as a consequence of earthmovers transporting surplus soil. Tables 12-9 and 12-10 show each buildings' total emissions of air pollutants from all their various sources. A comparison of their volume per unit of floor area is offered in Figs. 12-9 and 12-10.

Table 12-9: Volume of Various Pollutants Emitted by the So-Go Building at the Construction Stage

Pollutants Pollution sources	CO (T)	HC (T)	NO_X (T)	SO_X (T)	TSP (T)	CO_2 (T)	CH_4 (T)	Waste water(m^3)	COD generated volume (kg)	COD emission volume (kg)	BOD generated volume (kg)	BOD emission volume (kg)	SS generated volume (kg)	SS emission volume (kg)	Grease generated volume (kg)	Grease emission volume (kg)	Total phosphorous generated volume (kg)	Total phosphorous emission volume (kg)	Total N_2 generated volume (kg)	Total N_2 emission volume (kg)
Temporary power supply and fossil fuel consumption of the construction machinery	1.40	0.22	3.35	0.37	0.26	356.26	0.01													
The volatile organic emission of building coating operation		12.46																		
The TSP generated from construction					25.2															
floating dust from the traveling construction vehicles					5.2															
Waste water from construction personnel								8800	3520	880	1760	440	1936	440	880	88	71	35	352	88
Total	1.40	12.68	3.35	0.37	30.66	356.26	0.01	8800	3520	880	1760	440	1936	440	880	88	71	35	352	88
The per-floor-area average (kg/m^2)	0.018	0.160	0.042	0.005	0.4	4.48	0.001	0.11 (m^3/m^2)	0.044	0.011	0.022	0.006	0.024	0.006	0.011	0.001	0.001	4.4E-04	0.005	0.001

Note:

a. The emission of CO_2 and CH_4 were established according to Yang, 1996, p.16

b. The emission of the floating dust by the vehicles was calculated from equation: Q=(3*10)S.L.W.V see chapter seven

Table 12-10 Emission of various pollutants of Formosa building at the construction phase

pollutants Pollution sources	CO (T)	HC (T)	NO_X (T)	SO_X (T)	TSP (T)	CO_2 (T)	CH_4 (T)	Waste water (m^3)	COD generated volume (kg)	COD emission volume (kg)	BOD generated volume (kg)	BOD emission volume (kg)	SS generated volume (kg)	SS emission volume (kg)	Grease generated volume (kg)	Grease emission volume (kg)	Total phosphorous generated volume (kg)	Total phosphorous emission volume (kg)	Total N_2 generated volume (kg)	Total N_2 emission volume (kg)
Temporary power supply and fossil fuel consumption of the construction machinery	4.18	0.56	10.07	1.03	0.68	530.60	0.02	12285												
The volatile organic emission of building coating operation		16.99																		
The TSP generated from construction					74.48															
floating dust from the traveling construction vehicles					8.96															
Waste water from construction personnel								12285	4914	1229	2457	614	2703	614	1229	123	98	49	492	123
Total	4.18	17.55	10.07	1.03	84.12	530.60	0.02	12285	2914	1229	2457	614	2703	614	1229	123	98	49	492	123
The per-floor-area average (kg/m^2)	0.035	0.148	0.085	0.009	0.710	4.48	0.001	0.104 (m^3/m^2)	0.042	0.010	0.021	0.005	0.023	0.005	0.010	0.001	8.3E-04	4.1E-04	0.004	0.001

Note:

a. The emission of CO2 and CH4 were established according to Yang, 1997, p.16

b. The emission of the floating dust by the vehicles was calculated from equation: Q=(3x10)S.L.W.V see chapter seven

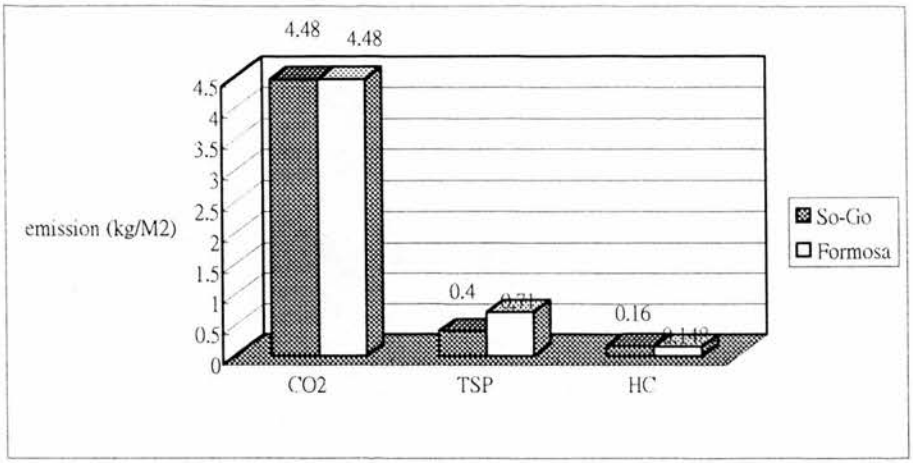


FIG. 12-9: Comparison of CO_2, TSP and HC Emissions per Unit Floor Area by So-Go and Formosa at the Construction Stage

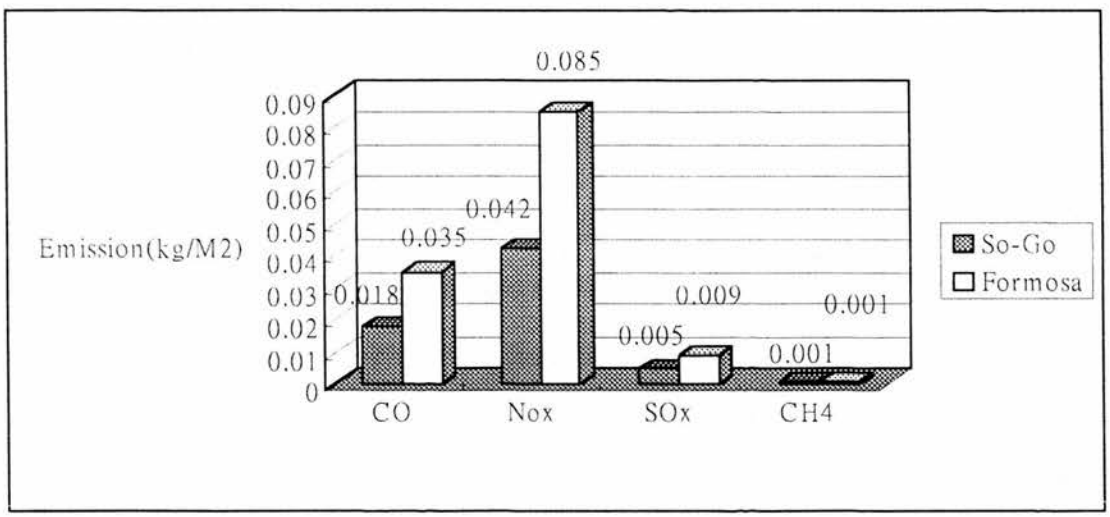


FIG. 12-10: Comparison of CO, NOx, SOx and CH_4 Emissions per Unit Floor Area by So-Go and Formosa at the Construction Stage

Of the various pollutants, CO_2 emissions were the highest; So-Go generated 356.26 tonnes and Formosa 530.6 tonnes. TSP emissions, whose source was particles raised from construction activities, came next at 30.66 tonnes (So-Go) and 84.12 tonnes (Formosa). Formosa's TSP emissions were 2.74 times more than So-Go's because of its longer construction period.

12.3.2 The Emission of Waterborne Pollutants

The major sources of this kind of pollution were from building staff and from the maintenance and cleaning of construction equipment. However, waste water from maintenance and cleaning are not considered here because the So-Go and Formosa sites both had waste water storage pools installed to clean out the mud and sediment which resulted from these two types of activity, enabling water to be recycled. We will focus on the waste water of the builders; the emission volumes are shown in Tables 12-9 and 12-10 above.

Amongst the waterborne pollutants, COD emissions were the highest. So-Go generated 880 tonnes and Formosa 1,229 tonnes. However, as measured per unit of floor area, So-Go's COD emissions were slightly higher than Formosa's at 0.011 kg/m^2 and 0.010 kg/ m^2 respectively. Phosphorous was the least voluminous emission at the construction stage; per unit of floor area, So-Go only emitted 0.44 g/ m^2 (35 kg in total) and Formosa 0.41 g/ m^2 (49 kg in total), as shown in Fig. 12-11.

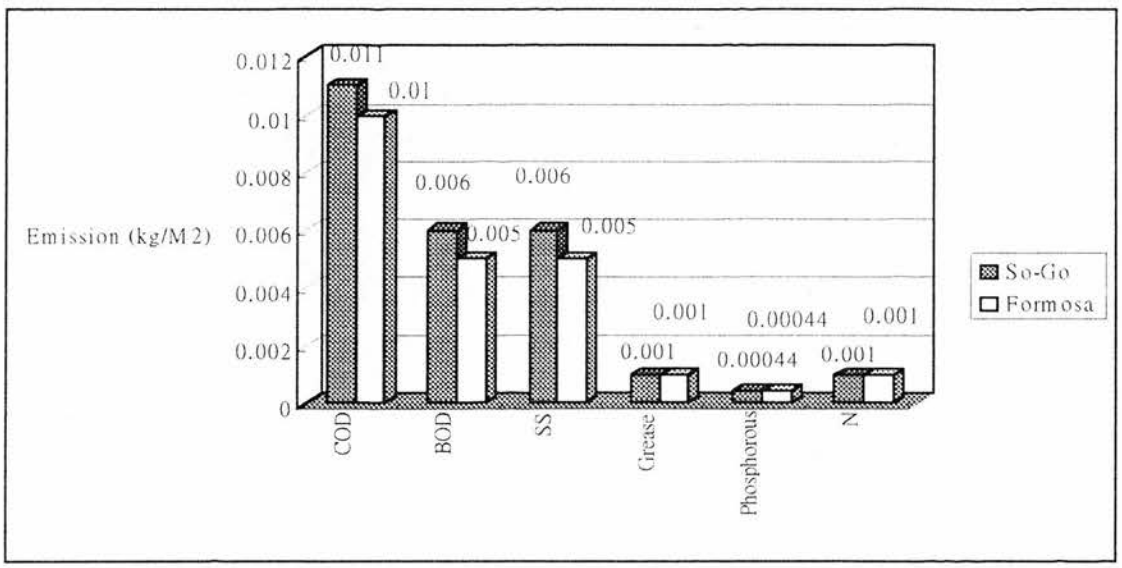


FIG. 12-11: Comparison of Emissions of Waterborne Pollutants from So-Go and Formosa per Unit of Floor Area at the Construction Stage

12.3.3 Socio-Economic Impacts

Socio-economic issues include the quality of public provision (e.g., public amenities, transportation and the safety of the community); the social environment (e.g., variation in local population and land use); and the economic environment (e.g., variation in the industrial structure, labour market or local income levels).

The most obvious impact of the construction stage is on traffic as delivery trucks and construction machinery and vehicles affect local traffic flow. The impact of earthmoving vehicles on traffic flow is most concentrated at the basement excavation phase of construction. During initial excavation, a total of 14,000 dump trucks (140 per day) removed surplus soil. In addition, during So-Go's construction stage, its developers applied for a 1.5 metre-wide area of road to be allocated for use by construction plant which temporarily affected traffic flow on the main road.

Besides the immediate effects on traffic, the noise and vibration of construction equipment and vehicles may bother local residents. So-Go's construction machinery increased local noise levels by 9 dB(A) and its transportation trucks generated an added increment of 5 dB(A). Though the impact of vibration on the quality of public amenity was not as obvious (Formosa's vibration level was 67 dB and So-Go's 60 dB) nevertheless the pounding of the piling machines was disruptive to the peace of the area.

The So-Go and Formosa Buildings each had c. 200 builders working on-site each day so the effect on the local population structure was minimal. The So-Go site was originally farmland with a detached building on it, while the Formosa site was originally a fish market. As these original uses were not in the public sector, the effect of the constructions on the community was also minimal.

In economic terms, these two projects brought some job opportunities to the area. So-Go and Formosa each employed c. 200 builders per day, though as most of the jobs were for construction technicians, this

had only a minor impact on the local job market. However, the very fact of their construction eventually increased the general prosperity of businesses in the local area which, in turn, improved the local labour market. Though both buildings did have a positive impact on the economic environment eventually, this was not the case when we consider the construction stage in isolation. When the projects were under construction, neighbouring businesses were inconvenienced and suffered reduced revenues, e.g., So-Go's construction affected Chung-Kung-Ju-Hsin's business quite badly at the time.

12.4 ENVIRONMENTAL IMPACTS AT THE OCCUPANCY STAGE

Environmental issues raised by the occupancy stage can be divided into effects on the physical environment (e.g., energy consumption and pollution) and the socio-economic environment (e.g., traffic, living standards etc.).

12.4.1 Energy Consumption

Typically, the main energy source at the occupancy stage of the building life-cycle is electricity followed by natural gas. As So-Go is predominantly used as a department store, 98% of its energy comes from electricity and only 1.1% from natural gas. Formosa, on the other hand, is a multi-purpose building housing a department store, a hotel, offices and restaurants. Of its total energy consumption, electricity accounts for 81.5%; natural gas 9.1%; boiler fuel 4.9%; and fuel oil 4.5%.

At its occupancy stage, the So-Go Building consumes 47,199 million kcal annually (5.25 million litres of oil equivalent). Per unit floor area, it annually consumes 590,000 kcal (65 litres of oil equivalent). Formosa's consumption at the occupancy stage is slightly higher than So-Go's at 53,698 million kcal (6 million litres of oil equivalent). Per unit floor area, its annual consumption is slightly lower than So-Go's at 51 litres of oil equivalent because Formosa's offices tend to use less energy than do either building's department stores. In addition, Formosa's parking bays (27,512.2 m^2 over five floors) occupy 23.2% of its

total floor area and these bays consume less energy than the floors housing the department store and restaurants. For a comparison of the two buildings, see Fig. 12-12.

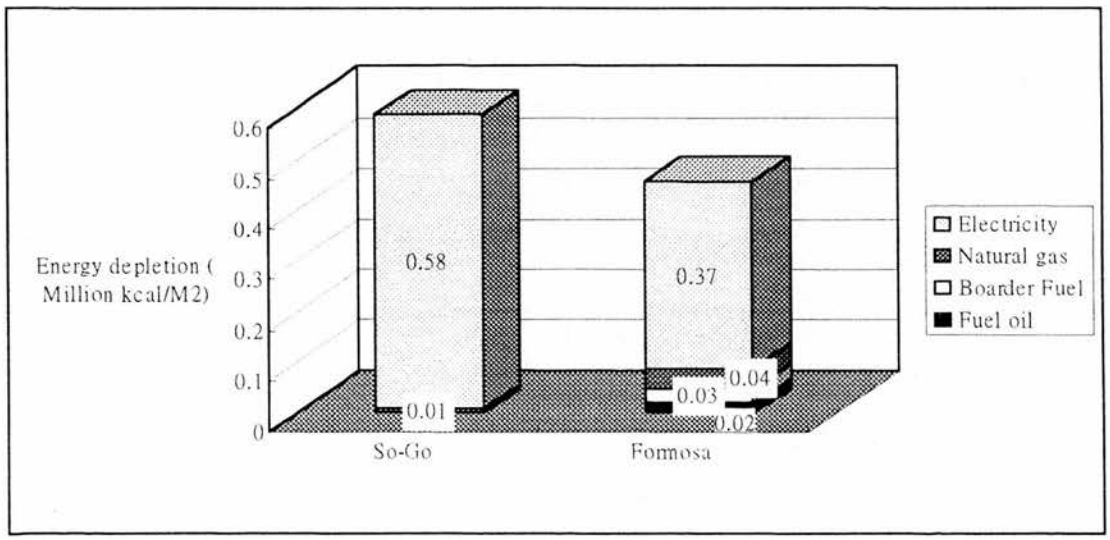


FIG. 12-12: Comparison of Energy Use of So-Go and Formosa per Unit Floor Area at the Occupancy Stage

Fig. 12-13 illustrates So-Go's and Formosa's energy consumption in relation to similar types of building in Taiwan. We can see that both use more energy than average.

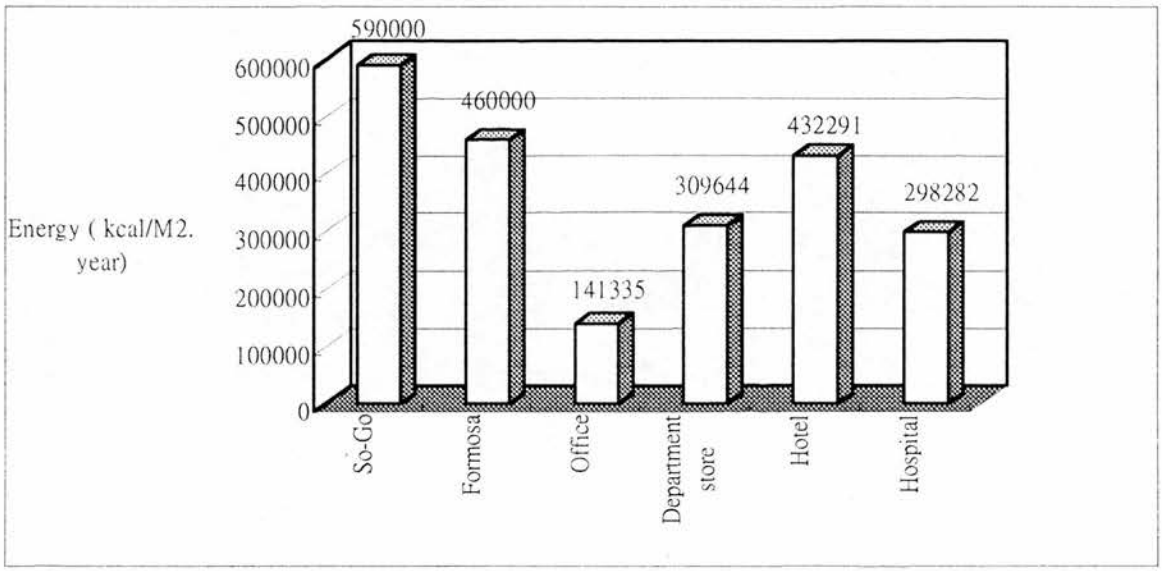


FIG. 12-13: Comparison of So-Go's and Formosa's Energy Consumption in Relation to Other Types of Building

Note: Data on offices, department stores, hotels and hospitals were obtained from Liu (1994, p.58, Table 3-20) though his figures are lower because they are based on 1992 estimates.

12.4.2 Atmospheric Pollutants

The sources of the air pollutants generated at the occupancy stage, apart from emissions from energy consumed, are restaurants and traffic. Air pollutants can be divided into those which act as greenhouse gases and those which do not.

Greenhouse gases include CO_2, CH_4, N_2O and $HcFc_{123}$. As Fig. 12-14 shows, CO_2 emissions are highest; So-Go annually generates 170.77 kg/ m^2 and Formosa 117 kg/ m^2. CH_4 emissions from both So-Go and Formosa are much lower at c. 0.01 kg/ m^2 per year, and N_2O and $HcFc_{123}$ emissions are lower still. As we can see from Tables 12-11 and 12-12, most of the CO_2 these buildings emit stems from their consumption of electricity. Looking at the structure of power generation in Taiwan, we see that nuclear and

hydroelectric plants account for 36.8% of the power generated in this country[1] so Taiwan's CO_2 emissions are slightly lower than the UK's, as Fig. 12-15 shows.

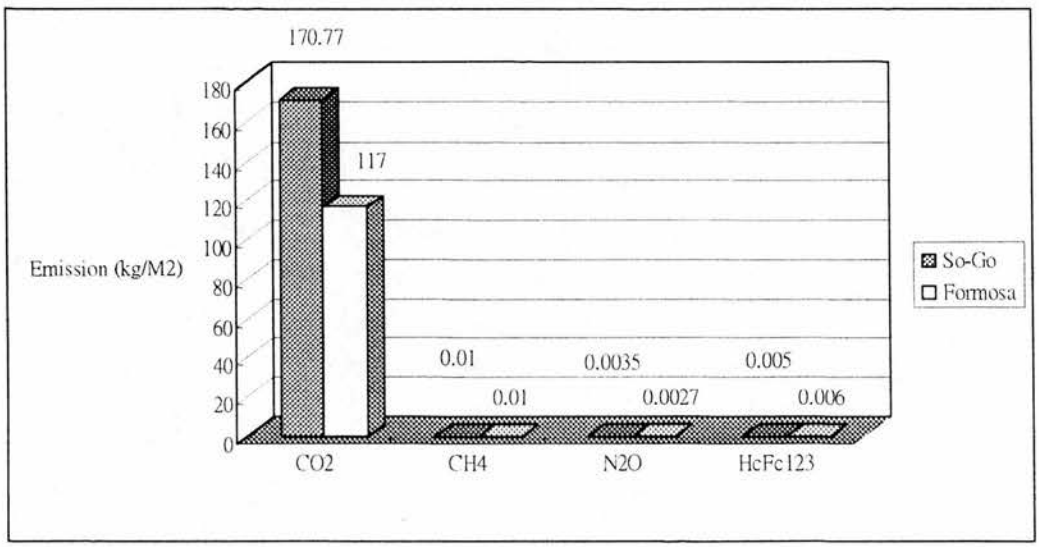


FIG. 12-14: Greenhouse Gas Emissions from So-Go and Formosa per Unit Floor Area at the Occupancy Stage

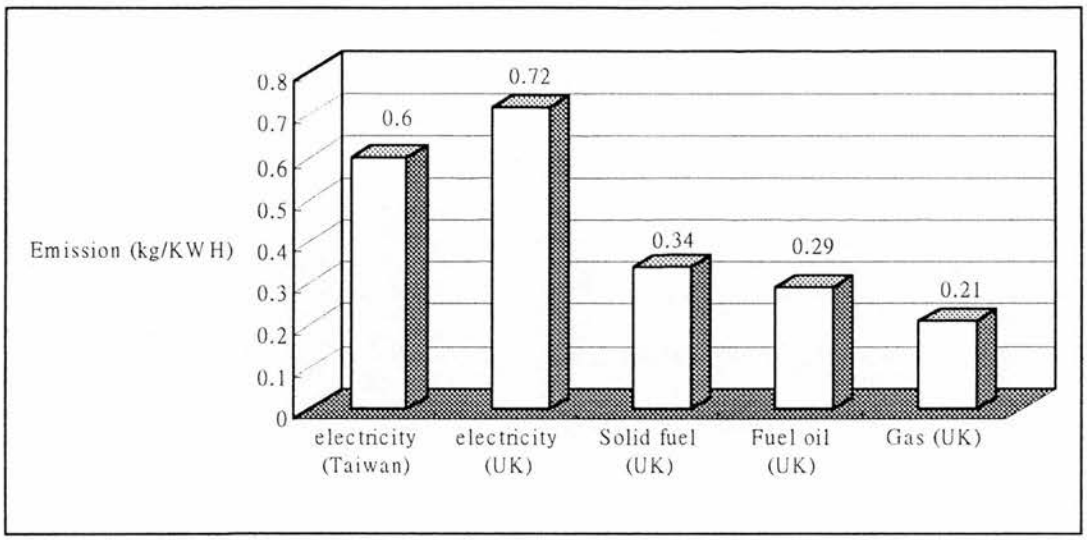
[1] Nuclear-powered stations account for 29.4% of Taiwan's total electricity generation and power generated from renewable resources account for 7.4% (EPA, 1997a, p.580). The equivalent proportions in the UK are 29% and 2% (DOE, 1996, p.44).

Table 12-11 Emission of various pollutants of SO-GO building during occupancy phase

Pollutants Pollution sources	Energy depletion (million kcal)	CO (T)	HC (T)	NO_X (T)	SO_X (T)	TSP (T)	CO_2 (T)	CH_4 (T)	Pb (T)	HCFC 123 (kg)	Waste water (m^3)	COD generated volume (kg)	COD emission volume (kg)	BOD generated volume (kg)	BOD emission volume (kg)	SS generated volume (kg)	SS emission volume (kg)	Grease generated volume (kg)	Grease emission volume (kg)	Total phosphorous generated volume (kg)	Total phosphorous emission volume (kg)	Total N generated volume	Total N emission volume	Solid wastes (T)
Energy depletion—Electric power	46721	2.25	0.33	24.69	40.37	2.06	12788	0.07	0.001															
Energy depletion—Natural gases	478	0.017	0.005	0.085	0.001	0.003		0.002																
Waste water											130670	52268	13067	26134	6534	28747	6534	13067	1307	1045	523	5227	1307	
Air conditioning refrigerants										385														
			14.1			42.2																		
Wastes																								1533
Emission from traffics		91.65	24.3	3.41	0.43	1.53	792	0.85	0.03															
Total	47199	93.91	38.73	28.18	40.80	45.79	13580	0.922	0.031	385	130670	52268	13067	26134	6534	28747	6534	13067	1307	1045	523	5227	1307	1533
The per-floor-area average (kg/m^2)	0.59 (million kcal)	1.18	0.49	0.35	0.51	0.58	170.77	0.01	3.9E-04	0.005	1.64 m^3/m^2	0.66	0.16	0.33	0.08	0.36	0.08	0.16	0.02	0.01	0.007	0.07	0.02	19

Table 12-12: Formosa's Annual Emissions of Major Pollutants at the Occupancy Stage

Pollutants Pollution sources	Energy depletion (million kcal)	CO tonnes	HC tonnes	NO tonnes	SO_X tonnes	TSP tonnes	CO_2 tonnes	CH_4 tonnes	Pb tonnes	$HCFC_{123}$ (kg)	Waste water (m^3)	COD generated volume (kg)	COD emission volume (kg)	BOD generated volume (kg)	BOD emission volume (kg)	SS generated volume (kg)	SS emission volume (kg)	Grease generated volume (kg)	Grease emission volume (kg)	Total phosphorous generated volume (kg)	Total phosphorous emission volume (kg)	Total N_2 generated volume	Total N_2 emission volume	Wastes tonnes
Energy depletion—Electric power	43736	2.11	0.31	23.11	37.79	1.93	11971	0.07	0.001															
Energy depletion—Natural gases	4884	0.17	0.05	0.87	0.005	0.03	312.88	0.02																
Energy depletion—Broiler fuel	2636	0.19	0.01	0.75	0.05	0.07	215.24	0.01																
Energy depletion—Fuel oil	2442	0.16	0.04	0.75	0.05	0.11	215.72	0.02																
Waste water				1.75							307330	122932	30733	61466	15367	67613	15367	30733	3073	2458	1229	12293	3072	
Air conditioning refrigerants										665														
Grease and smoke from the restaurant			99.79			299.37																		
Wastes																								3099
Emission from traffics		117.0	26.00	5.66	0.65	1.67	1074	1.16	0.06															
Total	53698	119.6	126.2	32.14	38.55	303.18	13788	1.28	0.061	665	307330	122932	30733	61466	15367	67613	15367	30733	3073	2458	1229	12293	3073	3099
The per-floor-area average (kg/m^2)	0.46 (million kcal)	1.01	1.07	0.27	0.33	2.56	117	0.01	5.2E-04	0.006	2.60 m^3/m^2	1.04	0.26	0.52	0.13	0.13	0.13	0.26	0.03	0.02	0.01	0.10	0.03	26



Note: Figures for Taiwan's CO_2 emissions from electricity generation come from the Taiwan Power Company. British figures are taken from Prior, 1993, p.7, Table 12-1.

FIG. 12-15: Comparison of the CO_2 Emissions of Taiwan and the UK

When we compare the two high-rise buildings' CO_2 emissions per unit of floor area with the evaluative indicators set for new office buildings in the UK (see Table 12-13), we find that So-Go's emissions exceed those indicators while Formosa's (at 117 kg/ m^2 per year) belong within the range of the "average energy target" (i.e. 120-90 kg/ m^2 per year). However, we must remember that the Formosa Building includes 27,512 m^2 of parking space; were we to deduct that space from the calculation, Formosa's annual CO_2 emissions would come to 152 kg/ m^2 per year and, like So-Go's, would exceed the top-level indicator. That said, it must also be remembered that both So-Go and Formosa are commercial buildings rather than office blocks and so we would expect higher CO_2 emissions from them.

Table 12-13: Evaluative Indicators for New Office Buildings in the UK

Emission of CO_2 (kg/m^2 per year)	comments
120-90	most average energy targets for office building
90-70	meets a good energy target
70-50	very good for a naturally ventilated building
50-40	excellent low-energy design
less than 40	advance on the achievement of the low-energy office designed
170.77	So-Go Building
117.00	Formosa Building

Data Source: evaluative indicators are taken from Prior, 1993, p.6

The other levels of air pollutant are shown in Tables 12-11 and 12-12 above. Of So-Go's annual polluting emissions, CO comes highest at 93.917 tonnes (mostly caused by traffic attracted to the building), followed by TSPs at 45.793 tonnes (mostly caused by the grease and smoke emitted from its restaurants). Of Formosa's annual emissions, TSPs come highest at 303.18 tonnes, followed by CO at 119.67 tonnes. A comparison of their emissions at the occupancy stage is shown in Fig. 12-16. Per unit of floor area, Formosa's exceed So-Go's; Formosa's TSP emissions per year are 2.56 kg/m^2 - 4.4 times those of So-Go. This higher annual TSP figure is accounted for by the fact that six floors of the Formosa Building are given over to restaurants.

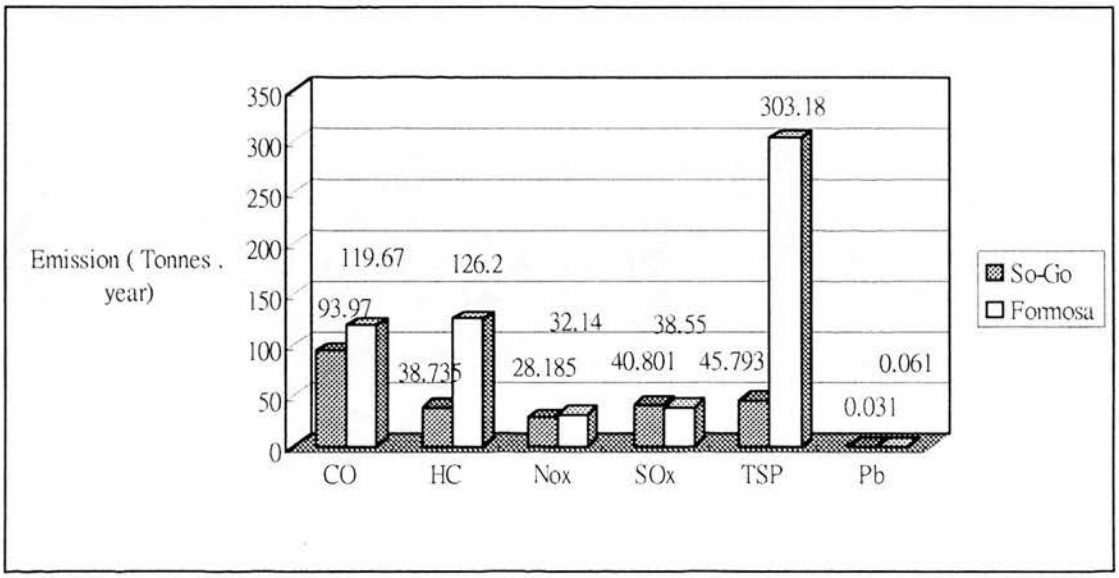


FIG. 12-16: Comparison of Emissions of Various Air Pollutants from So-Go and Formosa at the Occupancy Stage

12.4.3 Emissions of Waterborne Pollutants

At the occupancy phase, So-Go produces 130,670 m^3 of waste water per year (1.64 m^3 per m^2 of floor area). This volume is 63% lower than Formosa's (at 2.60 m^3/ m^2), as Formosa's hotel and restaurants tend to generate quite high volumes of waste water. Fig. 12-17 shows the volume of various waterborne pollutants emitted. Per unit of floor area, So-Go emits 0.16 kg/ m^2 of COD and Formosa 0.26 kg/m^2; So-Go emits 0.08 kg/ m^2 of BOD and Formosa 0.13 kg/m^2. Of all the pollutants, total phosphorous emissions are least: So-Go's level comes to 0.007 kg/m^2 annually and Formosa's only 0.01 kg/m^2. When all of these pollutants are discharged into water, they affect the ecology of the rivers into which they drain.

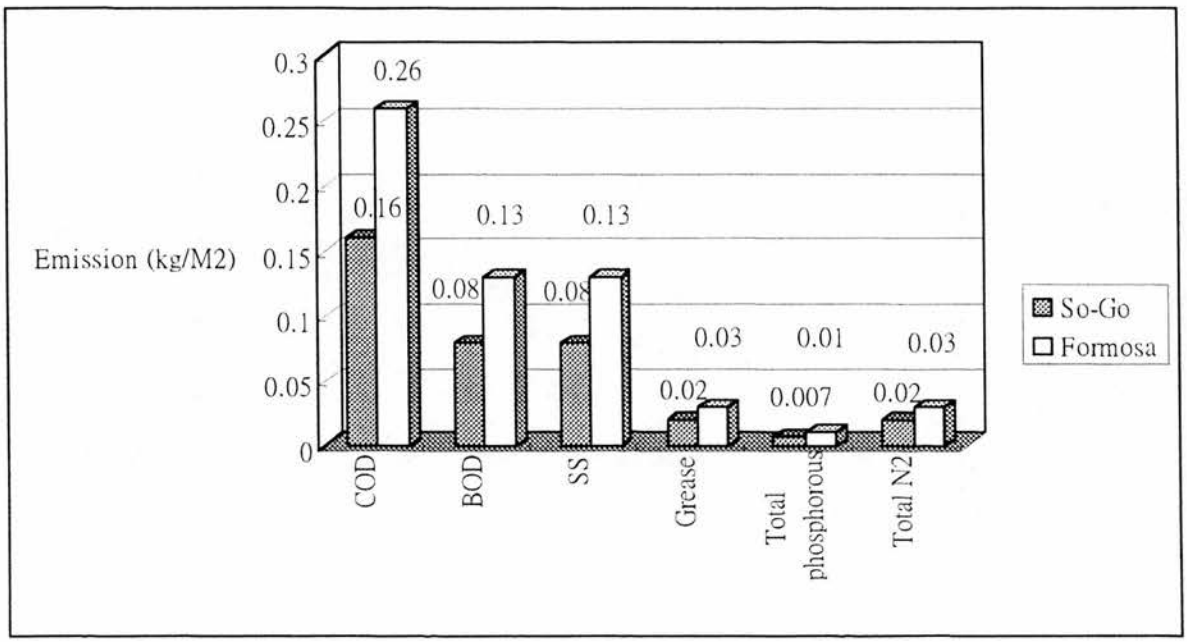


FIG. 12-17: Comparison of Polluting Effluent from So-Go and Formosa at the Occupancy Stage

12.4.4 Impacts on the Socio-Economic Environment

At the occupancy stage, these two buildings have both positive and negative impacts on the social and economic environment, on living standards and public facilities and on the community's ecology and landscape. In terms of the social environment, the most obvious impact is to do with the change in land use. So-Go, which is now a department store, sits on a site that was once farmland and Formosa on a site that was once a fish market. The re-zoning of the area has turned the neighbourhood of the So-Go and Formosa Buildings into a thriving commercial centre which, in turn, is altering the use made of land in the buildings' immediate vicinity.

The buildings' impact on the structure of the local population has been minimal. So-Go generated 434 additional jobs and Formosa 650. Most of these posts were filled locally; only 110 employees (about 0.15% of this neighbourhood's population) actually moved into the area as a result of the high-rises

opening for business. However, even if they have not greatly altered the local population, they have certainly changed the numbers of people who visit the district. On a normal day, So-Go attracts c. 8,930 people and Formosa expects to reach 16,410 people per day[2].

These extra 25,000 shoppers/commuters coming to the region per day significantly affect local parking and traffic conditions. When So-Go opened, the LOS on Mei-Tsun Road was downgraded from î to î and its standard deteriorated even further to Class E once Formosa opened. Parking problems have similarly escalated. Though both So-Go and Formosa possess internal parking bays, these spaces have been found to be insufficient in practice, leading to routine parking violations in the surrounding streets.

The two buildings are also affecting the quality of life in the neighbourhood in terms of their noise and their blocking of sunlight. Though So-Go's noise level does not exceed the noise control standard, it comes very close.[3] Meanwhile, the noise from the Formosa Building has already exceeded the standard, at 67.8 dB(A).[4] In addition, the high-rises are blocking sunlight on land and buildings to their immediate north. Although, the hours of overshadowing they cause on the winter solstice are still within the control regulations, both So-Go and Formosa block effective insolation to their north side for five and seven hours respectively.

The So-Go and Formosa Buildings cause wave interference which affects the signal reception of neighbouring buildings to a distance of two to three hectares. In addition, the local wind effects of the

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[2]Figures for So-Go's daily visitors were measured by the Taiwan Sugar Company on Friday, 8th November, 1996 (see Taiwan Sugar Company, 1997, p.7-12).

[3]On November 11th 1997, the EPB recorded a noise level of 64.8 dB(A) from So-Go which just managed to remain below the control standard of 65 dB(A).

[4]After the EPB monitored Formosa's noise and found it excessive, a civilian file complaint was raised against the developer who proposed a plan to improve the noise level on 19th September 1998. See Formosa Company, 1999, p.5.

high-rises affect the local community. According to a wind velocity test conducted on July 29th and 30th of 1998[5], the highest wind velocity reached 10.9 km/hr. This was lower than the standard of 17 km/hr set for comfort when standing and walking but when the strong winter winds are blowing, it is possible that the buildings' effect on local wind velocity exceeds this comfort standard.

The buildings have had a positive impact on the economic environment. Apart from generating the additional jobs mentioned above[6] and the positive knock-on effects for businesses in the vicinity, it is estimated that Taichung city government will earn an additional £16m in value-added tax revenue from these high-rises which is a great contribution to the region's finances.[7]

The buildings' impact on the local ecology has been minimal because they are sited in an area now zoned as a commercial district. They might have had some adverse effects on the streetscape due to their great height (91m and 117.25m respectively) but this possibility was redressed in their EIAs, when both were required to retract their frontages from the street so as to prevent passers-by from feeling overwhelmed by their size.

In sum, the environmental impacts of So-Go and Formosa at the occupancy stage are extensive, especially in terms of their effect on traffic and atmospheric pollution (the latter largely due to their high energy consumption). Nevertheless, some of the negative effects they might have had on the local environment were addressed and adjusted in their planning and design phases, providing us with evidence that the EIA

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[5]These wind velocity test figures were obtained from a full day of air quality monitoring conducted by Formosa Company on July 29th and 30th, 1998. See Formosa Company, 1999, appendix 4.

[6]According to its EIA report, So-Go was set to provide 434 new posts when operational. However, in the course of my interview with So-Go's Vice President on 6th December 1998, he mentioned that the store now employed 2,200 staff.

[7]This estimate was supplied by So-Go's Vice President (Mr. Tsai) in interview on 6th December 1998. He said that So-Go's turnover in 1997 came to £160m, generating £8m in tax.

process is a necessary step in planning high-rise developments for it really can make a difference to the operations of the buildings once occupied.

12.5 ENVIRONMENTAL IMPACTS AT THE DEMOLITION STAGE

The demolition stage has impacts on the physical environment from the activities of dismantling the building and disposing of its waste. How the demolition stage may affect the socio-economic environment is both less certain and less quantifiable. This section will take a predictive look at the pollution which is likely to be generated at the demolition stage of these two buildings.

Of the greenhouses gases, CO_2 emissions are highest at the demolition stage. At demolition, So-Go's CO_2 emissions are likely to reach 310,140 kg, CH_4 239 kg and N_2O 127 kg. Formosa's CO_2 emissions are likely to come to 461,904 kg, CH_4 355 kg and N_2O 190 kg, as s shown in Fig. 12-18. Formosa's CO_2 emissions are likely to be 1.49 times higher than So-Go's.

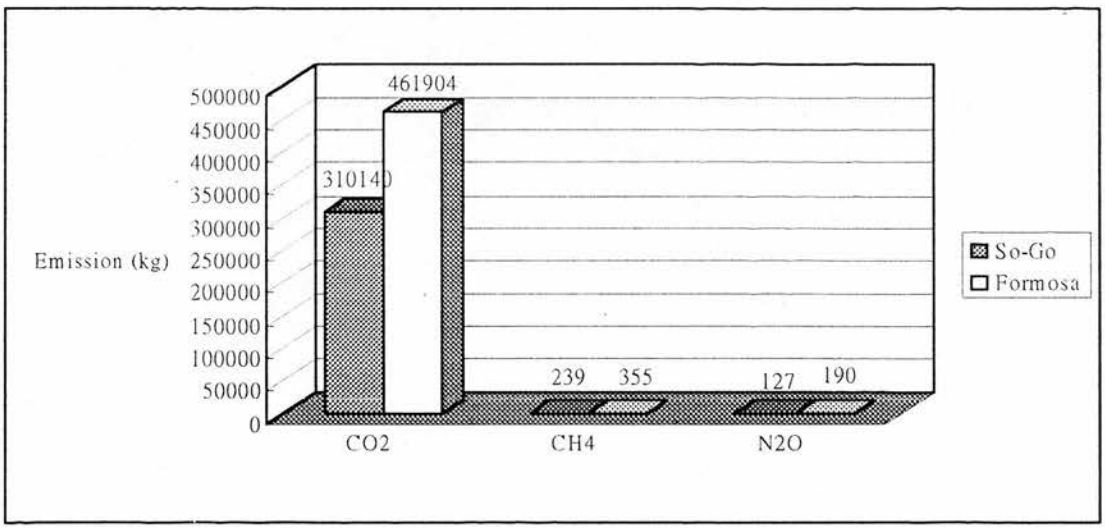


FIG. 21-18: Predictive Comparison of Greenhouse Gas Emissions from So-Go and Formosa at the Demolition Stage

Of the common air pollutants associated with the demolition stage, TSP emissions are highest. So-Go's demolition is likely to generate 22,927 kg of TSP and Formosa's 34,145 kg. NOx emissions are likely to be next highest as demolition machinery and trucks have a high NOx emission factor. So-Go's NOx emissions are likely to reach 12,724 kg and Formosa's 18,950 kg, as shown in Fig. 12-19. As Table 12-14 shows, the levels of the other air pollutants are likely to be low compared to the TSP and NOx figures.

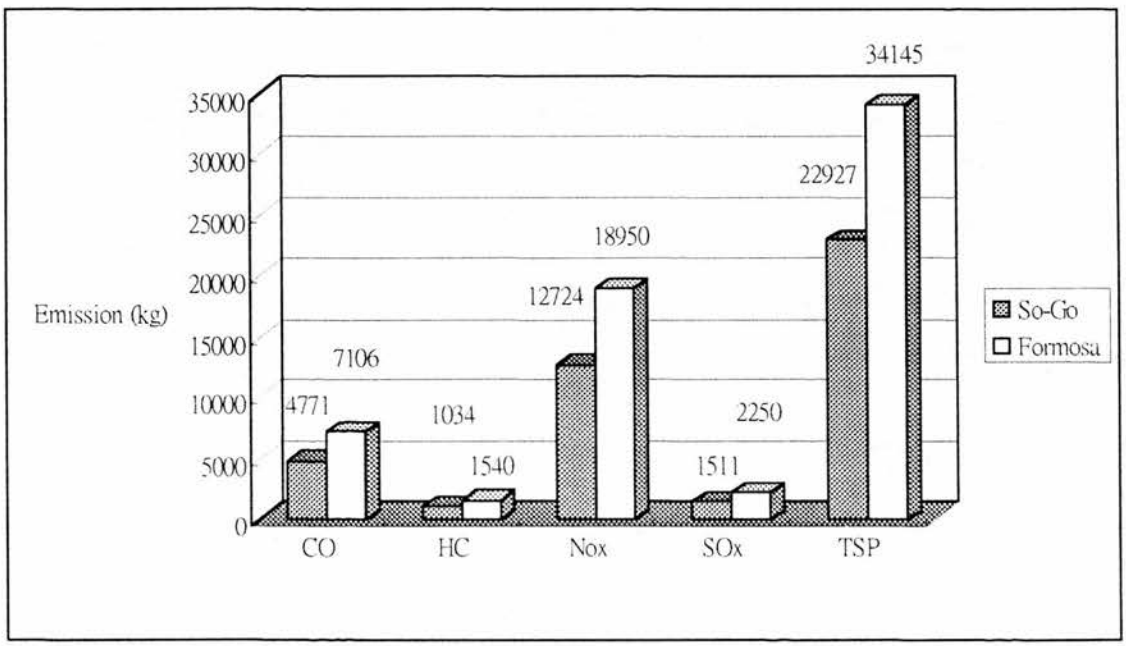


FIG. 12-19: Predictive Comparison of Air Pollutants Emitted by So-Go and Formosa at the Demolition Stage

Table 12-14: Predictive Estimates of Energy Consumed and Main Pollutants Emitted by So-Go and Formosa at the Demolition Stage

Pollutants		Unit floor area emission volume(kg/m^2)	So-Go Building	Formosa Building
Energy depletion(million Kcal)		12,806	1,018	1,517
CO	(kg)	0.0600	4,771	7,106
HC	(kg)	0.0130	1,034	1,540
NO_X	(kg)	0.0160	12,724	18,950
SO_X	(kg)	0.0190	1,511	2,250
TSP	(kg)	0.2883	22,927	34,145
CO_2	(kg)	3.9000	310,140	461,904
CH_4	(kg)	0.0030	239	355
Wastes	(kg)	1.855	$148x10^6$	$220x10^6$

Dismantling buildings produces waste which cannot be incinerated and which must be dumped in landfill sites. This process not only costs money but uses up land. When it reaches its demolition stage, So-Go is likely to generate 0.148 million tonnes of waste (a volume of 95,984 m^3) while Formosa is likely to generate 0.22 million tonnes (142,954 m^3).

Some demolition waste can be recycled, e.g., steel bars or stone. At the moment, steel bars are the most likely candidate for recycling, so we will restrict our predictive estimates to this item alone. Table 12-15 outlines the volume of steel bars which can be recycled from both high-rises and indicates the energy savings expected. Recycling So-Go's steel bars is likely to come to a volume of 13,000 tonnes with energy savings of 19,136 million kcal; Formosa's is likely to reach 15,000 tonnes with energy savings of 22,080 million kcal.

Table 12-15: Predictive Analysis of Waste Recycling and Processing from So-Go and Formosa at the Demolition Stage

Items		So-Go	Formosa
Production	Million tones	0.148	0.220
	M^3	95984	142954
Steel material recycled treatment	Recycled(tones)	13000	15000
	Energy saved(million Kcal)	19136	22080
Final processed volume	Million tones	0.135	0.205
	M^3	87834	133376
Final treatment cost (million pound)		1.05	1.60
Landfill needed for demolition wastes(m^2)		5270	8003
The average of every m^2 floor area	Recycled energy saved(kcal/m^2)	240634	186428
	Final treatment volume(tones/m^2)	1.70	1.73
	Final treatment cost(pound/m^2)	13.2	13.5
	Land area needed for burial recycled energy saved(m^2/m^3)	0.066	0.068

Note: a recycled steel bar volume is calculated with 75% of the total steel material used

Demolition waste needs to be processed prior to being placed in a landfill site. It is likely that So-Go's processing expenses will come to £1.05m and that it will use up 5,270 m^2 of landfill space; Formosa's will cost £1.6m and use 8,003 m^2 of space. Though landfill sites can be closed once full and re-designed as parks or playgrounds, the dumping of demolition waste within them has a significant on-going effect on the their sub-surface soil and hydrology.

Looking at the average value of each square metre of floor area, So-Go's recycled 240,634 kcal/m^2 is likely to be 129% more than Formosa 186,428 kcal/m^2. So-Go's volume of final waste which needs disposal is likely to come to 1.7 tonnes/m^2 - slightly lower than the 1.73 tonnes/m^2 which Formosa is likely to need. On this basis, So-Go's final disposal costs are likely to be £13.2/m^2, a sum lower than the £13.5/m^2 we may expect for the Formosa Building. So-Go's landfill requirement per square metre of floor area is likely to be 0.066 m^2/m^2 which is also lower than the likely 0.068 m^2/m^2 that Formosa will need, as Table 12-15 above shows.

The demolition stage is also associated with noise - which can often reach up to 80 dB (A) - and disruption to normal traffic. So-Go is likely to need 14,800 truck journeys to transport its demolition waste and Formosa 22,000.

12.6 THE ENVIRONMENTAL IMPACTS OF THE SO-GO AND FORMOSA BUILDINGS OVER THEIR LIFE-CYCLE

In general, the environmental impacts of buildings can be subdivided into areas like effects on the physical or socio-economic environment, ecology, landscape, culture and so on. As both So-Go and Formosa are city-centre high-rises, some of the environmental questions they evoke differ from those of buildings in general. Therefore, this section looks at these two buildings only in terms of their depletion of natural resources, emission of pollutants, their impact on the carrying capacity of the local environment and their impact on the socio-economic environment. We will adopt a cradle-to-grave assessment of these environmental themes.

12.6.1 Resources Depletion

The scope of EIA studies on high-rises often downplay, or even exclude, an assessment of the energy use of those buildings. But energy consumption depletes natural resources, whether from fossil fuel or abiotic origins, and these resources are typically non-renewable and of limited supply. Therefore, in building high-rise structures, we should maximise the utility of renewable resources and minimise the use made of non-renewable resources.

The main issue here is buildings' consumption of fossil fuels such as oil and natural gas. Over So-Go's life-cycle, it will consume 117,417 million kcal, which is equal to 14 million litres of oil equivalent[8], as shown in Table 12-16. The first stage of materials manufacture accounts for 56% of its total energy use, followed by its occupancy stage at 41%. The other three stages of transportation, construction and demolition together account for the remaining 3%. If we multiply the expected life span of the building (50 years) with the energy it consumed when occupied, we find that the energy consumed in this period will account for 97% of the total it needed over its whole life-cycle. If its steel bars are recycled at the demolition stage, there can be an additional energy saving of 16%, demonstrating that recycling construction materials can make an important contribution to energy savings.

[8]This estimate is based on the energy consumed annually. We can obtain the total energy consumption by multiplying the energy consumed annually by the building at the occupancy stage with the length of its expected total life span.

Table 12-16: So-Go's Depletion of Resources over the Different Stages of its Life-Cycle

Items	Unit	Life cycle										Total		Recycle	
		material production		material transportation		Construction stage		Occupancy stage		Demolition stage					
		Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio
Energy depletion	Million Kcal	66672	56	1320	1	1208	1	47199	41	1018	1	117417	100	-19136	-16
Water resources consumption	M^3	267937	60	*		21064	5	160000	35	*		449001 -	100	24739	6
Abiotic resource depletion potential	Kg	1.2E-07	100	*		*		*		*		1.2E-0.7	100	1.2E-0.7	
Use of recycled materials	tonne	1482	100	*		*		*		*		1482	100		
Land use	M^2							4694	100			4694	100		

Note:

a. * means minimal consumption or not calculated due to no consumption.

b. The operation stage is the average annual depletion

c. The evaluation of abiotic depletion potential (ADP) was relative to the worldwide stores, please refer to factors of table 4-3

d. The water resources consumption during production phase was calculated by wastewater produced plus 10% of vaporized or other depletion

Table 12-17: Formosa's Depletion of Resources over the Different Stages of its Life-Cycle

Items	Unit	Life cycle										Total		Recycle	
		material production		material transportation		Construction stage		Occupancy stage		Demolition stage					
		Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio	Quantity	Ratio
Energy depletion	Kcal	67385	54	977	1	1799	2	53698	42	1517	1	125376	100	22080	-18
Water resources consumption	M^3	373382	53	*		24776	4	296015	43	*		694173	100	28545	4
Abiotic resource depletion potential	Kg	2.2E-07	100	*				*		*		2.2E-07	100		
Use of recycled	Tonne	1153										1153	100		
Land use	M^2							6891	100			6891	100		

Note:

a. Same as table 12-16

b The energy depletion and water usage was according to what actually used (Floor area is 74391.59 m^2), the depletion of unused B1, B2, and 1~10th floor was estimated with SO-GO's average figures.

Formosa's pattern of energy use is similar to So-Go's, as Table 12-17 shows. Formosa's first stage of materials manufacture accounted for 54% of the total energy consumed, followed by the occupancy stage at 42%. The remaining three stages between them account for only 4%. If Formosa's steel bars are recycled at its demolition stage, an additional 22,080 million kcal can be saved which is equal to 2.5 million litres of oil equivalent or about 18% of its total energy consumption.

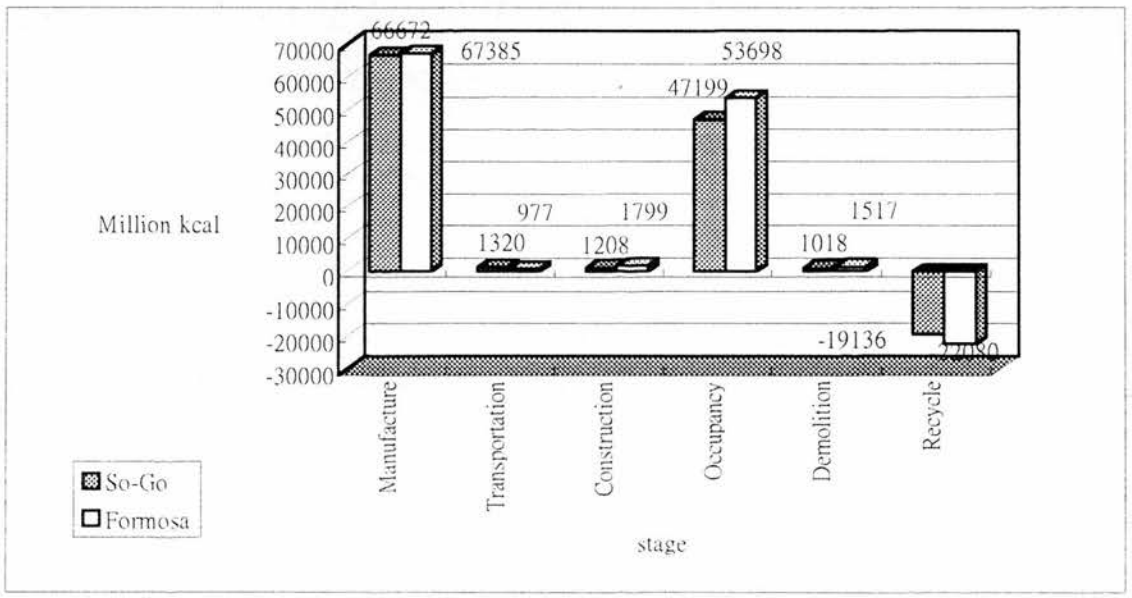
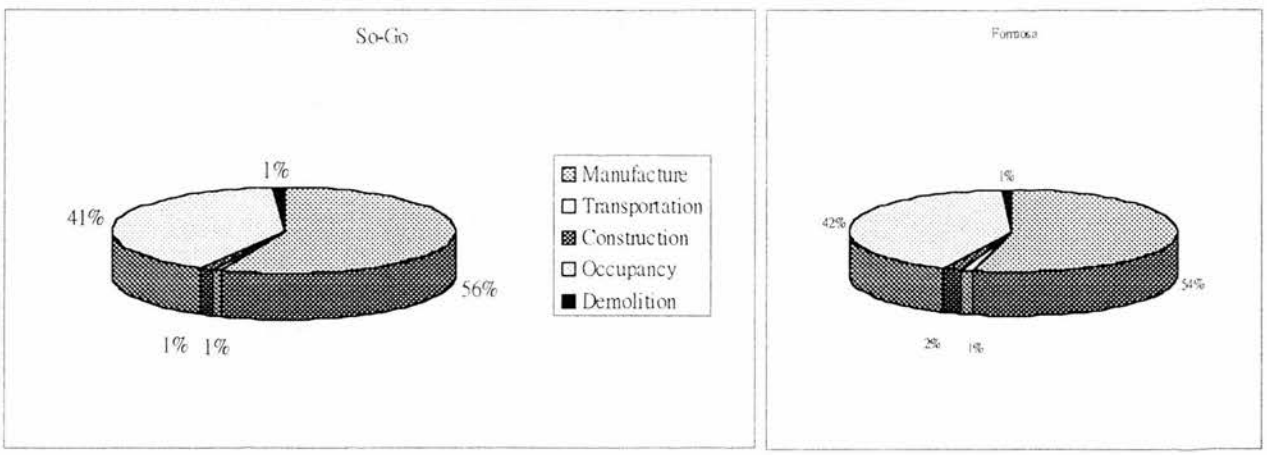


FIG. 12-20: So-Go's and Formosa's Use of Energy at Each Stage of the Life-Cycle



Note: The depletion volume at the occupancy stage stands for the annual depletion volume

FIG. 12-21: Comparison of So-Go's and Formosa's Ratio of Energy Use at Each Stage of the Life-Cycle

Despite Taiwan's abundant rainfall throughout the year, only 21% of it is usable as a resource because two-thirds of the country is precipitously mountainous and its rivers characteristically flow extremely fast (EPA 1997a, p.100). As water is thus a scarce resource for the island, it is always counted as an assessment item in the EIA of high-rise building projects. Over its life-cycle, So-Go will use 449,001 m^3 of water. The first stage uses most, accounting for 60% of its total water consumption, followed by the occupancy stage at 35%. As Figs. 12-22 and 12-23 show, the construction stage accounted for 5% of its use of water. If we assume So-Go has a 50-year life span and we base our estimate of total water consumed on that assumption, then its occupancy stage will account for 96% of the total the building uses.

Formosa's pattern of water usage is similar to So-Go's. Its total will come to 694,173 m^3. As Fig. 12-22 shows, its first stage accounts for 53% of that, at 373,382 m^3, followed by the occupancy stage at 43%. If Formosa is also assumed to have a 50-year life span and we base our estimate of water use on that, the water it consumes in the occupancy stage will also account for 97% of its total.

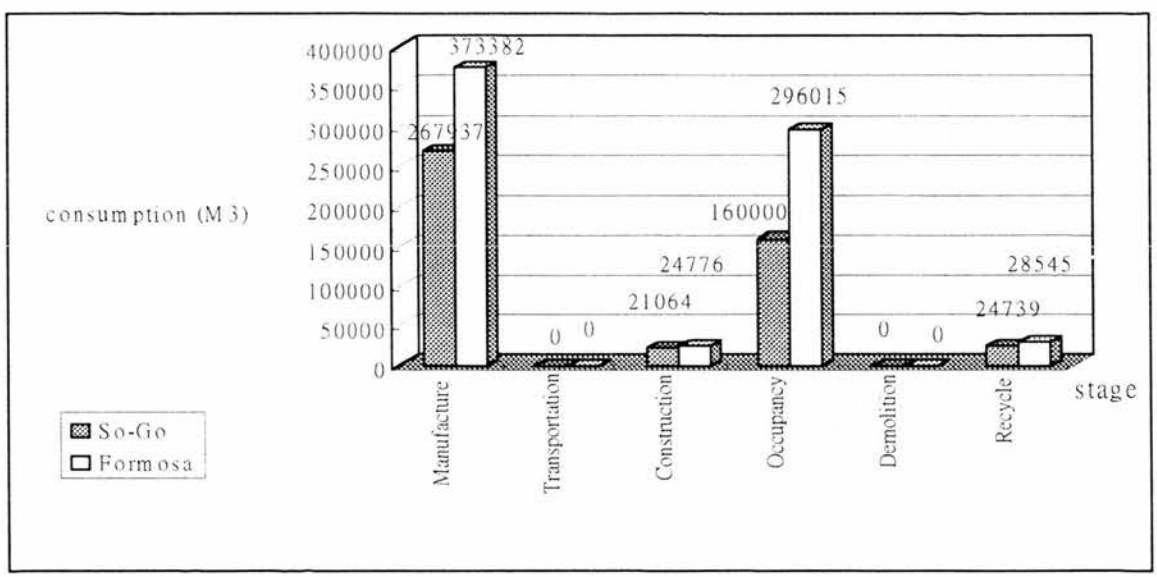
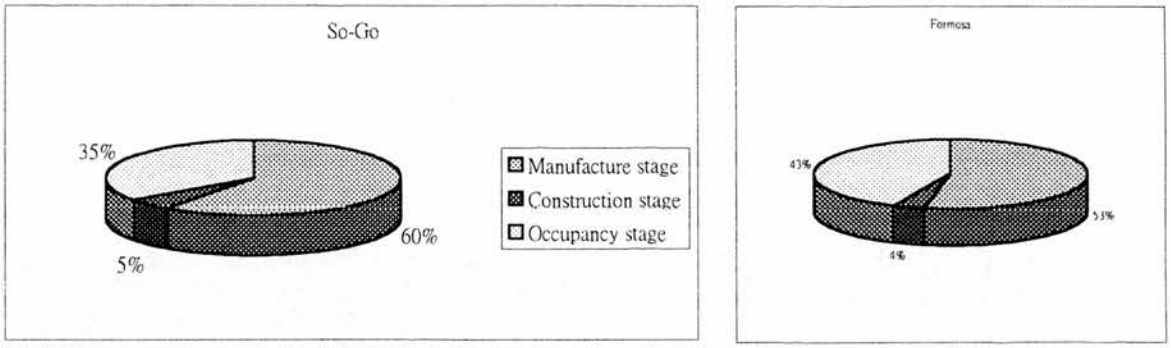


FIG. 12-22: So-Go's and Formosa's Depletion of Water Resources over the Different Stages of the Life-Cycle



Note: The depletion volume of the occupancy stage stands for annual depletion volumes.

FIG. 12-23: Comparison of So-Go's and Formosa's Water Depletion Ratio over the Different Life-Cycle Stages

Abiotic resources include Cadmium (Cd), Lead (Pb), Mercury (Hg), Copper (Cu), Tin (Sn) and Zinc (Zn) as shown in Table 4-3 of Chapter Four. Of these, the most frequently used for building work are lead and copper. Lead is often used for water pipes and copper for hot water pipes and for parts of doors and windows. During its first stage of materials manufacture, So-Go required 1.2E-0.7 kg of Abiotic Depletion Potential (ADP) materials, and Formosa 2.2E-0.7 kg. Aside from those, So-Go also needed 17,607 tonnes of steel materials and 501 tonnes of metal (aluminium) curtain wall; Formosa needed 20,485 tonnes of steel materials and 781 tonnes of metal (aluminium) curtain wall.

12.6.2 Emission of Pollutants

Over the building life-cycle, both atmospheric and waterborne pollutants are emitted. The former category includes CO, HC, NOx, SOx, TSP, CO_2, CH_4, Pb, and HcFc $_{123}$, and the latter COD, BOD, SS, grease, total phosphorous, and total N_2.

Per unit of floor area, So-Go's CO emissions are higher than Formosa's at 1.421 kg/ m^2 and 1.186 kg/ m^2 respectively. Comparing the different stages of their life-cycle, the occupancy stage for both buildings is the phase with the largest CO emission ratio, at over 80% as Fig. 12-24 shows. The reason for this is that

occupied high-rises attract high volumes of traffic. If we multiply the volume emitted at the occupancy stage with the buildings' expected life span, then this stage accounts for 99% of the total CO emitted.

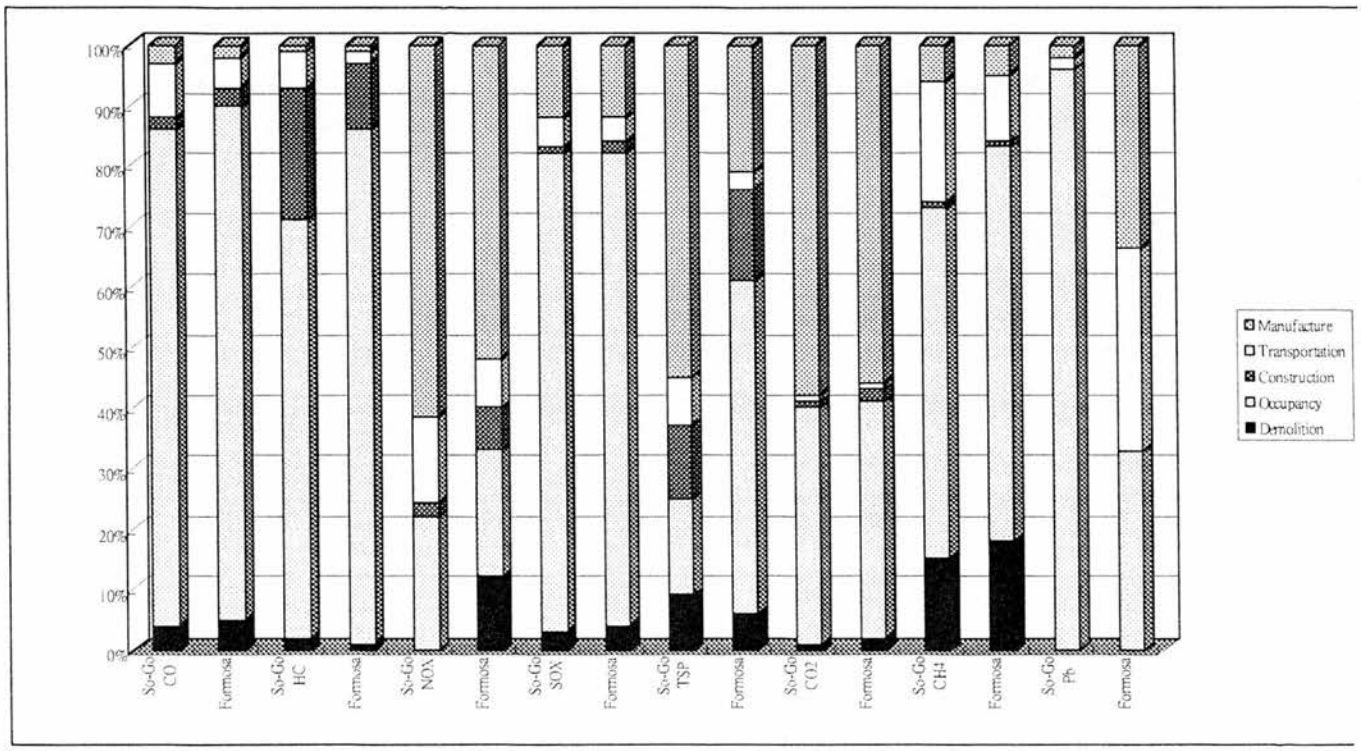


FIG. 12-24: The Emission Ratio of Air Pollutants over the Life-Cycle of the So-Go and Formosa Buildings (%)

The pattern of HC emissions from both buildings over their life-cycle is quite similar to CO emissions except that painting the buildings in their construction stage released large amounts of volatile organic contaminants. Thus So-Go's construction stage accounted for 22% of its total HC emissions and Formosa's 11%, as shown in Table 12-18.

Table 12-18 Emission of various air pollutants of life cycle stages of SO-GO and Formosa building

Pollutants / Life cycle		CO			HO			NO_X			SO_X		
		Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)
So-Go building	Construction material production	2.59	0.033	3	0.19	0.003	1	81.25	1.02	56	5.89	0.074	12
	Construction material transportation	10.36	0.13	9	3.23	0.041	6	18.99	0.239	13	2.49	0.031	5
	Construction stage	1.4	0.018	2	12.68	0.16	22	3.35	0.042	2	0.37	0.005	1
	Occupancy stage(per year)	93.92	1.18	82	38.74	0.49	69	28.19	0.35	20	40.80	0.51	79
	Demolition stage	4.77	0.06	4	1.03	0.013	2	12.73	0.16	9	1.51	0.019	3
	Total	113.04	1.421	100	55.87	0.704	100	144.51	1.811	100	51.06	0.639	100
Formosa building	Construction material production	2.57	0.022	2	0.20	0.002	1	79.03	0.667	52	5.70	0.048	12
	Construction material transportation	6.93	0.059	5	2.14	0.018	2	12.71	0.107	8	1.70	0.014	4
	Occupancy Stage	4.18	0.035	3	17.55	0.148	11	10.07	0.085	7	1.03	0.009	2
	Application stage(per year)	119.67	1.01	85	126.2	1.07	85	32.14	0.27	21	38.55	0.33	78
	Demolition stage	7.11	0.06	5	1.54	0.013	1	18.95	0.16	12	2.25	0.019	4
	Total	140.46	1.186	100	147.63	1.249	100	152.9	1.289	100	49.23	0.42	100

Table 12-18 Emission of various air pollutants of life cycle stages of SO-GO and Formosa building (Continued)

Pollutants / Life cycle		TSP			CO_2			CH_4			P_b		
		Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)
So-Go building	Construction material production	147.83	1.86	55	19834.8	249	58	0.09	0.001	6	0.0007	8.2E-06	2
	Construction material transportation	21.34	0.268	8	360.31	4.53	1	0.323	0.004	20	0.0005	5.8E-06	2
	Construction stage	30.66	0.4	12	356.26	4.48	1	0.01	0.001	1			
	Occupancy stage(per year)	45.79	0.58	16	13580	170.77	39	0.922	0.01	58	0.031	3.9E-04	96
	Demolition stage	22.93	0.29	9	310.14	3.9	1	0.24	0.003	15			
	Total	268.55	3.398	100	34441.51	432.68	100	1.585	0.019	100	0.0322	3.9E-04	100
Formosa building	Construction material production	112.66	0.951	21	19672.99	166	56	0.09	0.001	5	0.0007	5.6E-06	1
	Construction material transportation	15.02	0.127	3	238.59	2	1	0.22	0.002	11	0.0003	2.6E-06	1
	Construction stage	84.12	0.710	15	530.6	4.48	2	0.02	0.001	1			
	Occupancy stage(per year)	303.18	2.56	55	13788.89	117	39	1.28	0.01	65	0.061	5.2E-04	98
	Demolition stage	34.15	0.29	6	461.91	3.9	2	0.36	0.003	18			
	Total	549.13	4.638	100	34692.98	293.38	100	1.98	0.017	100	0.062	5.2E-04	100

The ratio of NOx emissions are higher at the materials manufacture stage than at other phases of the life-cycle. So-Go's first stage NOx emissions account for 56% of the volume it emits over the whole life-cycle and Formosa's 52%. The reason for this is that the manufacture of concrete and steel bars consumes a great deal of electricity and fuel which, in turn, generates high volumes of NOx. CO_2 emissions are like NOx in that they result from the consumption of large amounts of electricity and fuel at the materials manufacture stage. So-Go's first stage CO_2 emission ratio is 58% and Formosa's 56%. If we multiply the volume emitted at the occupancy stage with the buildings' expected life span, the occupancy stage accounts for 97% of CO_2 emitted over the whole life-cycle.

So-Go's materials manufacture stage accounts for the highest proportion of the building's TSP emissions - about 55% of its total. The reason is that crushing gravel in the process of manufacturing concrete aggregate throws up lots of particulate pollutants. Formosa's requirement for concrete was less than So-Go's as it has a steel structure. However, its six floors of restaurant space generate high levels of particulate pollutants, making its TSP emissions at the occupancy stage higher than those at the materials manufacture stage - 55% and 21% of the total respectively. If we multiply the volume emitted at the occupancy stage with the building's expected life span, then the occupancy stage accounts for 98% of TSP emissions over the whole life-cycle.

The emission ratios of air pollutants differ from those of waterborne pollutants over the different stages of the life-cycle. As Table 12-19 shows, So-Go will generate 383,049 m^3 of waste water over the course of its life; its first stage alone generated 243,579 m^3 or 64% of the total. The main reason for this is the amount of water needed to process gravel and to manufacture steel bars and marble. As Fig. 12-25 shows, the waste water So-Go produces at the occupancy stage accounts for 34% of its total. However if So-Go's expected life span of 50 years is taken into account, then its occupancy stage can be expected to account for 96% of the waste water it produces over its life-cycle.

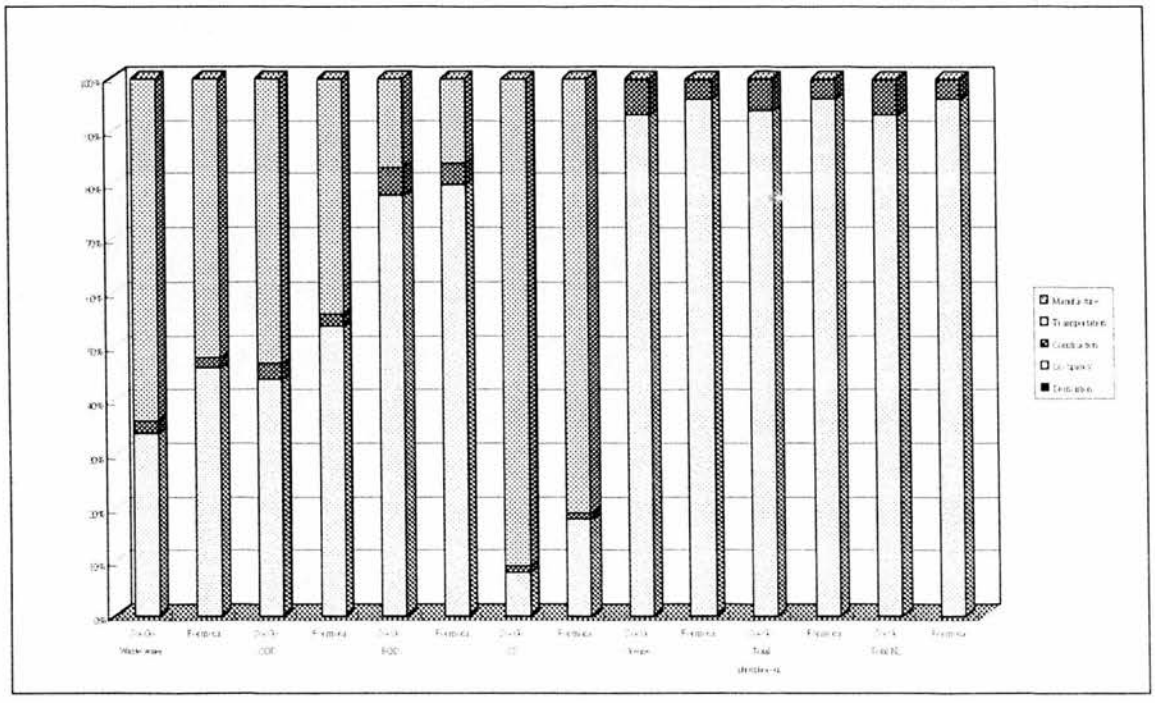


FIG. 12-25: The Ratio of Effluent Produced by the So-Go and Formosa Buildings at Different Stages of the Life-Cycle

The pattern of COD emissions at each stage follows that of waste water produced. So-Go's first stage accounts for 53% of its total COD emissions, largely as a consequence of the processing of gravel and the manufacture of marble. Formosa's COD emissions are similar to So-Go's with the exception that the Formosa Building required less gravel for its construction so its proportion of waste water and COD emitted at the first stage is less than So-Go's, at 52% and 44% respectively, as we saw in Fig. 12-25.

Compared to other stages, the occupancy stage is associated with the highest levels of BOD emissions because the effluent from this stage contains large amounts of BOD. In So-Go's case, this stage accounts for 78% of its total and Formosa's proportions are similar. So-Go's materials manufacture stage only

Table 12-19: Volume of Waterborne Pollutants Emitted by the So-Go and Formosa Buildings at Different Stages of the Life-Cycle

Pollutants / Life cycle		$HcFc_{123}$			Waste water			COD			BOD		
		Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)
So-Go building	Construction material production				243579	3.06	64	15931	0.20	53	1382	0.02	17
	Construction material transportation												
	Construction stage				8800	0.11	2	880	0.011	3	440	0.006	5
	Occupancy stage(per year)	0.39	0.005	100	130670	1.64	34	13067	0.16	44	6534	0.08	78
	Demolition stage												
	Total	0.39	0.005	100	383049	4.81	100	29878	0.371	100	8356	0.106	100
Formosa building	Construction material production				339438	2.87	52	25110	0.21	44	3117	0.03	16
	Construction material transportation												
	Construction stage				12285	0.104	2	1229	0.01	2	614	0.005	4
	Occupancy stage(per year)	0.67	0.006	100	307330	2.6	46	30733	0.26	54	15367	0.13	80
	Demolition stage												
	Total	0.67	0.006	100	659053	5.574	100	57072	0.48	100	19098	0.165	100

Table 12-19: Volume of Waterborne Pollutants Emitted by the So-Go and Formosa Buildings at Different Stages of the Life-Cycle

(continued)

Pollutants / Life cycle		SS			Grease			Total P			Total N_2		
		Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)	Emission volume (T)	Emission volume per m^2floor area (kg/m^2)	Ratio (%)
So-Go building	Construction material production	70828	0.89	91									
	Construction material transportation												
	Construction stage	440	0.006	1	88	0.001	7	35	4.4E-04	6	88	0.001	7
	Occupancy stage(per year)	6534	0.08	8	1307	0.02	93	523	0.007	94	1307	0.02	93
	Demolition stage												
	Total	77802	0.976		1395	0.021	100	558	0.007	100	1395	0.021	100
Formosa building	Construction material production	68872	0.58	81									
	Construction material transportation												
	Construction stage	614	0.005	1	123	0.001	4	49	4.1E-04	4	123	0.001	4
	Occupancy stage(per year)	15367	0.13	18	3073	0.03	96	1229	0.01	96	3073	0.03	96
	Demolition stage												
	Total	84853	0.715	100	3196	0.031	100	1278	0.01	100	3196	0.031	100

accounts for 17% of the total because the BOD emission factors for materials like steel bars, marble and gravel are quite low; Formosa's first stage comes to 16% of its total. If we take the buildings' expected life span into account, their occupancy stages will account for 99% of the BOD emitted over the life-cycle.

SS emissions are highest at the first stage, due mainly to the processing of gravel and marble, and account for c. 80% of the total emitted over the whole life-cycle. SS emissions from So-Go's first stage account for 91% of its total, and Formosa's 81%. If we take the expected 50-year life span of the buildings into account then SS emissions from So-Go's materials manufacture stage will only account for 18% of So-Go's total and 9% of Formosa's total.

Waste water is the main source of other waterborne pollutants like grease, total phosphorous and total N_2. Therefore, the occupancy stage has the highest emission ratio for the above pollutants, accounting for over 90% of the total volume emitted over the life-cycle, as Fig. 12-25 above shows.

12.6.3 Effects on the Local Environment and the Environmental Carrying Capacity

The damage high-rises may cause to their local environment and to environmental carrying capacity are divided into 17 different evaluation items. Using the estimates of pollutants emitted discussed in the previous section, we can summarise the effect of the So-Go and Formosa Buildings on different environmental themes across the different stages of their life cycle. (See Tables 12-20 and 12-21).

Table 12-20: Evaluation Table of So-Go's Impacts on the Physical Environment across the Different Stages of its Life-Cycle

Environment themes	Unit	Life cycle				
		Construction material production	Construction material transportation	Construction stage	Operation stage	Demolition stage
Global warming	Tonnes	19990	396	363	13641	336
Acid rain	Tonnes	63	16	3	61	11
Ozone depletion	Tonnes	*	*	*	0.01	*
Photochemical oxidant formation	Tonnes	0.072	1.218	5	15	0.4
Nitrification	Tonnes	11	3	1	5	2
Human toxicity	Tonnes	71	18	3	77	12
Atmospheric pollution	billion m^3	978	1156	264	9757	590
Waterborne pollution	Million tonnes	12	*	4	66	*
Solid waste disposal	m^2	**	*	5967	424	5270
Noise	dB(A)	**	**	73.4	64.8	79.8
Vibration	dB	**	**	60	34.2	61
Geology and soil(sink)	cm	*	*	2.9	*	*
Overshadowing	Hr	*	*	*	5	*
Local wind effects	Level	*	*	*	Comfortable	*
Interfere wave	ha	*	*	*	2	*
Ecotoxicity, aquatic	m^3	1400,,000	928000	*	62000.000	*
Ecotoxicity, terrestrial	m^3	30100 *	199520	*	13330.000	*

Note: * means not calculated due to minimal degree of impact, ** included in the other sectors (such as industry)

Table 12-21: Evaluation Table of Formosa's Impacts on the Physical Environment across the Different Stages of its Life-Cycle

Environment themes	Unit	Life cycle				
		Construction material production	Construction material transportation	Construction stage	Operation stage	Demolition stage
Global warming	Tonnes	19823	262	550	13881	501
Acid rain potential	Tonnes	61	11	8	61	16
Ozone depletion	Tonnes	*	*	*	0.01	*
Photochemical oxidant formation	Tonnes	0.076	0.81	7	48	0.6
Nitrification	Tonnes	11	2	2	7	3
Human toxicity	Tonnes	69	12	9	83	18
Atmospheric pollution	10 billion m^3	837	777	760	13350	879
Waterborne pollution	Million tonnes	19	*	6	154	*
Solid waste disposal	m^2	*	*	10881	857	8003
Noise	dB(A)	**	**	76.2	67.8	80
Vibration	dB	**	**	74	34.9	63
Geology and soil(sink)	Cm	*	*	7	*	*
Overshadowing	Hr	*	*	*	7	*
Local wind effects	Level	**	*	*	Comfortable	*
Interfere wave	ha	*	*	*	3	*
Ecotoxicity, aquatic	m^3	1400,000	614000	*	122000,000	*
Ecotoxicity, terrestrial	m^3	301000	132010	*	26230,000	*

Note: * means not calculated due to minimal degree of impact, ** included in the other sectors (such as industry)

Global warming is a global environmental issue. Over high-rises' life-cycle, the major source contributing to this problem is the emission of greenhouse gases like CO_2, CH_4, and N_2O - CO_2 alone accounting for over 90% of all greenhouse gas emissions. Over the entire life-cycle, So-Go's GWP comes to 34,726 tonnes and Formosa's 35,017 tonnes. Per unit of floor area, So-Go generates 0.43 tonnes/ m^2 GWP and Formosa 0.29 tonnes/ m^2, showing that So-Go's GWP is about 1.48 times that of Formosa. There are two reasons to explain So-Go's higher GWP. First, it required more material for its construction than did Formosa. Second, its use as a department store implies a higher requirement for energy than Formosa's mixed use does. Hence, So-Go's greenhouse gas emissions can be expected to be greater than Formosa's over the life-cycle.

Comparing the effect of the different stages on global warming (see Fig. 12-26), So-Go's first stage accounts for 58% of its total effect, followed by its occupancy stage at 39%, with the remaining three stages together accounting for 3%. Formosa's first stage accounts for 57% of its total effect, followed by its occupancy stage at 39%, with the remaining three stages together accounting for 4%. If the expected 50-year life span of the buildings is also taken into consideration, then the GWP at the occupancy stage will account for 96% of the buildings' total effect over their whole life-cycle.

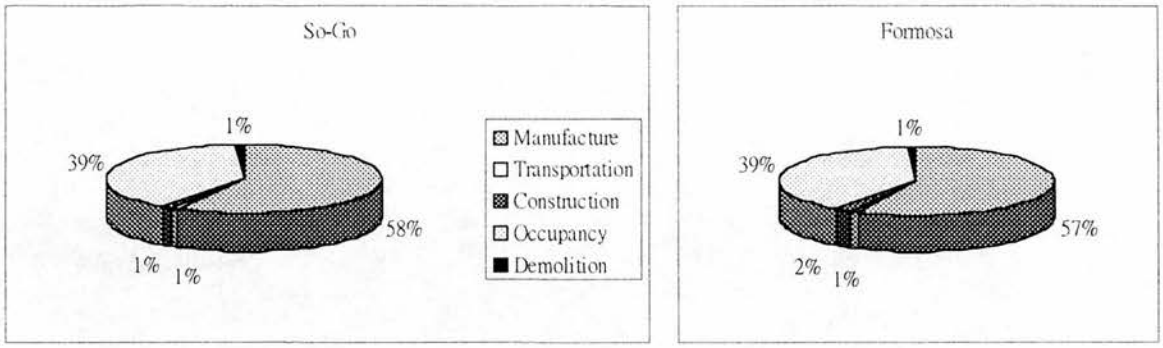


FIG. 12-26: So-Go's and Formosa's Effect on GWP at Different Stages of their Life-Cycle

The precursor substances of acid rain are SOx and NOx. As SOx is generated as a consequence of energy consumed and NOx of vehicle exhausts, the buildings' contribution to the formation of acid rain appears most marked at the materials manufacture stage and at the occupancy stage. As we saw in Table 12-20 above, So-Go's acid rain potential (AP) over its life-cycle is 154 tonnes or 0.0019 tonnes/m^2. Table 12-21 shows that Formosa's AP over the life-cycle is 157 tonnes or 0.0014 tonnes/m^2, suggesting that Formosa's ARP is about 74% of So-Go's. Comparing the AP of So-Go's different life-cycle stages, we see that the first stage accounts for 41% of So-Go's total, the occupancy stage 40% and the transportation stage 3%, as Fig. 12-27 shows. The same Figure also shows that Formosa's materials manufacture stage and occupancy stage account for 39% each, and its demolition stage 10%. If the buildings' expected 50-year life span is taken into consideration, then the AP of the occupancy stage will account for about 96% of the buildings' total AP over the whole life-cycle.

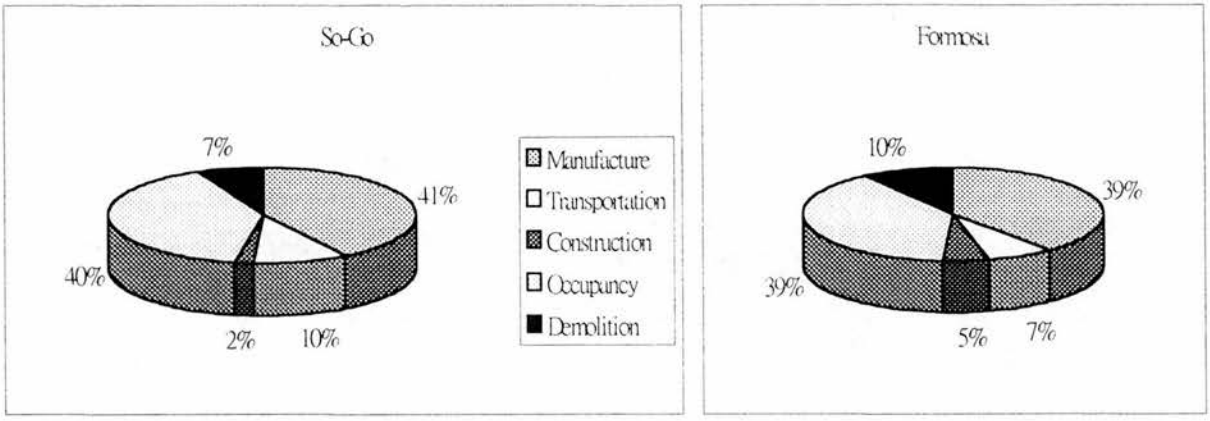


FIG. 12-27: So-Go's and Formosa's Effect on AP at Different Stages of the Life-Cycle

Buildings' contribution to depleting the ozone layer mainly stems from the emissions of CFCs and HCFCs from their air-conditioning refrigerants. The So-Go and Formosa Buildings both selected HcFc123 as their air-conditioning refrigerant so this will be the substance we assess when evaluating the buildings' contribution to ozone layer depletion. The ozone depletion potential (ODP) is 0.014 (CFC11 = 1). As Tables 12-20 and 12-21 show, So-Go's and Formosa's ODP comes to 0.01 tonnes so their impact on this environmental problem is not significant.

The main chemicals which contribute to photochemical oxidant formation are HC and CH_4. To assess the buildings' contribution to this problem we translate their emissions of HC and CH_4 into the photochemical oxidant creation potential (POCP). Results are shown in Tables 12-20 and 12-21. So-Go's volume of POCP is 21.69 tonnes or 0.0003 tonnes/ m^2. Formosa's volume of POCP is 1.7 times more than So-Go's at 56.486 tonnes or 0.0005 tonnes/m^2. The reason for Formosa's higher volume is that six floors of the high-rise are given over to restaurants which produce lots of HC. This also accounts for why Formosa's occupancy stage generates 85% of its total POCP, followed by its construction stage at 12%, with the remaining three stages account for 3% between them (see Fig. 12-28). Fig. 12-28 also shows that So-Go's occupancy stage accounts for 69% of its total POCP, followed by its construction stage at 23%. If the

buildings' expected 50-year life span is taken into consideration, then the POCP emitted at the occupancy stage will account for over 98% of the total POCP generated.

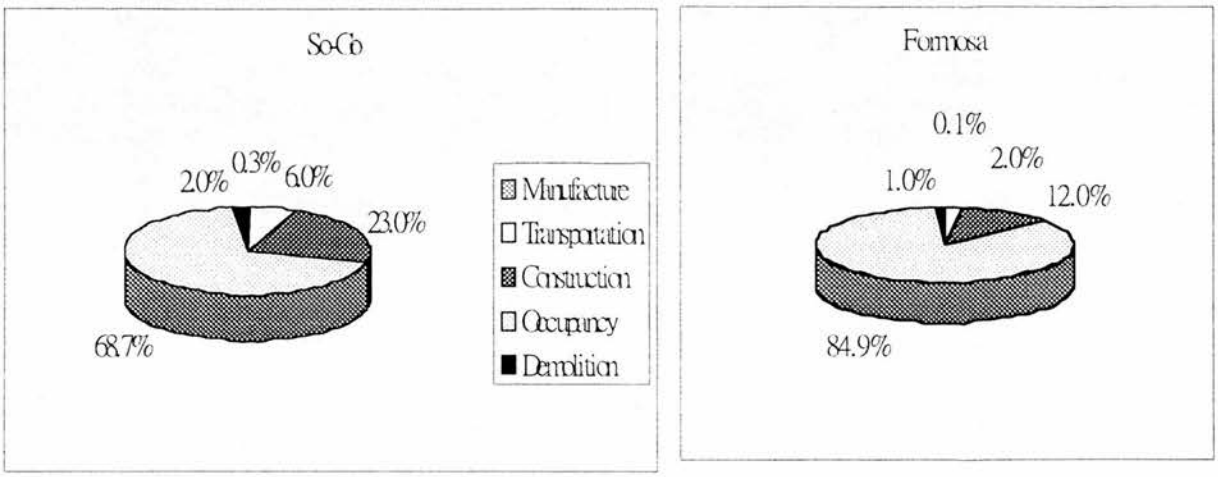


FIG. 12-28: So-Go's and Formosa's Effect on POCP at Different Stages of the Life-Cycle

The substances which contribute to the eutrophication effect are N_2, phosphorous, No_x and COD. Our evaluation is conducted using the effect index which translates these substances into the Nutrification Potential (NP). Over its life-cycle, So-Go generates 22 tonnes of NP or 0.00028 tonnes/m^2. Half of its NP is emitted at its materials manufacture stage, 22% at its occupancy stage and 14% at its transportation stage, as Fig. 12-29 shows. If So-Go's expected 50-year life span is taken into consideration, then the NP generated at its occupancy stage will account for about 93% of its NP total. Fig. 12-29 shows that Formosa's pattern of NP emissions is similar. The Formosa Building generates 25 tonnes of NP or 0.00021 tonnes/m^2 - about 75% of So-Go's total. Formosa's first stage accounts for 44% of its total, followed by the occupancy stage at 28%, the demolition stage at 12%, with the remaining two stages accounting for 8% each. Because Formosa has a steel structure it had less need than So-Go for concrete when it was under construction. For that reason, Formosa's emissions at both the materials manufacture and transportation stages are less then So-Go's.

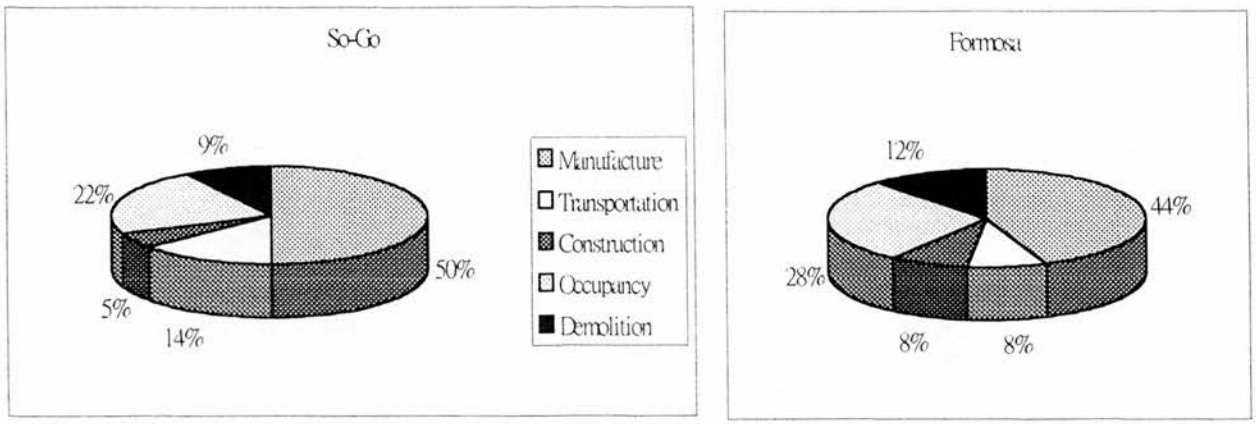


FIG. 12-29: So-Go's and Formosa's Effect on NP at Different Stages of the Life-Cycle

Substances toxic to humans include air pollutants like NOx, SOx, CO, and Pb. Over its life-cycle, So-Go generates 181 tonnes of Human Toxicity (HT) or 0.0023 tonnes/m^2. Formosa generates 191 tonnes of HT or 0.0017 tonnes/m^2 - about 74% of So-Go's level, showing that So-Go's HT per unit of floor area is greater than Formosa's. So-Go's and Formosa's HT ratio at the occupancy stage is 42% and 44% respectively, as Fig. 12-30 shows.

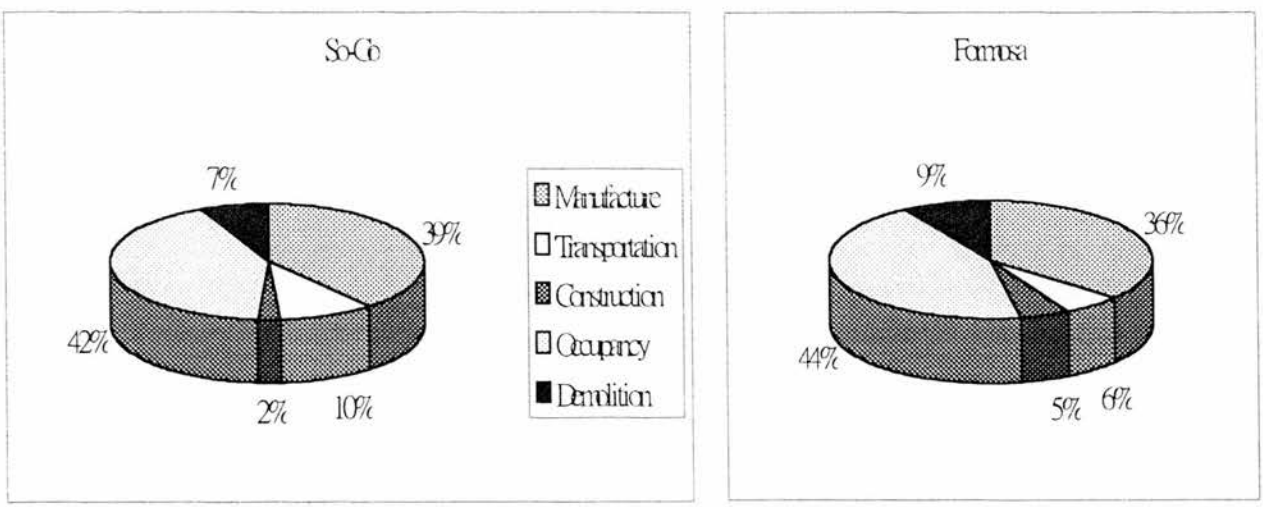


FIG. 12-30: So-Go's and Formosa's Effect on HT at Different Stages of the Life-Cycle

To gauge the effect of the buildings' air pollutants over the life-cycle, we use the concept of the critical dilution volume (CDV). Stressors include substances like SOx, NOx, CO, Pb and TSP. With respect to the total dilution volume, the CDV of air pollution generated over So-Go's life-cycle comes to 12,745 billion m^3 or 0.16 billion m^3/m^2 of floor area. Formosa's total dilution volume comes to 16,603 billion m^3 or 0.14 billion m^3 for every m^2 of floor area - about 88% of So-Go's total. The occupancy stage has the highest impact: So-Go's occupancy stage accounts for 76% of its total and Formosa's 80%, as Fig. 12-31 shows. If the expected 50-year life span of the buildings is taken into consideration, then the occupancy stage will account for about 99% of the total. The reason why this stage is associated with the highest proportion is that petrol-driven vehicles visiting the occupied buildings generate high levels of CO emissions.

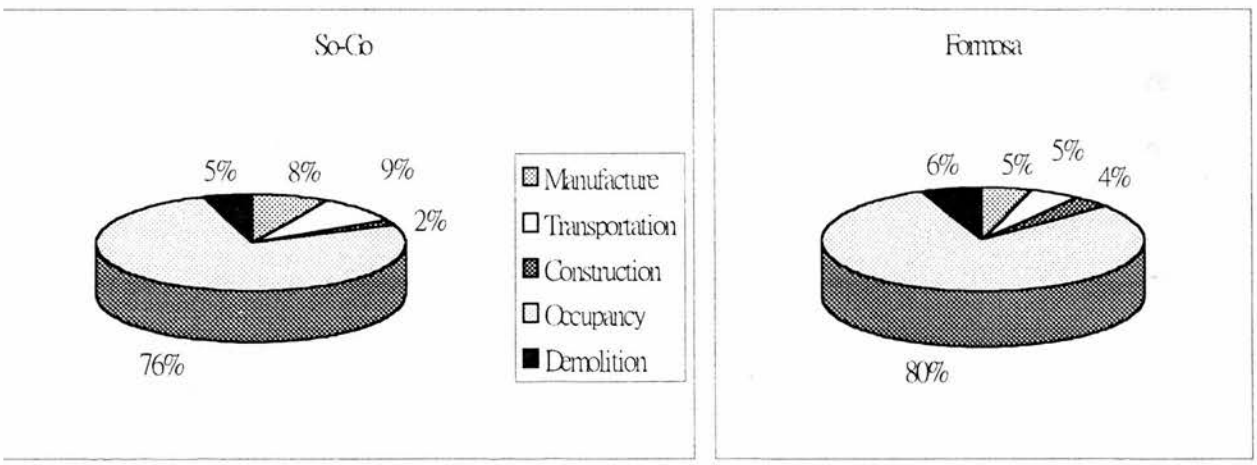


FIG. 12-31: So-Go's and Formosa's Effect on Air Pollution at Different Stages of the Life-Cycle

We also use the CDV concept to quantify the effect of the buildings' waterborne pollutants. So-Go's dilution volume for waterborne pollution generated over its life-cycle comes to 82 million tonnes or 1,031 tonnes of CDV for every m^2 of floor area. Formosa's comes to 1,511 tonnes/ m^2 - about 146% of So-Go's CDV. This shows that the Formosa Building's waterborne pollutants have a greater impact than do So-

Go's. As Fig. 12-32 shows, the occupancy stage of both buildings contributes most to their waterborne pollution volume over the life-cycle, i.e., over 80%.

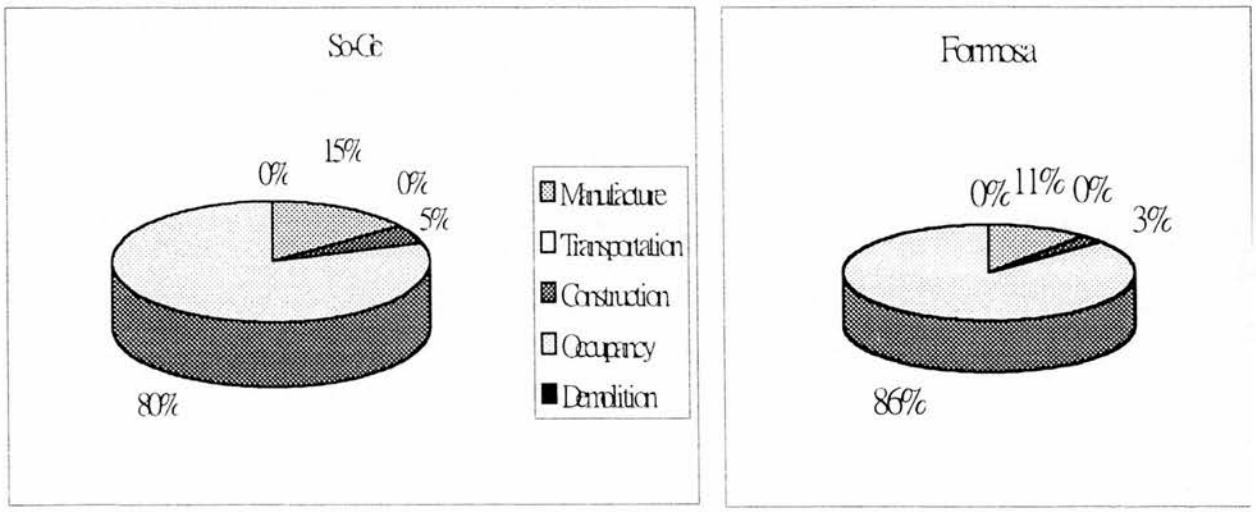


FIG. 12-32: So-Go's and Formosa's Waterborne Pollution at Different Stages of the Life-Cycle

The assessment of the environmental impact of solid waste is based on the area of landfill needed to dispose of it. Over its life-cycle, So-Go requires 11,584m^2 of landfill space, while Formosa requires 17,930m^2 or 0.15m^2 per m^2 of floor area - about 107% of So-Go's landfill requirement. Comparing the solid waste generated at different stages, we see from Fig. 12-33 that the construction stage's volume is highest, followed by the demolition stage's. If the expected 50-year life span of the buildings is taken into consideration, then the occupancy stage will account for about 65% of the total.

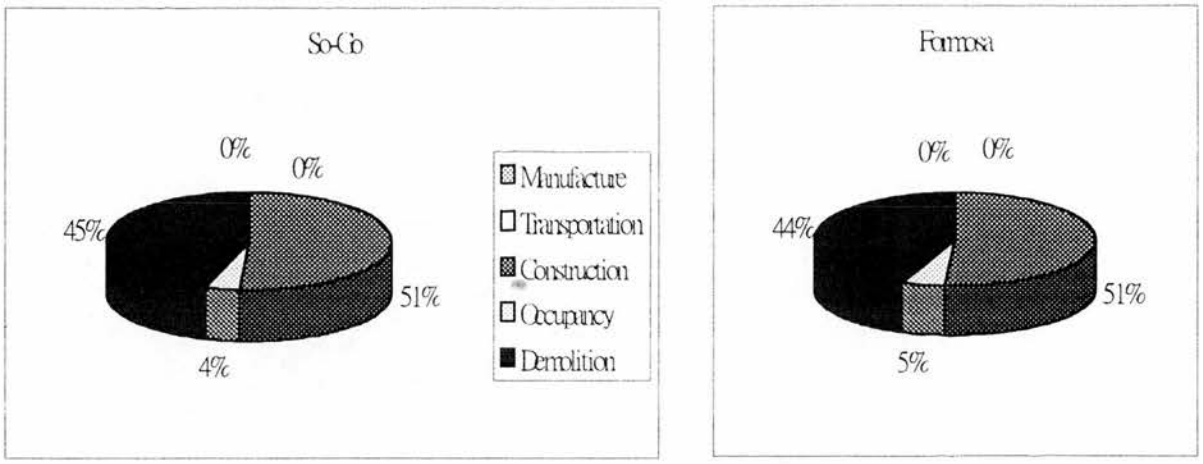


FIG. 12-33: So-Go's and Formosa's Solid Waste at Different Stages of the Life-Cycle

As Tables 12-20 and 12-21 show, the So-Go and Formosa Buildings also affect the local environment in terms of their noise, vibration, overshadowing, local wind effects and wave interference. So-Go's noise levels at the construction and occupancy stage comply with the noise control standard, but when its demolition stage arrives the 79.8 dB(A) noise of the breaker will exceed that standard and mitigation measures will need to be put in place. Formosa's noise levels at both the construction and occupancy stages have exceeded the noise control standard: at both stages appeals were raised against the building for the noise of its air-conditioning equipment. Neither high-rise has caused vibration damage to neighbouring buildings. As for the buildings' impact on geology and soil, their construction did lower the underground water table causing some subsidence on adjacent land but the level has not proved significant.

Both buildings have caused some overshadowing of neighbouring buildings or land. So-Go has shortened the effective insolation hours at a neighbouring area by five hours at the winter solstice but as five hours of effective insolation still remain at that area on that day, So-Go complies with the local building code. Formosa has shortened a neighbouring area's effective insolation by seven hours yet it too remains within the terms of the local building code as the affected area still receives three hours of effective insolation.

The buildings have had some impact on the micro-climate. Both So-Go's and Formosa's alteration of local wind velocities has not been so severe as to prevent pedestrians from walking comfortably in the vicinity. However, both buildings have created an electric wave blockade: So-Go's wave interference spans two hectares and Formosa's (due to its greater height) three hectares on its eastern side.

Both buildings emit some ecotoxic substances such as lead (Pb). When we convert Pb emissions at each stage into measures of Aquatic Ecotoxicity (ECA) and Terrestrial ecotoxicity (ECT), we find that Formosa's ECA, per m^2 of floor area (at 1,047 m^3/m^2), is about 1.29 times that of So-Go's (at 808 m^3/m^2). Formosa's ECT per m^2 of floor area (at 225 m^3/m^2) is about 1.3 times that of So-Go's (at 170 m^3/m^2). The occupancy stage accounts for the highest proportion of ECT and ECA emissions.

So-Go's and Formosa's impacts on the local environment and the environmental carrying capacity differ depending on which issue is being addressed. In the traditional EIA system, the assessment exercise focuses almost exclusively on a building's occupancy stage with some attention also being paid to elements of the construction stage. The remaining three stages that we have considered here are not dealt with, though our analysis makes clear that these stages have an even greater effect on some environmental problems (e.g., global warming, acid rain, human toxicity, nutrification potential and waste disposal) than do the construction and occupancy stages. If an evaluation of these three stages were to be included in a high-rise's EIA, not only could the project's likely effect on these themes be made explicit, but more careful consideration could be given to topics such as the project's choice of building materials, its proposed structure, and its choice of construction methods.

12.6.4 Impacts on the Socio-Economic Environment

As high-rises' impacts on the socio-economic environment range from the social and economic environment through to issues of culture and landscape, and their effect varies depending on which stage of the life-cycle is under discussion, we need to conduct a stage-by-stage evaluation as Table 12-22 shows.

Table 12-22: So-Go's and Formosa's Impacts on the Socio-Economic Environment at Different Stages of the Life-Cycle

Stages in the Building Life-Cycle						
Categories	Environmental items	Materials Manufacture	Materials Transportation	Construction	Occupancy	Demolition
Social environment	Community population	Minor impact	Minor impact	increase in pop.	increase in pop.	Short-term influx of non-local staff
Economic environment	Industrial structure	Increase of related construction materials business	Minor impact	Increase of production volume	Increase of weight of tertiary industry	Increase of weight of secondary industry - Minor impact
	Change of job market and economics	Increased employment in secondary businesses	Increased employment in transportation business	Increased employment in construction & plumbing	Increased employment in service sector	Increased employment in construction
	Land use	Gravel quarrying and change of land use	Building of temp. road, change of land use	Farm land changed to construction site	Farm land changed to high-rise building	Construction site during demolition
Public service facilities	Public facilities	Minor impact	Minor impact	Building staff increase demand for local facilities	Increased demand for local facilities (e.g. school, park	Minor impact
	Public utility	Increased demand for water	Minor impact	Increased demand for water and electricity	Increased demand for water, electricity, natural gas and tele-communicati ons	Minor impact
	Traffic	Minor impact	increased local traffic flow	increased local traffic flow, machinery affects traffic flow	Attracted traffic downgrades LOS to E, F.	Construction machinery affect traffic flow,.
	Parking facilities	Minor impact	Minor impact	Additional parking for construction staff	Additional parking for visitors	Minor impact
	Community security	Minor impact	Transportation vehicles affect community security	construction affects community security	Increased need for fire control and medical care	construction affects communi security
Community culture	Community relationship	Minor impact	Minor impact	Minor impact	Increased pop., social structure changes	Minor impact
	Cultural assets	Minimal affection	Minor impact	Minor impact	Minor impact	Minor impact

Stages in the Building Life-Cycle						
Ecology and landscape	Ecology	Extraction of raw materials affects natural environment	Minor impact	Minor impact	Minor impact	Minor impact
	Landscape	Extraction of raw materials affects natural landscape	Minor impact	Minor impact	Minor impact	Minor impact

So-Go and Formosa are both commercial high-rises, located close by each other. Though Formosa is taller than So-Go, both of them have roughly the same effect on the socio-economic environment. For both, the main impact of their first stage was to increase the activity of secondary industry. As staff numbers and production volumes increased in the materials manufacturing sector, the sector's water requirements also increased. In addition, their demand for building materials provided the impetus for the gravel extraction and lumbering needed for manufacture which, in turn, altered the affected regions' ecology and landscape.

The high-rises' main impact at the transportation stage were the changes they wrought in the labour market, local traffic conditions and community security. At their transportation stage, So-Go and Formosa respectively generated 11,912 and 9,084 truck journeys which provided employment, increased the volume of cargo travelling on the local roads, and increased the road safety risks of local residents.

At the construction stage, So-Go and Formosa affected the social environment, the economic environment and public facilities provision. Their impact on the social environment was minimal though the construction phase did involve employing staff on-site (affecting the local population structure to some extent) and the change in land use which accompanied the buildings' construction also affected local land prices. In economic terms, So-Go and Formosa fed into the growth of the construction, water and

electricity industries which, in turn, affects those industries' staffing levels and production volumes. Finally, the So-Go and Formosa Buildings increased local demand for public facilities, and the trucks and machinery needed to build the high-rises affected local traffic flow which resulted in a downgrading of the LOS on local roads.

The occupancy stage of these buildings is obviously the most pervasive and wide-ranging in terms of its effect on the socio-economic environment. For one thing, these high-rises have contributed to the growth of the tertiary service sector in the district. The influx of new staff to the area has had some effect on the local population structure but the buildings' impact in this respect is minimal because most recruits came from the local labour pool. Increases in the service sector population have raised the gross domestic product of the tertiary industry and subsequently modified Taichung's business structure. Furthermore, the fact that 10,000 people access these two commercial high-rises places additional burdens on local public facilities such as roads and entertainment centres. As these facilities have deteriorated in quality it is likely that the local government will need to improve them, placing additional financial pressure on its budget. However, So-Go and Formosa have also brought financial gains to the local government in the form of additional VAT revenues of £16m.

It is likely that the buildings' demolition stage will have only a minor impact on the socio-economic environment as it is such a short phase. Some benefits may be felt in terms of the additional employment the demolition task will generate but, against that, it is likely that prevailing traffic flow and LOS on local roads will also temporarily worsen.

As we have seen, each stage brings its own benefits and problems. Undoubtedly, the occupancy stage is the most important in terms of its effects, followed by the construction stage and the demolition stage. Though the impacts of the first two stages of the building life-cycle (i.e. materials manufacture and

transportation) are not as wide-ranging as the remaining three, the depth of their impact on the particular items they do affect may be more profound than is evident at the remaining three stages. For this reason, we should not ignore the socio-economic impacts of any of the stages of the building life-cycle.

12.7 SUMMARY

This chapter attempts to apply the LEIA concept to the So-Go and Formosa case studies so as to illustrate how a full assessment of the building life-cycle yields important information about the totality of the environmental impacts of high-rises(see Figure 12-34). The chapter incorporates issues of global concern such as acid rain, global warming, ozone layer depletion, energy consumption, resources depletion and so on, and attempts to integrate LCA evaluation concepts with the more traditional EIA criteria used to assess high-rise buildings.

For each of the five stages of the life-cycle (materials manufacture, transportation, construction, occupancy and demolition) we assess their impact on specific environmental themes (depletion of natural resources, carrying capacity and local impacts and effects on the socio-economic environment). From the data we have presented, we know that the EIA's traditional focus on just two of the stages of the life-cycle is not sufficient to provide a full assessment. Some of the impacts of the first, second and final stages of the life-cycle are much more profound than those which occur at the third and fourth stages (i.e., construction and occupancy).

For example, So-Go's construction and occupancy stages account for only 42% of its total energy consumption and for only 44% of Formosa's. Or again, all the depletion of abiotic resources caused by these high-rises being built occurred at the first stage of materials manufacture. As for waste water produced, So-Go's construction and occupancy stages account for only 36% of its total effluent and for only 48% of Formosa's.

In addition, the contribution these buildings make to global warming, acid rain, the nutrification potential, human toxicity and solid waste disposal cannot be properly acknowledged if we restrict our focus to their construction and occupancy stages where their effect on these themes is minor. Predictions of environmental impact based on these two stages alone is likely to yield estimates which are far lower than the actual evidence suggests they are. From examining these two case studies, we see that the scope of the traditional EIA system should be expanded to incorporate the LEIA concept so as to provide a more in-depth environmental assessment of buildings over their life-cycle.

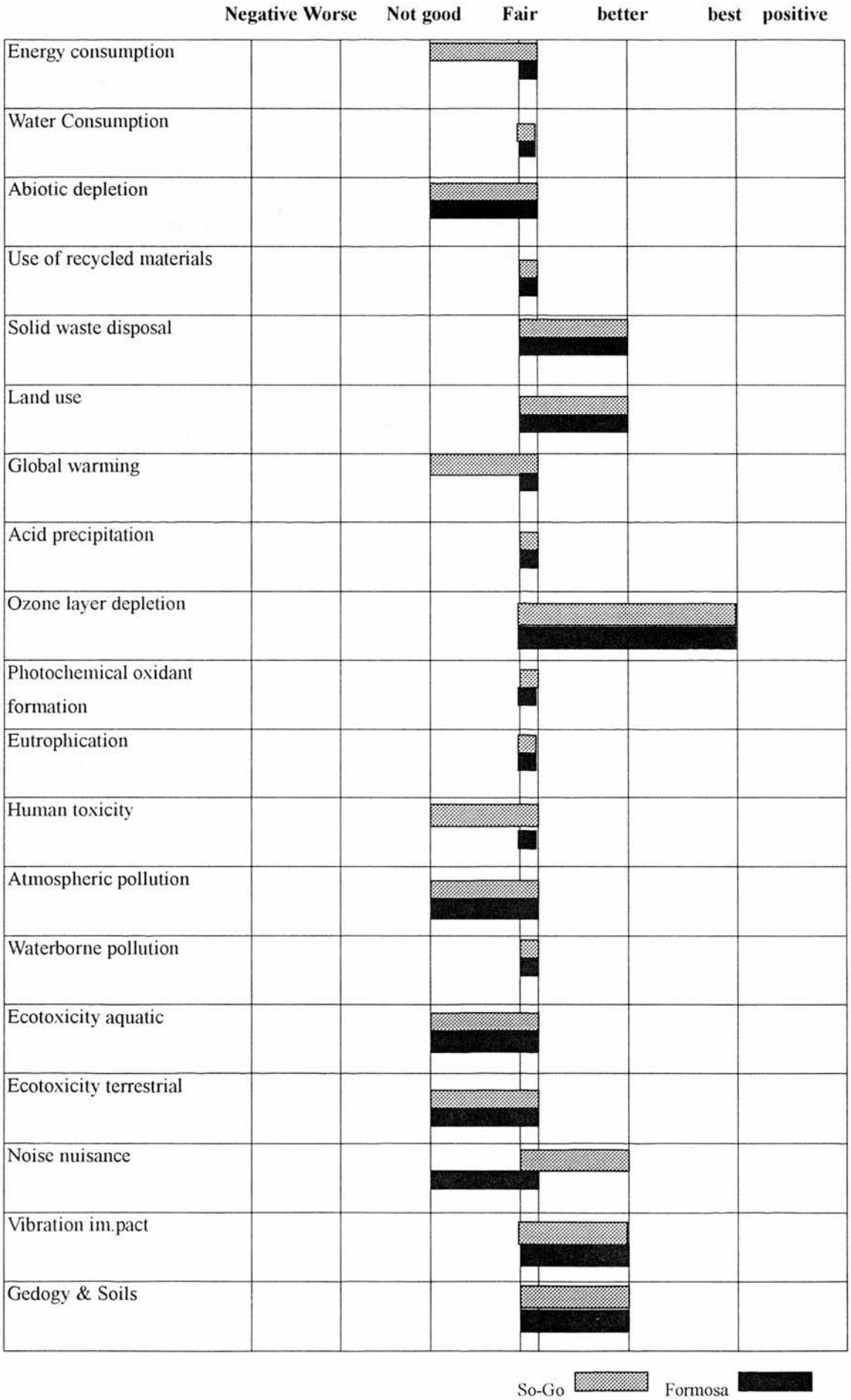


FIG. 12-34: Performance of relative Sustainability of So-Go and Formosa Building

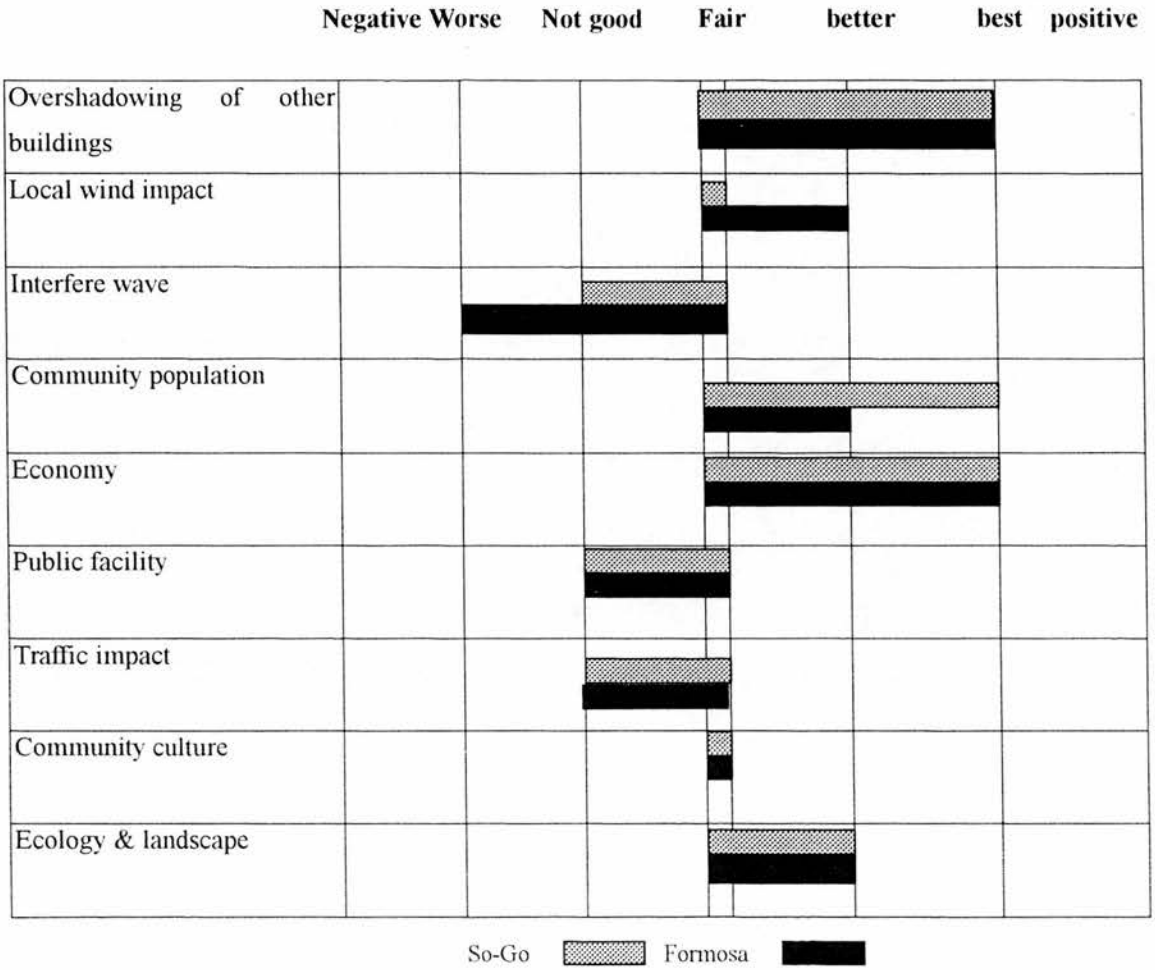


FIG. 12-34: Performance of relative Sustainability of So-Go and Formosa Building

Environmental impacts during the whole life-cycle of So-Go and Formosa buildings can be divided into depletion of resources, physical environmental impact and socio-economic environmental impact. For the aspect of resource depletion, the assessed items include energy consumption, water resource consumption, abiotic resource depletion and use of recycled materials. As for physical environment, the assessed items consist of climate change, acid rain, ozone layer depletion, photochemical oxidant formation, eutrophication, human toxicity, atmospheric pollution, waterborne pollution, solid waste disposal, noise, vibration, geology and soil, overshadowing of other buildings and land, local wind effects, interfere wave, aquatic ecotoxicity and terrestrial ecotoxicity. Socio-economic impacts cover population in the community, economic environment, public service facilities, community culture, ecology and landscape, etc.

For resource depletion, the energy consumption volume for the whole life-cycle of So-Go building is 117 billion Kcal; however recycled construction materials during the demolition phase can save 19 billion Kcal. The energy consumption volume for Formosa building is 125 billion Kcal and recycled construction materials during the demolition phase can save 22 billion Kcal. As for a unit floor area, So-Go building consumes 1.477 million Kcal/m^2, while Formosa building 1.059 million Kcal/m^2, only 72% of So-Go building. For water resource consumption, Formosa building consumes more, 104% of that for So-Go building. The main reason is because restaurants and hotels are contained within the Formosa building, which requires a greater demand of water. Use of recycled materials is assessed when steel used containing blast furnace slag, re-use of bricks, use of demolition materials, lightweight walls containing 50% waste materials, etc. Only steel produces recycled materials in both cases. 1 m^2 of floor area for So-Go building requires 18.6 kg of steel containing waste materials, which is 1.9 times of that for Formosa building. Speaking of integral resource depletion, Formosa building performs better on energy consumption and abiotic resource depletion; however, So-Go does even better on water resource use and use of recycled materials.

For physical environmental impact, the global warming potential per unit floor area in So-Go building is 436.69 kg/m^2 and that in Formosa building is 295.05 kg/m^2, which reveals that So-Go building emits a greater amount of greenhouse gases as it consumes more energy. The same situation can be applied to acidification potential. So-Go building has 1.94 kg/m^2 and Formosa building 1.34 kg/m^2, which is 69% of the former. Items like ozone depletion potential, eutrophication, atmospheric pollution and human toxicity have a higher proportion in So-Go building. However, Formosa building imposes greater impact upon waterborne pollution, solid waste disposal, aquatic ecotoxicity and terrestrial ecotoxicity.

As for the physical environmental impacts at each phase of the life cycle for So-Go and Formosa buildings, the manufacturing phase of construction materials has the greatest impact upon energy consumption, water resource use, abiotic resource depletion, use of recycled materials and global warming. They account for more than half of the total amount during the whole life cycle. In addition, waste management during the demolition phase is also a critical item for solid waste assessment.

The occupancy phase imposes greater impact upon noise, vibration, overshadowing of other buildings and land, local wind effects, photochemical oxidant formation, atmospheric pollution, waterborne pollution, human toxicity and ecotoxicity.

As for the aspect of socio-economic environment, major impact items during the manufacturing phase of construction materials are change of the industrial structure, and acquisition of materials affecting ecological environment as well as natural landscape. Primary environmental issues during the transporting phase of construction materials include structure of employed population, traffic transportation and safety in the community, etc. Affected items are more during the constructing phase, including land use change, structure of employed population, public utility, public facilities, traffic transportation, parking facilities

and community safety, etc. As for the major impact items during the occupancy phase, they cover population in the community, industrial structure, structure of employed population, public facilities, public utility, traffic impact and safety in the community, etc. Dominant items are community safety and traffic transportation impact during the demolition phase.

Three assessed dimensions are established in compliance with the goals and concept of sustainable development, coupled with EIA for the whole life cycle of studied cases. Resource depletion was not incorporated into EIA items before and several global issues are included for assessment extent from the aspect of physical environmental impacts. It is not hard to find that the other four phases (in addition to the occupancy phase) also result in significant environmental impacts. Under-estimation will come into existence if only based on the EIAs at occupancy and constructing phases. As a result, LEIA can be applied appropriately for the analysis of environmental impacts during the whole life cycle.

Aiming at LEIA case study of So-Go and Formosa buildings in this chapter, we are going to take the results as the major basis for analyzing the building sustainability performance of the EIA system in the next chapter.

CHAPTER THIRTEEN: EVALUATION OF THE EFFECTIVENESS OF EIA IMPLEMENTATION

In Chapter Three an evaluation framework to determine the effectiveness of an EIA system was created. The procedure, implementation, application and completion of an EIA were analysed with respect to high-rise buildings. In this Chapter, the discussion will focus on the effectiveness of the EIA system for this type of building.

The evaluation framework for an EIA system is split into: policy, practice and performance (the 3Ps). These 3Ps cover ten main issues, each of which have their own assessment criteria. Under policy, the issues include legal regulation, procedure, and decision-making; practice includes issues of implementation processes, decision-making control mechanisms, and enforcement monitoring. The main focus of this aspect is to determine whether an EIA is truly effective in a real situation. The performance aspect includes natural resource depletion and carrying capacity, local impact, and quality of life issues. These mainly focus on results from case studies to assess whether the EIA process can improve sustainability so reducing impact on the environment.

13.1 EVALUATION OF THE EFFECTIVENESS OF AN EIA - POLICY

Evaluation of the policy dimension includes examination of the legal regulations as well as process and decision-making aspects. The objective of a policy evaluation is to analyse the legal basis, administration organisation, application of the strategic environment assessment (SEA) system, regulation of the EIA report, screening and scoping processes, the EIA review, monitoring and auditing processes, alternatives, mitigation measures and to assist in the decision-making process. Results of the assessment are shown in Table 13-1.

Evaluation of legal regulation

This encompasses legal basis, administrative organisation, the application of a SEA and the regulations for an EIA report.

Table 13-1. Evaluation of the Effectiveness of Policy in the Taiwan EIA system

Issue	Meet criteria	Objects	Meet criteria
legal regulation		Legal Basis	
		Administrative Organi-zation	
		Application of SEA	
		EIA Report	
procedure		Screening Process	
		Scoping Process	
		EIA Report Review	
		Monitoring & Auditing	
Decision-making Aspect		Alternatives	
		Mitigation Measures	
		Assist of Decision mak-ing	

Note:

Few issues met the criteria (only about 25%)

a half of the issues met criteria with the standard.

most of the issues met the criteria (about 75%)

almost every one issue met the criteria

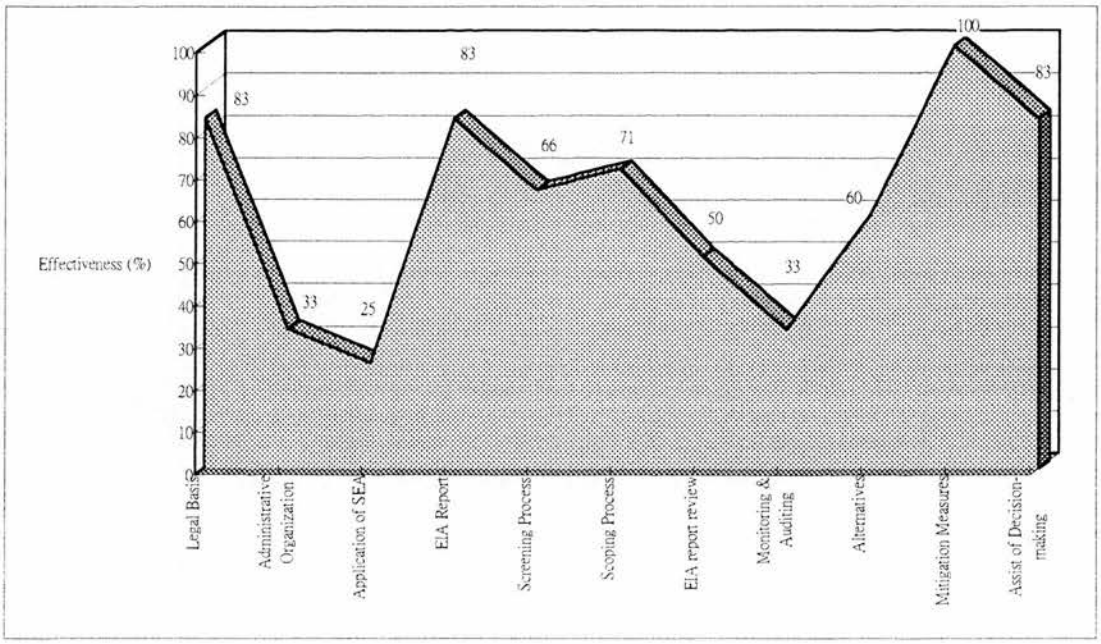


FIG. 13-1: Evaluation of the Effectiveness of Policy in Taiwan EIA system

Note: The percentage of the effectiveness is presented according to the percentage.

Under Legal Regulation and among the above four objectives, only the regulation of the EIA report and legal basis do not meet one criterion whereas in the application of an SEA and administrative organisation a number of criteria were not met. The result of the evaluation is in Figure 13-1. The length of the axis indicates the percentage of criteria met.

Regarding the legal basis of the EIA system, in Taiwan an EIA Act and other related regulations have been promulgated. The Act covers issues on the coverage and content of the EIA, its range of application, and any necessary penalties. As with the general process of an EIA, a general regulation has to take effect. Therefore, among the six criteria, all but the EIA process has met the requirements. Unclear issues in the EIA process include the timing and objectives for the EIA review committee.

With administrative organisation only a third of the criteria are met. The criteria met were the clear function of the role of, and the co-operation between each organisation in, the EIA process. Criteria not

met include the adjustment and reallocation of manpower within each organisation in order to implement the EIA. This, therefore, hinders the enforcement of monitoring and surveillance. A further criteria not met is whether the EIA system can be carried out without bias and free from political intervention; in Taiwan, the chair of the EIA committee is the city mayor, the rules and budget for the EIA committee have to be reviewed by publicly elected organisations[1].

In the application of the SEA system the majority of evaluation criteria are not met. Nevertheless, regulations for carrying out the SEA are met as the EIA Act covers them. As the application of Taiwan's SEA system does not met cover all the criteria of the 3Ps a significant environmental impact must be expected. Although there are nine policies included in the SEA process, environmental policy is not one of them. Neither the SEA process nor guidelines for different policies have been regulated. Prior to 1998 it was not a requirement to carry out a SEA process on issues of policy.

Most of the regulations regarding the EIA report meet the set requirements. The only failing is that during the preparation period of the EIA report, public consultation and participation is not a requirement in the Taiwanese EIA system.

To sum up, in the evaluation of legal regulation, Taiwan's EIA system meets approximately 60% of the necessary requirements (Figure 13-1). However, Figure 13-1 also indicates that in order to fully establish legal regulation there are a number areas that need to be improved to achieve an effective EIA system.

Evaluation of procedure

The evaluation of the EIA procedure focuses on the screening, scoping, EIA review, monitoring and auditing processes.

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[1]An example of political intervention: the rules for the EIA committee for Taichung City have been rejected twice by the City Council because of worries that an over-strict review would affect developers' rights. This resulted in an EIA committee with no legal basis.

Amongst screening regulations, about two-thirds meet the evaluation criteria (Table 13-1). This includes the range of applications for an EIA and the necessary actions when conducting the EIA process on public and private projects. There are prepared guidelines that proponents and environmental authorities must follow. Moreover, when screening is put into action thresholds and criteria must be met. The current failing in the screening process is the lack of facility for either public participation or appeal against any screening decisions.

Most regulations for the scoping process meet the requirements, including the open nature of the process and public participation. These, together with the establishment of guidelines for various action-specific developments, help improve the effectiveness in the carrying out of the EIA system. However, the process does lack a mode of appeal against any scoping decisions. This may be due to the fact that the scoping process cannot be conducted at an early stage (ie. before the production of an EIS) so any alternatives cannot be fully discussed and evaluated. The scoping process is brought in at the second level (ie. at the EIR stage) so the consideration of any alternatives is limited to any decisions made in the initial stage. Location-matter, no-action, technical and other alternatives cannot be comprehensively considered, so affecting the effectiveness of the whole system.

In Taiwan's EIA report review system, only half met the criteria of the establishment of an EIA committee to review the report, guidelines for making judgements, and the availability of the EIA results for public inspection. However, there are clearly some weaknesses in the EIA review system ie. there is no declaration of the need for public participation, and no methods to appeal against results. The dissemination of conclusions from the EIA review is currently a one-way, not two-way, communication.

Finally, monitoring and auditing. A third of the process meet the requirements. The timing of monitoring and auditing is too late as it is only carried out once the construction, or occasionally the operational, phase has begun. The findings from monitoring and auditing are not open to public

scrutiny. However, legislation demands that monitoring and auditing be actually carried out. Monitoring will ensure that any unexpected discoveries not picked up in the original assessment, that may cause a negative environmental impact, will be taken into consideration to reduce the effect.

In general, the procedural aspect in Taiwan's EIA system does not meet requirements. A more open EIA process, with public participation and an appeal procedure will enhance the effectiveness of the EIA system.

Evaluation of decision-making

The assessment of the decision-making process focuses on the regulations for decision-making within the EIA system. This includes any alternatives, mitigation measures, and decision-making support.

In Taiwan, the consideration of feasible alternatives is not comprehensive enough. The assessment of alternatives is a mere formality[2]. Alternatives are not considered until the EIA review stage. This actually misses the purpose of proposing alternatives in the first place although their assessment is listed as a requirement in the EIA report. Regulations for alternative measures have explicitly stipulated, but still many of the issues still do not meet the criteria (Table 13-1).

Mitigation measures play a very important part in Taiwan's EIA system. From an early stage in the development of an EIA system the main purpose is to protect the public from inconvenience. All the requirements for mitigation measures are met (Table13-1). For example, the EIA Act enforces the inclusion of mitigation measures with published guidelines an operational reference.

Regulations focus mainly on mechanisms assisting with the decision-making process. With respect to Taiwan's EIA system, the EIA review committee must be set up during the decision-making process so

[2]In an article reviewing the implementation of an EIA system in Taiwan it is indicated that comprehensive and reasonable alternatives have been neglected. Only in the review of the EIA report are several simple alternatives presented (Ni, 1998, pp. 5-6).

final decisions can be made according to the review conclusions. The EIA Act in Taiwan prohibits the decision-maker from making a verdict before the EIA report has been fully reviewed. Therefore, most supporting and regulatory issues of decision-making meet the criteria requirements, except that committee members may be swayed by politics[3].

Overall, 60% of policy meet requirements with the decision-making aspect rating the highest and legal regulation and process aspects being relatively equal. Looking at evaluated items factors, mitigation measures are the most thoroughly carried out, followed by the regulation of the EIA report, and the assistance in the decision making process. Immediate improvements are needed in the use of the SEA, and monitoring and auditing.

Further reasons for the ineffectiveness of Taiwan's EIA system is an early design stage, a lack of public participation, and the late consideration of alternatives. Moreover, the enforcement of monitoring and auditing practices are stipulated in the EIA Act although there are no strict rules or the manpower to carry out the job. These all reduce the effectiveness of the EI system.

[3]Some EIA committee regulations require that members of the committee have to be agreed first by the City Council (e.g. Taichung City). The members chosen will be politically affected.

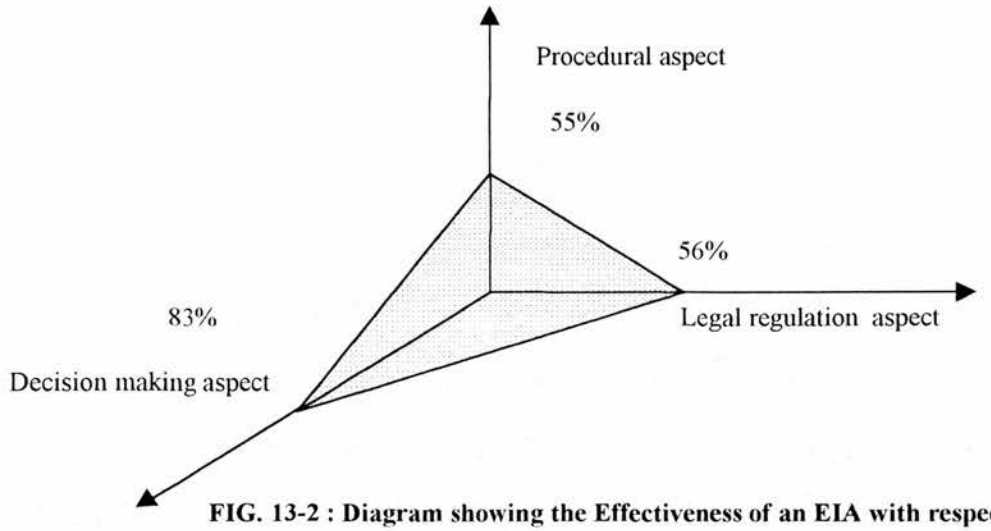

FIG. 13-2 : Diagram showing the Effectiveness of an EIA with respect to Policy

13.2 EVALUATION OF THE EFFECTIVENESS OF AN EIA - PRACTICE

In the evaluation into the effectiveness of the practice of an EIA, the degree to which the implementation of the process conforms to procedure is assessed. Assessing categories include the implementation process, decision-making procedure and the enforcement of monitoring. Assessment objectives include the degree of compliance of the process, timing and costs, decision-making process, the mechanism of decision-making control, the carrying out of mitigation measures, and review follow-up.

Evaluation of the implementation process

Evaluation of the implementation process focuses on compliance to the original design and timing and cost issues. To ensure effectiveness of the screening process, thresholds and criteria are used to determine whether a development proposal may result in a significant impact on the environment. However, the inappropriate timing of the scoping process (during the second stage) limits the assessment and selection of alternatives, and the lack of the public participation are weaknesses of the process. In general, only half the processes reach a standard level of requirement (Table 13-2).

Table 13-2 : Evaluation of the Effectiveness of the Practice Dimension

Issues	Level of Standard	Objects	Percentage of meet criteria
Implementation process		Procedure compliance	
		Time & Cost	
Decision-making process		Decision-making Procedure	
		Decision-making Control mechanism	
Monitoring & Surveil-lance Execution		Mitigation Measures Execution	
		Following-up the Con-clusion of Review	

Note:

means few criteria have been met (about 25% of the issues).

means a half of criteria have been met

means most criteria have been met (about 75% of the issues).

means almost every criteria have been met.

The average cost of an EIA in Taiwan is 0.098% of the total project cost, low when compared to the 0.1-1% determined by Therivel *et al* (1996, p. 186) (see also Marr, 1997, p. 198) (Table 13-3). Using the So-Go and Formosa Building case studies as examples, the cost for the environmental management plan is 0.85% of the total construction cost, which again is low when compared with the usual 1.3%[4]. When assessing manpower there is an average of 3.84 persons per case study over an average of 8.5 months, which equates to 33 person-months per case study. This is also low when compared to 40 person-months in the EU. The average EIA timespan in Taiwan is about 34 weeks. This is in contrast with 20 weeks in the UK, 80 in Germany and 40 in the Netherlands (Table 13-3). On the whole, assessment of the effectiveness of timing and costs only meet half of the criteria. Indications are that

[4]In general, environmental protection is 1.3% of the total cost see Fan, 1997, p. 197

quality must be reinforced during the EIA.

The decision-making procedure meets most of the evaluation criteria as the results of the EIA review have been taken into account, and the conclusion, results and reasons are publicised. Although control mechanisms are necessary to avoid arbitrary and capricious decisions being made, the effectiveness is questionable. The application of the judicial control mechanism is not suitable in the EIA process, as there is a separation between executive and judicial organisations creating problems for public complaint. The public control mechanism cannot function properly due to the lack of (or late) public participation. In case studies, it was noted that there was no public comment during the EIA process and that, in general, public participation in Taiwan is very low when compared to that of the UK and Germany (Table 13-3). Only professional and procedural control mechanisms functioned normally.

Table 13-3 : Comparison Table for EIA timings and costs in Taiwan

Item	Taiwan's Statistic	Other Research	Comparison
EIA Assessing Cost	0.0998% of total	Common: 0.5% UK: 0.6%	Low
Environment Budget	0.85% of total	Taiwan Common: 1.3%	Low
Assessing Time	34 weeks(8.5 month)	UK: 22 weeks Germany: 80 weeks Holland: 40 weeks US: 48-72 weeks California: 24-48 weeks	Fair
Assessing Manpower	33 person/month (average 3.84 person per case, 8.5 month per case)	EU: 40 person/month	Low
EIA Report Length	162 pages(appendix excluded)	UK: 21-50pages:50%; 51-100 pages: 30% A Germany: 51-100pages: 25%; 101-150: 40% above 150: 23%	Longer but fair
Decision and Reviewing Time	30 weeks(7.6 months)	UK: 23 weeks A Germany: 60 weeks	Fair
Review Result	5% of rejected(4 among 78 cases)	Unsatisfactory and very unsatisfactory: UK: 7% A Germany: 7%	Fair
Comments received from the public	Nil(So-Go & Formosa building)	Without public comment: UK: 20% A Germany: 60% Comment(1-10petitions): UK: 30% A Germany: 38%	Low

Observation of the So-Go and Formosa Building case studies highlights the fact that mitigation measures are not fully carried out. However, this also relates back to the competent and environmental authorities, and a lack of manpower to effectually follow-up, monitor and supervise. This will reduce the effectiveness of the EIA process. With respect to the following-up of the review conclusions many of the criteria requirements are met.

In general, only half the practice criteria are met (Figure 13-3) with the implementation of mitigation measures having the lowest score. This is a reflection of the allocation of manpower by the competent and environmental authorities resulting in a lack of follow-up and supervising. The effectiveness of decision-making control mechanisms is also under 50%. This is due to the inappropriate design of the system with public participation being poorly timed with inadequate and insufficient attendance. Moreover, the supervision of a judicial control mechanism is not included in the EIA system due to the separation of administration and judicature. However the Control Yuan, a quasi-judicial body, is gradually playing a more important role in the judicial control mechanism[5].

The decision-making procedure meets the most criteria. The procedure is clearly regulated by the EIA Act, with a set of rules to be followed by the decision-makers eg. decisions must not be made before the results from the EIA review, all of which must be publicly announced, and if the result from the EIA review is inappropriate, the decision-maker cannot approve it. All these rules aim to enhance the effectiveness of decision-making.

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[5]Control Yuan is one of five government Yuans under the Taiwanese president. During the implementation of the Formosa Building EIA process, some city council members objected to the arbitrary and capricious decision taken by the city government. They appealed to the Control Yuan (Chinatimes News, 2 March 1999, p. 11 Taipei; Taiwan)

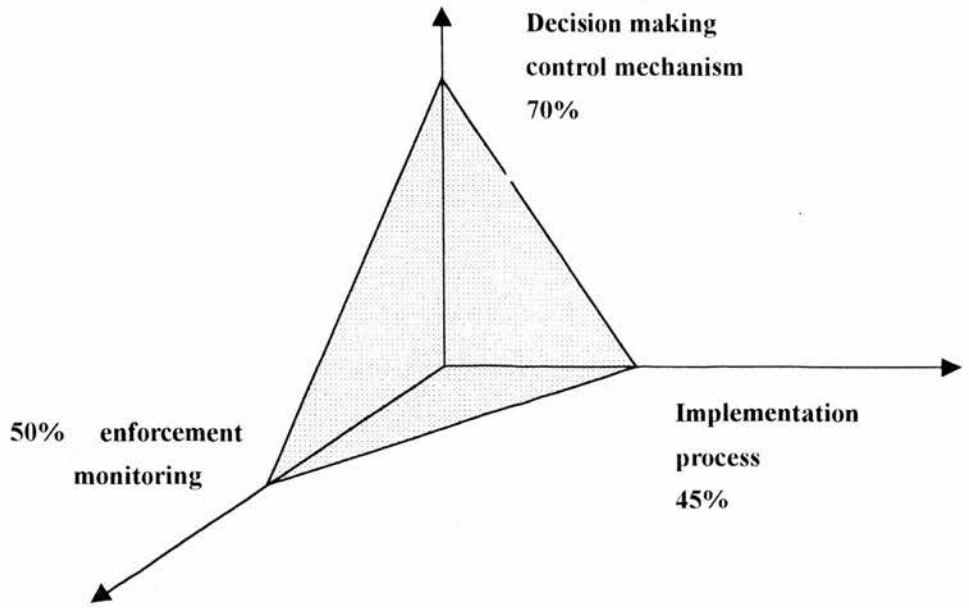


FIG. 13-3 : Diagram showing the Effectiveness of an EIA with respect to Practice

Table 13-4 : National EIA Agency Manpower

Approximate numbers working in the (national) EIA agency/branch in various countries and organisations	
Staffing numbers	Number of countries
No response	3
0-5	3
6-10	7
11-15	3
15-20	2
21-30	-
30-50	3
>50	4

Note: Five work at the national EIA agency in Taiwan.

Data source: Commission for EIA, 1998a, p. 274

13.3 EVALUATION OF THE EFFECTIVENESS OF AN EIA - PERFORMANCE

Evaluation from a performance perspective is based on the case studies to determine the influence of the EIA process, and whether the process can help achieve the sustainable development goal.

Evaluation factors include natural resource depletion, carrying capacity, local impacts, and the quality

of life. There are two evaluation indices: the effectiveness of the EIA assessment, and the sustainability of the proposal. Examination of mitigation measures, alternatives, impact prediction, and an environmental management plan assess this effectiveness. These can be divided into three levels: effective, fair and ineffective. The sustainability index is assessed by comparison with other buildings to determine whether an effective sustainable strategy is adopted. This can be divided into five levels: best, better, fair, not good, and worse. With respect to the quality of life factor, this latter index only evaluates positive or negative impacts.

In Chapter Two, four objectives were detailed regarding sustainable development:

1. To maintain a healthy economy, improve the human living environment, and protect humans and the environment.
2. The optimal use of non-renewable resources.
3. The sustainable use of renewable resources.
4. To minimise damage to environmental carrying capacity as a result of economic activities, and to minimise risks to human health and biodiversity.

These four objectives will be used as criteria in the evaluation of sustainability. All results are represented in a wind rose diagram where the length of the arrow indicates the extent of effectiveness and sustainability.

Evaluation of natural resource depletion

The objective of sustainable development is to minimise, but optimise, the use of non-renewable resources while using renewable resource sustainably in the building structure. Building components such as metals, minerals and oil derivatives, are non-renewable materials. Timber and water are natural, renewable resources.

In the evaluation of natural resource depletion, issues include energy consumption (mainly fossil fuel), water consumption, abiotic resource depletion, the use of recycled materials, solid waste disposal, and

land use (Table 13-5). Using the So-Go and Formosa Buildings as examples, energy consumption was not assessed by the EIA, rendering the process ineffective in this instance. Energy depletion is actually higher than other residential and office buildings in Taiwan (Table 13-6): the So-Go and Formosa Buildings use 2.03 and 1.46 times that of other residential and office buildings respectively. As the energy consumption of a commercial building is always higher than for offices, the Formosa Building is considered 'fair' whilst the So-Go Building is 'not good' ie. less sustainable than buildings outwith the EIA process.

Table 13-5 : Evaluation of the Natural Resource Depletion Aspect of the So-Go and Formosa Buildings

Item	So-Go Building		Formosa Building	
	Effect of EIA Process	Sustainability	Effect of EIA process	Sustainability
Energy	Ineffective	Not good	Ineffective	Fair
Water	Effective	Fair	Effective	Fair
Abiotic	Ineffective	Not Good	Ineffective	Not Good
Use of recycled materials	Ineffective	Better	Ineffective	Fair
Solid waste disposal	Fair	Fair	Fair	Fair
Land use	Fair	Fair	Fair	Better
Overall result				

Note: a. The indexes for effect of EIA process are effective, fair and ineffective. The indexes for sustainability are best, better, fair, not good and worst.

b. The overall result evaluation is according to the effective, best and better items of total items.

c. The Legend as Table 13-1

Table 13-6 : Comparisons between Energy Consumption and the Global Warming Potential of the So-Go and Formosa, Residential and Office Buildings

		Material Manufacturing	Transporting phase	Construction phase	Occupancy phase	Demolition phase	Total
Energy Consumption per Floor Area (kcal m^{-2})	So-Go	838,398.95	16,598.97	15,186.53	593,526.40	12,801.33	1,476,512.18
	Formosa	568,952.27	8,249.11	15,186.53	453,388.72	12,808.49	1,058,585.12
	Residential	519,997.85	14,401.54	15,186.53	113,199.00	13,866.32	676,651.21
	Office	539,910.28	14,085.14	15,186.53	141,335.00	13,718.00	724,234.95
Global Warming Potential per Floor Area (kg m^{-2})	So-Go	251.37	4.98	4.56	171.54	4.23	436.68
	Formosa	167.37	2.21	4.64	117.20	4.23	295.65
	Residential	219.64	5.18	4.52	26.40	4.67	260.41
	Office	229.18	5.07	4.52	25.60	4.61	268.98

Note: Residential and office building data are extracted from Yang, 1996, p. 27 and Cheng, 1997, pp. 17-21

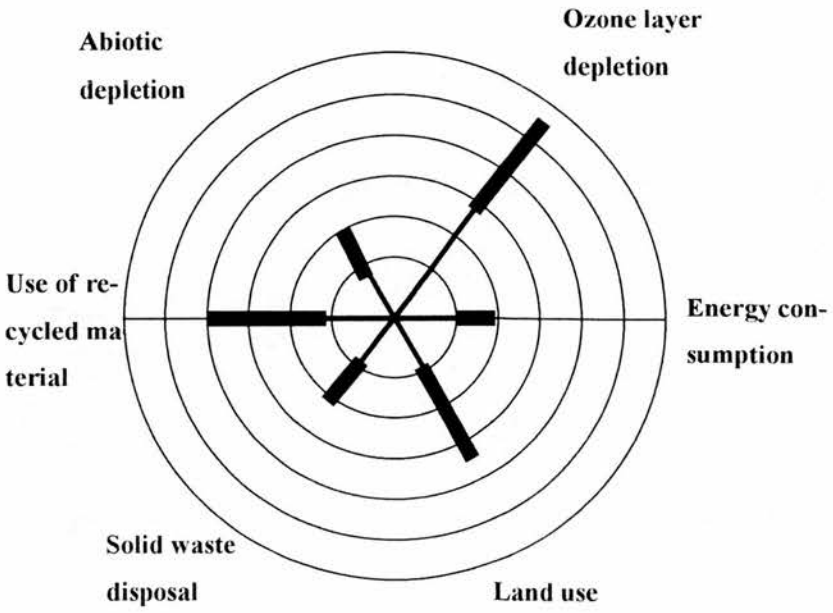
Both the So-Go and Formosa Building have been assessed for the volume of water consumption and water-saving measures by the EIA. Although the EIA process is effective ensuring a positive influence on water use, neither building have built a water recycling system. Some water-saving devices are in force, but there is no comprehensive water conservation plan so can only score 'fair' with respect to the sustainability performance.

As, the use of abiotic resources was not a consideration in the EIA process for either building, the process must be deemed ineffective. In construction, both buildings used vast quantities of the abiotic resource (eg. lead, cooper, steel and aluminium). No alternative materials such as the use of recycled materials, demolition materials, products containing waste, by-product materials or the re-use of bricks or stones were considered. Therefore, the sustainability value is 'not good' although the So-Go Building's use of recycled materials was 'better' than the Formosa Building.

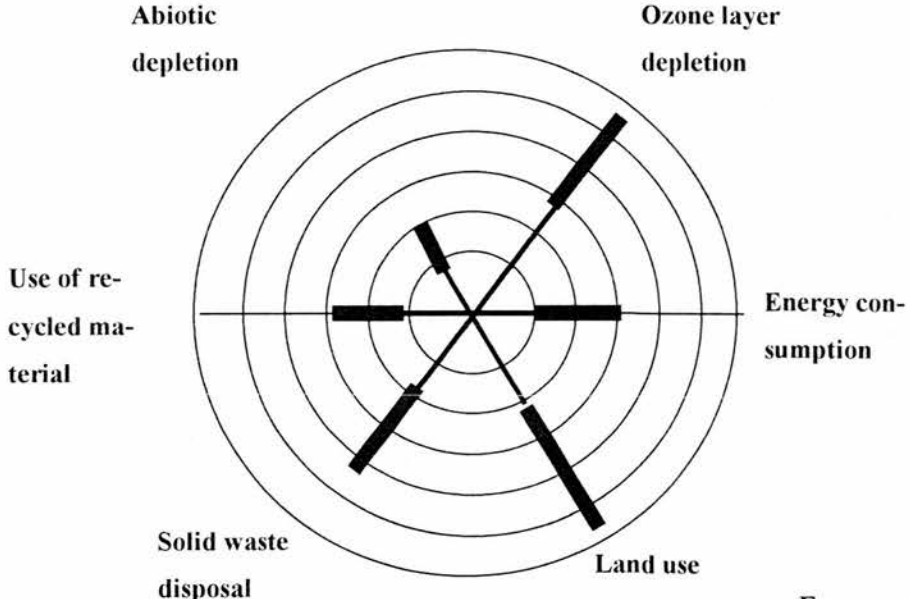
Waste disposal, key sustainable development objectives are to minimise the production of solid waste, and to recycle as much as possible ie. reduce, reuse, and recycle. Waste was an assessable item in the EIA process for both buildings. However, the assessment only applies to the construction and operation phase in the life cycle of a building, not to the demolition phase, which is where most waste is produced and disposed. Therefore, the effectiveness can only be rated as 'fair' as the plan for recycling and reduction only applies to a few specific solid wastes.

The key sustainable development goal for land-use is to prevent the use of sites of high ecological value by the redevelopment of urban land. This is not a major issue in the EIA process, hence the evaluation rating of 'fair'. From a sustainability performance perspective, the Formosa Building scored 'better' as the site was a redevelopment indicating an efficient use of the land.

For an overall evaluation of natural resource depletion, one of six issues were effective in the EIA process for each case study whilst only one of the six issues achieved a sustainability performance (Figure 13-4).



So-Go building



Formosa building

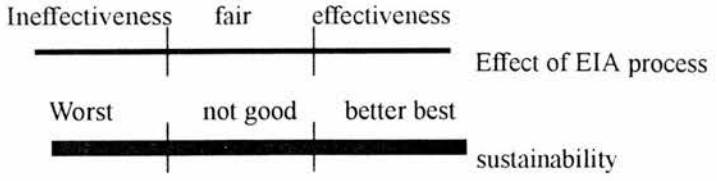


FIG. 13-4 The evaluation of effectiveness of EIA in natural resource depletion of So-Go building and Formos- Building

Carrying Capacity Impact

The EIA process is 'ineffective' as neither building assesses the effects of global warming and the emission of greenhouse gases (Table 13-7). The global warming potential (GWP) of the So-Go Building is 63% higher than that for office buildings (Table 13-6) so is sustainability 'not good'. The GWP of the Formosa Building is similar to office buildings with a sustainability performance of 'fair' (Figure 13-5).

Table 13-7 : Evaluation of the Carrying Capacity Impact of the So-Go and Formosa Buildings

Item	SO-GO Building		Formosa Building	
	Effect of EIA process	**Sustainability**	**Effect of EIA process**	**Sustainability**
Global warming potential	Ineffective	Not Good	Ineffectiveness	Fair
Acid Rain Potential	Fair	Fair	Fair	Fair
Ozone Depletion Potential	Effective	Best	Effective	Best
Photochemical Oxidant Formation	Ineffective	Fair	ineffectiveness	Fair
Nitrification Potential	Fair	Fair	Fair	Fair
Human Toxicity	Fair	Not Good	Fair	Fair
Atmospheric Pollution	Fair	Not Good	Fair	Not Good
Waterborne Pollution	Effective	Fair	Effective	Fair
Ecotoxicity of Aquatic	Ineffective	Not Good	Ineffective	Not Good
Ecotoxicity of terrestrial	Ineffective	Not Good	Ineffective	Not Good
Overall Result				

The main aim of sustainable development with respect to acid deposition is to limit the emission of various acidifying substances. The main sources are from energy consumption and transport. Acidifying pollutants (NO_x SO_x) were assessed and review during the EIA process of the So-Go and Formosa Buildings. However, there is no definite mitigation or alternative plan for the reducing of emissions. The effectiveness of the EIA process, and the sustainability performance, are both rated 'fair'. To try and counteract stratospheric ozone layer depletion the key goal is to restrict causal atmospheric emission of substances. The main substances are those with a high ozone depletion potential (ODP) such as CFC_{11}, CFC_{12} and Halon. In the EIA process for the case study buildings was 'effective' as such emissions were covered limiting the use of high ODP materials. Both buildings met the key sustainability objective (to replace high ODP substances with low such as $HCFC_{123}$ (0.014 ODP) and $HCFC_{22}$ (ODP 0.05)) resulting in a 'best' sustainability performance.

The reduction of emissions of photochemical oxidant formation (fundamental to eutrophication and human

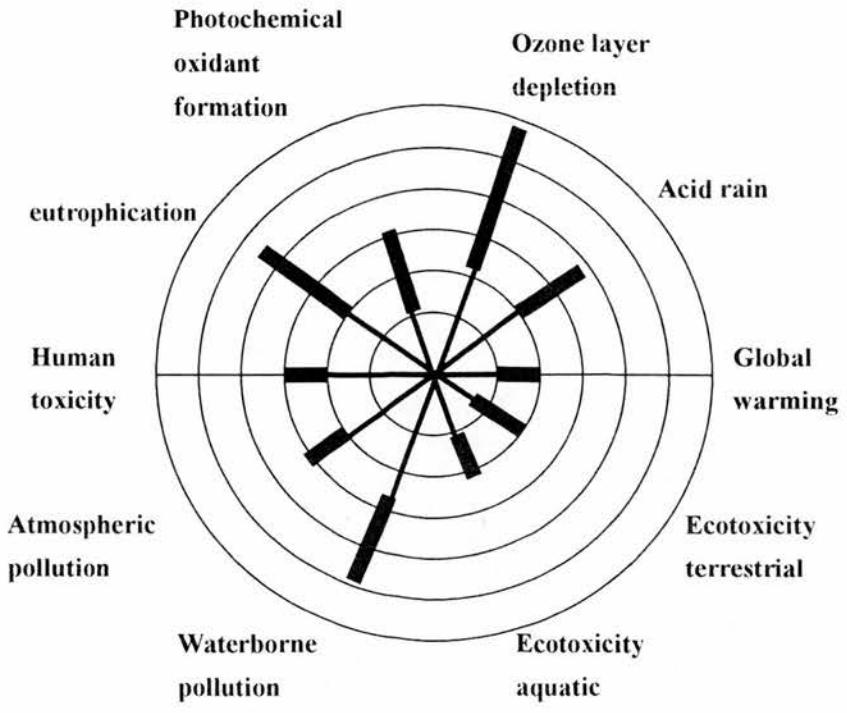
toxicity issues) is a sustainable development aim. Sources include HC, CH_4, NO_x, COD, SO_x, CO and Pb from energy consumption, kitchen emissions and transport. Although the prediction of the emission of the above substances was a part of the EIA process for the two buildings, there was no attempt made to establish the effect on the environment and to introduce effective reducing measures. Estimations focused on transport exhaust fumes during the construction and operation periods. HC emissions from kitchens and the burning of fossil fuels were not assessed. The So-Go building has a 138% greater impact, with regards to human toxicity, than the Formosa Building; a 'not-good' level of sustainability for the So-Go building (Figure 13-5).

Controls on air pollution is a major sustainable development objective for atmospheric pollution. Reduction of air pollution will help safeguard the risks of adverse effects on natural ecosystems, human health and the quality of life. The emissions of air pollutants are assessed in both EIA processes for the So-Go and Formosa Buildings. However, of the building's life-cycle, only the construction and operation periods were included so only pollutants from transportation and construction were considered. Therefore, the EIA is inadequate and insufficient with respect to time. i.e. during the construction period, the environmental authority has implemented monitoring for the So-Go building's TSP emissions. Results from the monitoring indicate emission levels are higher than predicted (Table 13-8), a sustainability performance of 'not good'.

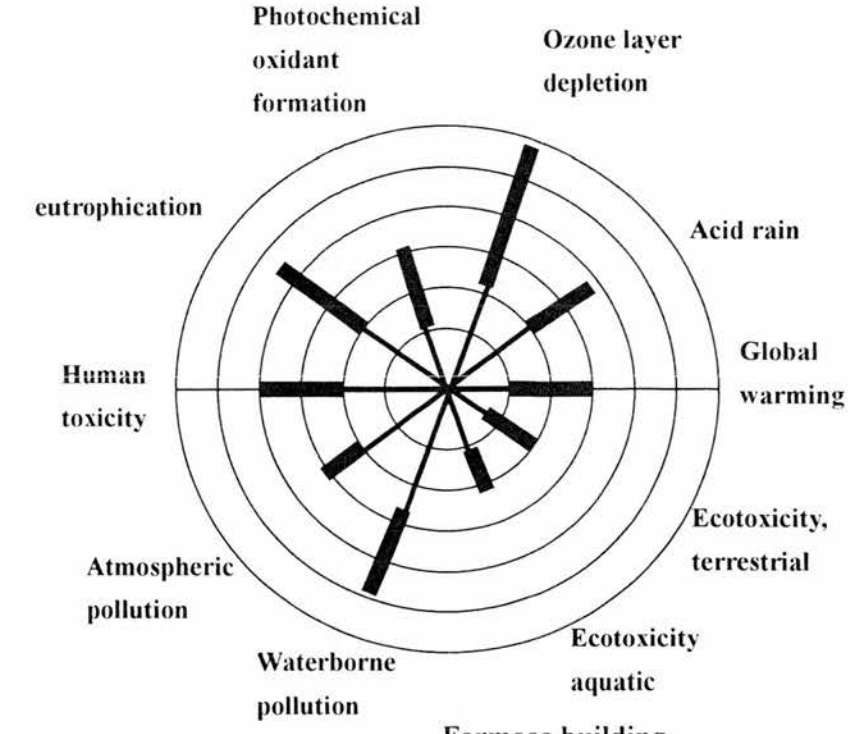
Table 13-8 : Results of TSP Monitoring during the Construction Period for the So-Go Building

Date	Wind Direction	Temperature (℃)	Moisture (%)	Weather	Wind Speed (m sec^{-1})	TSP Concentration	Difference	Average factor of Emissions $kg/m^2/month$	Emission	Construction Items
16/12/1944	North-east	31	36	Sunny	1.28	Up-wind 705 Construction 935 Leeward 1372	667	0.1922	1.13	Preparation
9/1/1995	North-east	26	48	Sunny	1.22	Up-wind 1082 Construction Leeward 2718	1636	0.5888	12.66	Excavation
2/3/1995	North-east	18	72	Sunny	0.74	Up-wind 655 Construction 1349 Leeward 788	1133	1.4467	9.60	Basement
27/3/1995	North-east	32	40	Sunny	0.65	Up-wind 586 Construction 865 Leeward 1182	596	0.2629	5.65	Lower level Structure
22/4/1995	North	28	60	Sunny	0.66	Up-wind 296 Construction 518 Leeward 458	162	0.1224	2.63	Upper level Structure
12/5/1995	North	30	48	Sunny	0.74	Up-wind 399 Construction 5014 Leeward 489	90	0.1064	2.28	Floor

Data source: Taichung Environmental Protection Bureau, 1998, pp. 6-16 and pp. 7-28



So-Go building



Formosa building

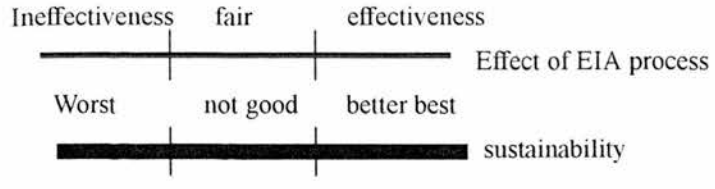
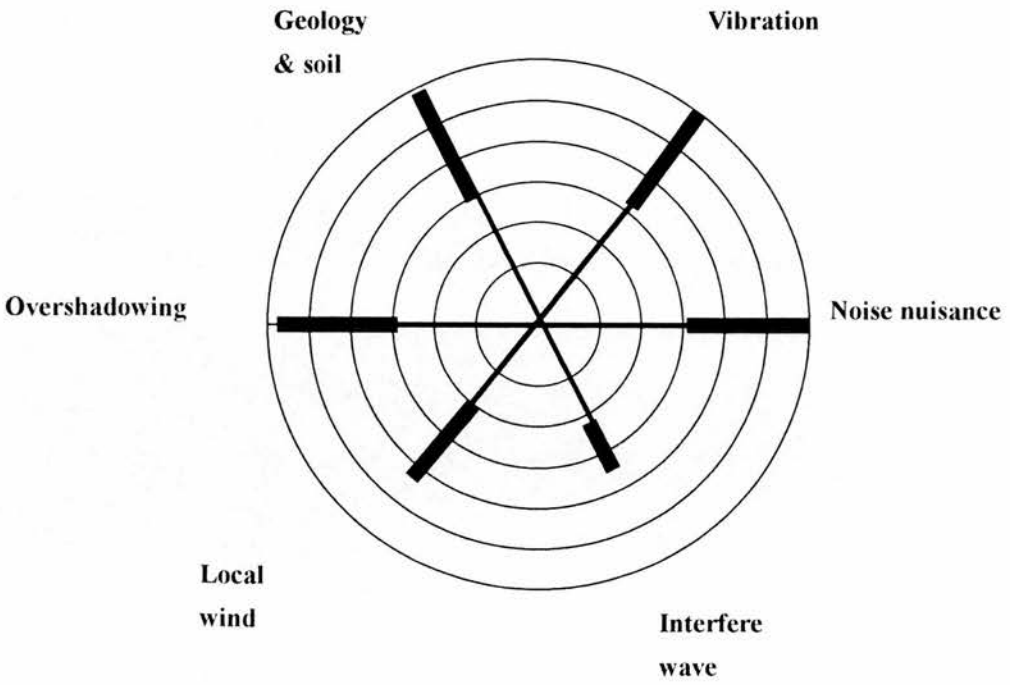
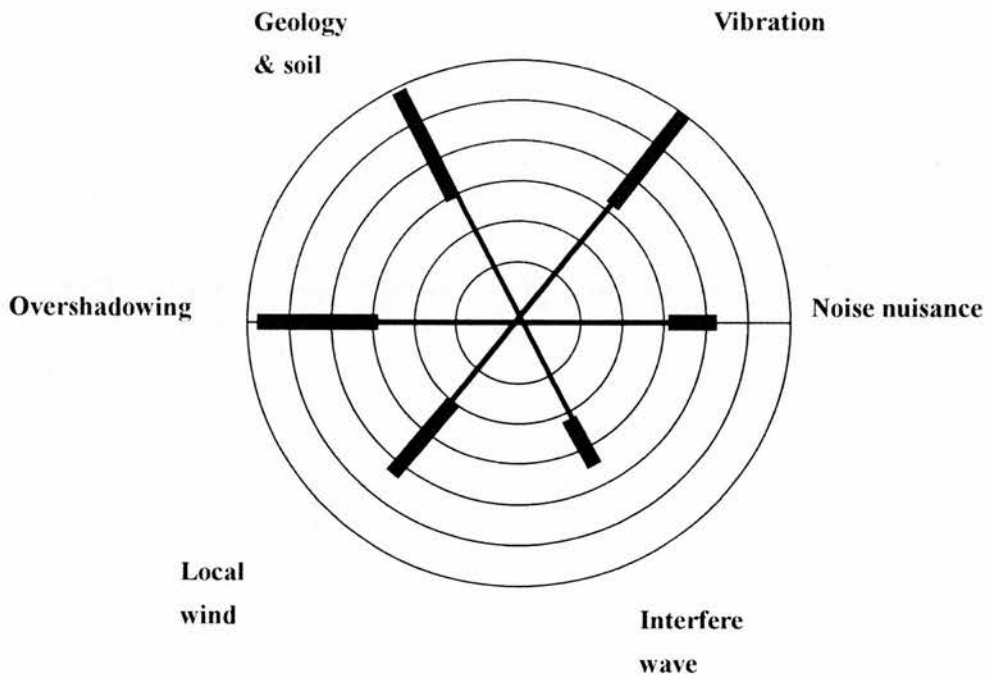


FIG. 13-5 The evaluation of effectiveness of EIA in carrying impacts of So-Go building and Formosa Building



So-Go building



Formosa building

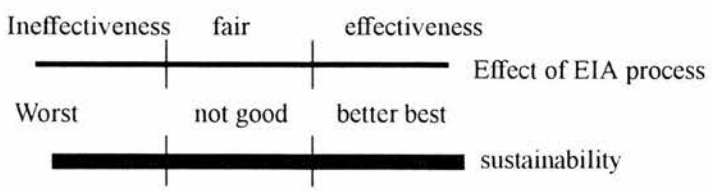


FIG. 13-6 The evaluation of effectiveness of EIA in local impact of So-Go building and Formosa Building

Regarding waterborne pollution, the key objective is to reduce pollutants so improving water quality and the aquatic environment. During the EIA process, as water contaminants are an assessment issue the effectiveness of water pollution assessment and mitigation measures is good. However, construction produces a lot of waste that are released into the river so the sustainability performance is 'fair'. The ecotoxicity of aquatic and terrestrial species are not assessment items rendering the EIA process 'ineffective'. As there are no overall plans to reduce contaminants, the sustainability performance does not meet the requirements.

In general, two of the ten (20%) environmental factors were assessed effectively during the EIA process and review. Regarding sustainable performance, only one of the ten (10%) environmental issues achieved sustainable development criteria.

Local Impact

The main objective for local impact assessment is to reduce the risks on the community (ie. human health and quality of life). There are six issues that must be examined when building high-rises: noise pollution; vibration; geology and soil; overshadowing of other buildings and land; local wind effects; and interference waves (see .Table 13-9).

Table 13-9: The Evaluation of local Impact Aspect of So-Go and Formosa Buildings

Item	SO-GO Building		Formosa Building	
	Effect of EIA process	**Sustainability**	**Effect of EIA process**	**Sustainability**
Noise nuisance	Effective	Better	Effective	Not good
Vibration	Effective	Better	Effective	Better
Geology & Soil	Effective	Better	Effective	Better
Overshadowing of other buildings	Effective	Best	Effective	Better
Local wind effect	Fair	Fair	Effective	Fair
Interfere wave	Fair	Not Good	Fair	Not Good
Overall Result				

Note : see Table 13-1

Noise pollution, vibration, geology and soil, and overshadowing were assessment issues for both buildings; all with alternatives and mitigation measures. The EIA process is, therefore, evaluated as being 'effective' and the sustainability performance is 'good'.

Local wind effects were also assessed for both buildings. However, as the So-Go building does not have to perform wind tunnel tests, mitigation measures do not reach expected objectives. However, interference effects by each building were not assessed, and there is no comprehensive plan to reduce any impact.

In general, most local impact issues are assessed during the EIA process so contributing to sustainable development. Of the six issues, the So-Go Building attained four, and the Formosa Building five, to a degree of 'effective'. As for the sustainability performance the So-Go Building achieved four out of four issues towards sustainable development, whilst the Formosa Building scored three out of six issues.

Socio-economic Environment

The main aim in this sector towards sustainable development is to promote a healthy economy and environment to meet people's needs and to improve the quality of life. This social environment aspect is to balance the urban population, to increase public services, build sense of community, and improve living standards. A healthy economy needs to be maintained to promote the quality of life while also protecting human health and the environment.

From a community population structure perspective, the objective is to balance urban population. During the EIA process for both buildings, the impact on the community and urban population distribution are assessment items analysing population movement and the impact of this on the environment. Therefore the EIA process is 'effective', with a positive sustainability performance (Table 13-10).

Economic environment; both the So-Go and Formosa Buildings are for business purposes changing the economic structure of western Taichung City from a mixture of secondary and tertiary industry, to solely tertiary industry. Therefore, during the EIA process advantages and disadvantages of changes to the industrial structure, land usage and economic transformation have been assessed and analysed. The result of the EIA process is 'effective' and the sustainability performance is 'positive'.

Due to an escalating population the demand on public facilities, including parks, schools, roads and

recreational facilities, is also increasing. High-rise buildings place very high demands on water, electricity, gas, and telecommunication facilities. This issue is assessed to reduce the direct impact, but the effectiveness is still limited as only a small amount of open space is provided to pedestrians (Table 13-10).

An increased population also increases the traffic load. Although this impact is assessed, there is no plan for an improvement strategy so traffic congestion caused by the two buildings is not efficiently reduced. The EIA process is, therefore, 'ineffective'. Car parking problems have predicted and dealt with, the EIA process is 'effective', and sustainability performance is 'positive' (Table 13-10).

Impact on the community's culture is small, nevertheless it is assessed in the EIA together with ecological and landscape issues. For the latter, as both buildings are sited on a main road in Taichung City improvements to the impact of the high-rise buildings have been made; an 'effective' EIA process.

In general, from a socio-economical aspect, two-thirds of EIA processes for both buildings were effective and helpful. Almost half the sustainable objectives were met for both building, therefore, the impacts of the So-Go and Formosa Buildings on the neighbourhood are 'good'.

Table 13-10 : Evaluation of Socio-Economic Aspects of the So-Go and Formosa Buildings

Type	Item	SO-GO Building		Formosa Building	
		Effect of EIA process	Sustainability	Effect of EIA	Sustainability
Structure of community population	Population	Effective	+	Effective	+
	Urban Population	Effective	+	Effective	O
Economic Environment	Industry Structure	Effective	+	Effective	+
	Land Usage	Effective	+	Effective	+
	Economy Change	Effective	+	Effective	+
Public facility	Public service	Fair	-	Failed	-
	Public Facility	Effective	O	Effective	O
Traffic impact	Transportation	Ineffective	-	Ineffective	-
	Parking Facility	Effective	+	Effective	+
	Community Safety	Fair	O	Fair	O
Community Culture	Community Culture	Fair	O	Fair	O
	Culture Asset	Fair	O	Fair	O
Ecology & Landscape	Ecology	Effective	O	Effective	O
	Landscape	Effective	+	Effective	+
Overall Assessment					

Note:

a. Same as Talbe13-5.

b. The impact of socio-economy is represented by +(positive impact), O(not much impact) and (negative impact).

c. The overall assessment is resulted from the among of "+" divided by the total items.

d. Legends same as table 13-1

13.4 SUMMARY

The effectiveness of Taiwan's EIA system was evaluated using the triangulation test (the 3P's, policy, practice and performance). This has been discussed from the implementation of the EIA system perspective, and sustainability performance (Table 13-11).

Among the 3P's, the policy dimension reached the highest degree of effectiveness, as about 64% of the issues met the necessary requirement. About 55% of the practice issues met their requirement whilst only 36% reached their sustainable development goals (Figure 13-6). In essence, Taiwan's EIA system is 'good', but the implementation process did not meet the EIA system goals.

In general, about half of the issues to determine the effectiveness of Taiwan's EIA system met their target. Shortcomings included the lack of public participation and its inappropriate timing. During the first stage of the EIS assessment the public briefing only occurred after the decision-making process was complete. Moreover, among development cases where an EIA process should be applied, 70% were decided at the first stage meaning a second stage assessment was not required. This second stage is where public participation occurs. There is a need for a public and juridical control mechanism to avoid arbitrary and capricious come outs.

Taiwan's EIA Act (1995) includes legislation for the application of a SEA, although guidelines were not completed until 1998. The range set needing to apply the SEA process does not actually cover everything likely to cause a significant environmental impact. Prior to 1998 there was no policy, plan or programme to which the SEA process had been applied.

Table 13-11: The Evaluation of the Effectiveness of Taiwan's EIA system

Aspect	Effectiveness	Item	Effectiveness	Issue	Effectiveness
Policy		Legal Regulation		Legal basis	
				Organization structure	
				SEA application	
				EIA report	
		Procedure		Screening process	
				Scoping process	
				EIA review	
				Monitoring & auditing	
		Decision-making		Alternatives	
				Mitigation measures	
				Decision-making support	
Practice		Execution process		Procedure compliance	
				Time & cost	
		Decision-making process		Decision-making procedure	
				Decision-making control mechanism	
		Monitoring		Mitigation measures execution	
				Follow-up the conclusion of review	
Performance		Natural Resource		Effect of EIA process	
				Sustainability performance	
		Carrying capacity impact		Effect of EIA process	
				Sustainability performance	
		Local impacts		Effect of EIA process	
				Sustainability performance	
		Socio-economic impact		Effect of EIA process	
				Sustainability performance	

Note:

a. few criteria are met (only about 25% of the issues)

b. about a half of the issues are met.

c. most of issues are met (about 75% of the issues).

 d every issue is met.

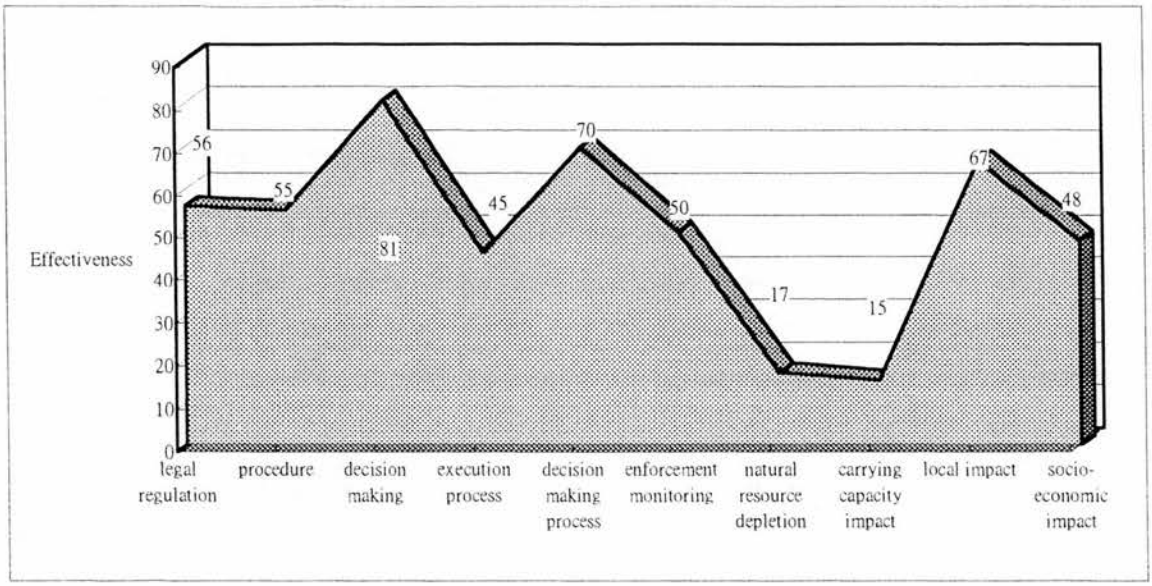


FIG. 13-7 : Evaluation of the Effectiveness of Taiwan's EIA system

There were also no criteria for the EIA report review process. After a decision was made there was no means to appeal if the public was dissatisfied.

The monitoring and auditing factor was one item with a low degree of effectiveness. This is because the process only starts after the construction stage. As there is no clear process and timing criteria, monitoring and auditing is of little effect.

From the timing and costs of EIA implementation, it appears that there is only a low budget for EIA, that time is short, and that manpower needed to carry out the assessment is not enough. This results in a long and descriptive but low quality EIA report.

There is not enough scope during the implementation of the EIA. Using the assessment of natural resource depletion as an example, only water consumption and solid waste disposal was assessed. This means that although there has been an EIA it is unlikely to meet sustainability requirements. This is also true for carrying capacity impact. Many important impacts, which may influence the environment, have not been taken into consideration eg. global warming, ecotoxicity, and acid precipitation. Aside from this, the whole building

life-cycle is not assessed as the EIA focuses more on the construction and operational periods rather than manufacturing, transportation, and demolition periods. This results in an 'under-estimate'.

Although only half of the issues in Taiwan's EIA system have met the evaluation criteria, the system is already a milestone in environmental protection in Taiwan. About 100 development proposals have to undergo an EIA each year. The outlook for Taiwan's environmental protection and sustainable development is, therefore, good.

CHAPTER FOURTEEN: CONCLUSIONS

This chapter contains research summaries and conclusions, a final discussion, and offers recommendations for the future. Section 14.1 begins the Chapter by presenting answers to the central problem. The development and implementation of the EIA system in Taiwan are then discussed in Section 14.2, and Section 14.3 is a summary of the comparison of EIA practice between the So-Go and Formosa Building case studies. Section 14.4 looks at the application of life-cycle environmental impact assessment (LEIA) to high-rise buildings, and analyses the environmental impact at each stage of the life cycle. In Section 14.5 the strengths and shortcoming of the Taiwanese EIA system are presented together with proposed recommendations for improvement. Section 14.6 gives a short concluding remark with suggestions for further research.

The relationship between the objectives (outlined in Section 1-4) and the structure of this research are detailed in Figure 1-4. Although previous chapters have covered these objectives in depth, in summary they are to:

- examine the development and implementation of the EIA system in Taiwan for high-rise buildings. To analyse potential factors that directly influences the EIA system.
- evaluate the effectiveness of the EIA system in Taiwan.
- present suggestions for the improvement of the effectiveness of the EIA system in Taiwan for high-rise buildings.

The first aim was discussed in Chapters Three to Eight. The second aim was analysed in Chapter Thirteen as a result of discussions carried out in Chapters Nine to Twelve. Section 14-4 will, therefore, examine the third and final aim.

14.1 ANSWERS TO THE CENTRAL PROBLEMS

The central issues to this thesis are:

- How effectively is the EIA system carried out on high-rise building projects in Taiwan?
- Which aspects can be considered effective or non-effective?
- How can the effectiveness of the EIA system be increased when applied to high-rise buildings?

The first two central problems, which were fully analysed in Chapter 13, are discussed and summarised in this Section. In brief, the effectiveness of the EIA refers to the promotion of a more sustainable development, and the acceptance of giving a development proposal the go-ahead. Based on this definition, a triangulation test evaluation of the EIA system in Taiwan was conducted, where about half the items evaluated met the set criteria.

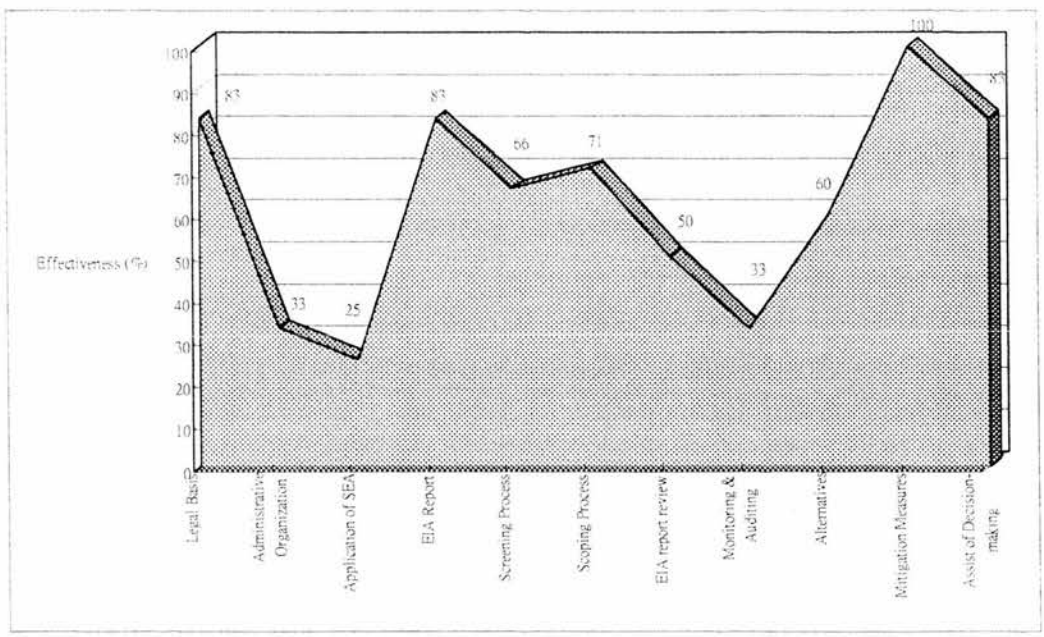


FIG 14-1 : Effectiveness of the EIA system: Policy

The effectiveness of the procedural and decision-making aspects of the EIA system was evaluated with respect to policy. Evaluation results indicated that three-quarters of the decision-making aspect, but only

about half the legal regulations and procedural items, were effective (Chapter 13) ie. more than 50% of the policy factor meets the principles for effectiveness in the EIA system. For evaluated targets, regulations related to mitigation measures are the most effective (100%), which reveals that in Taiwan more emphasis is placed on the presentation and assessment of mitigation measures. Three-quarters of the decision-making targets are met as policymakers cannot make decisions before the EIA report review conclusions. However, for the EIA report review to be objective and effective, a committee is established responsible for reviewing. Policymakers have to follow any conclusions made by the committee, which has the right to veto. At least two thirds of the committee members are scholars and experts, the chairman is an elected politician from the local government, and the budget is confined to the review of the public representative agency. The independence of the committee is, therefore, questionable.

At a legal level, the EIA system in Taiwan met most (four fifths) of the evaluation criteria. In addition, guidelines established by the EIA Act for new developments are well established. Nevertheless, the effectiveness of the SEA application is low with only one quarter satisfying the effectiveness criteria. A reason for this is that although SEA applications are clearly defined, the procedures and principles are not. Moreover, a SEA application does not cover all policies that will impose significant environmental impacts. Therefore, in 1998 there was no SEA applications as principles had not yet been completed.

The effectiveness of the policy aspect can be divided into strong, medium and weak categories (Figure 14-1). Strong effectiveness targets included legal basis, EIA report regulations, screening and scoping processes, alternatives, mitigation measures, and assistance with decision-making, more than three quarters of which met the evaluation criteria. Medium effectiveness targets include monitoring and auditing, and EIA review. This indicates that follow-up procedures are not effective as there are no clear regulations for the role and timing of monitoring, which makes it difficult to achieve all the goals of the EIA system. A weak category includes SEA applications and administrative organisation. As a SEA

application has never been practised the organisational structure has never needed to cope with the implementation of the EIA system although it is obvious that manpower is insufficient. As about 64% of the analysed items satisfy criteria in the evaluation of the effectiveness of an EIA, the design of the EIA system in Taiwan is fairly effective.

In the practice dimension, the decision-making process meets all effectiveness requirements. This includes that no decision can be made until the EIA committee reaches its conclusions, and that the decision is publicly announced. The effectiveness of the implementation of mitigation measures is low however as there is an insufficient enforcement of monitoring. Nevertheless, the implementation of the review conclusions is effective (three quarters), the reason being that many review conclusions have to be practised and finished prior to project approval ie. if the developer cannot attain requirements, the project is rejected. From an EIA practice perspective, only half the timing and cost factors are effective as the assessment costs of an EIA case, and the budget for environmental protection, are low. Naturally, a low budget will affect the quality of the report. Expenditure for an EIA in Taiwan accounts for just 0.09% of the total costs (against 0.6% in the UK). Environmental protection accounts for 1.3% of the total costs.

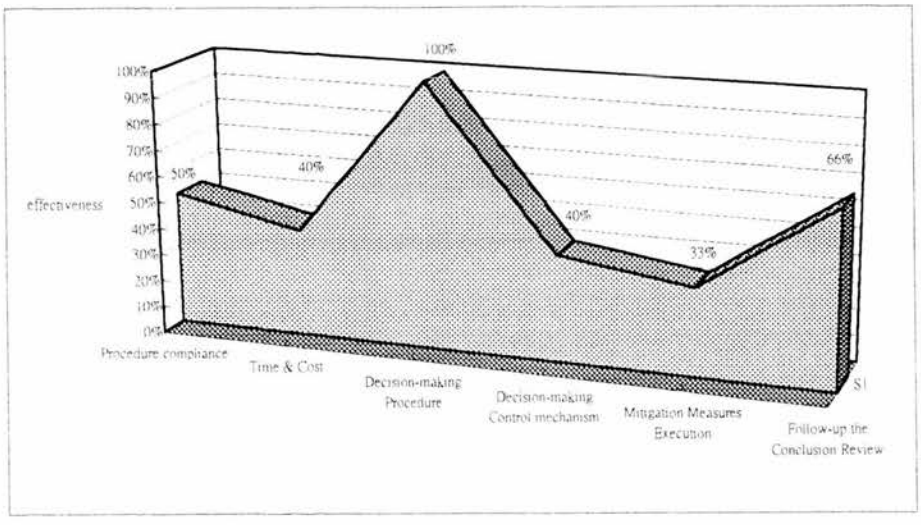


Fig 14-2 : Effectiveness of the EIA system: Practice

From the practice perspective (Figure 14-2) the decision-making procedure and the implementation of review conclusions are the most effective as over three-quarters of each aspect met the evaluation criteria. Procedural compliance, timing and costs, and the decision-making control mechanism are in the medium category as only half the evaluation criteria are satisfied. Scoping cannot be developed as the timing of public participation is too late, the channels for public participation are insufficient, and scoping is confined to the second stage of the EIA. Based on timing and costs, the duration of the assessment, the review period and time for decision-making are reasonable whilst costs tend to be low. Effective decision-making control mechanisms include professional and procedural. However, general public, judicial, evaluative, and outside agency control mechanisms do not function effectively. In addition, the implementation of mitigation measures falls into the weak category for EIA practice. This means mitigation measures and follow-up tasks are not carried out according to the EIA report, leading to a lower effectiveness of EIA practice.

From the performance aspect, the objective for sustainable development is evaluated. This research uses the So-Go and Formosa high-rise buildings as case studies. Evaluation criteria for sustainable development are divided into depletion of natural resources, carrying capacity, local impacts, and quality of life. The depletion of natural resources shows the lowest sustainability performance. Only the use of the water resource and solid waste disposal are listed as assessment items producing a positive effect during the EIA process. Other items, such as energy consumption, use of abiotic resources and recycled materials, and land use are not assessed resulting in a weak sustainability performance. The total energy consumption at each phase during the life-cycle of So-Go Building (where the occupancy phase is one year) is 1,476,512Kcal m^{-2}, which is more than that for general offices. The Formosa Building also exceeds use by general offices by more than 50%. As a result, the application of an EIA cannot effectively promote sustainable development for high-rise buildings.

To determine the effectiveness of carrying capacity and local impacts, damage to the carrying capacity of the environment, the risk to human health, biodiversity, and local impacts should be assessed and minimised ie. the lower the environmental impact, the greater the sustainability. In the evaluation of sustainability aspects of global warming, acid rain, photochemical oxidant formation, eutrophication, human toxicity, atmospheric and waterborne pollution, solid waste, local wind effects, interference, and ecotoxicity of aquatic and terrestrial habitats are assessed as bad or fair, only two fifths were sustainable.

As for the quality of life, two thirds were assessed as effective during the EIA process. Evaluation objectives include economic maintenance to promote a quality of life whilst protecting health and the environment. However, only half of the factors for sustainable performance met targets. Community population and economic environment are the most effective followed by ecology and landscape. Public service facilities and traffic impact noted a weak sustainability performance. This indicates that an EIA cases impose a negative impact on the level of public service facilities in the community.

With the integrity of policy, practice and performance, about half satisfy the evaluation criteria for an effective EIA. Policy was the most effective (64%), with practice at 55% and the sustainability performance of the building at only 37% (Figure 14-3). This indicates the overall design of the Taiwanese EIA system was good. However, due to manpower, structure, and psychological attitude factors, practice effectiveness was not so good ie. original design system goals cannot be met. There was a large gap between performance and the EIA goal for sustainable development as EIA concepts have not been fully mastered. Several important environmental impacts and issues were not assessed resulting in a weak sustainability performance.

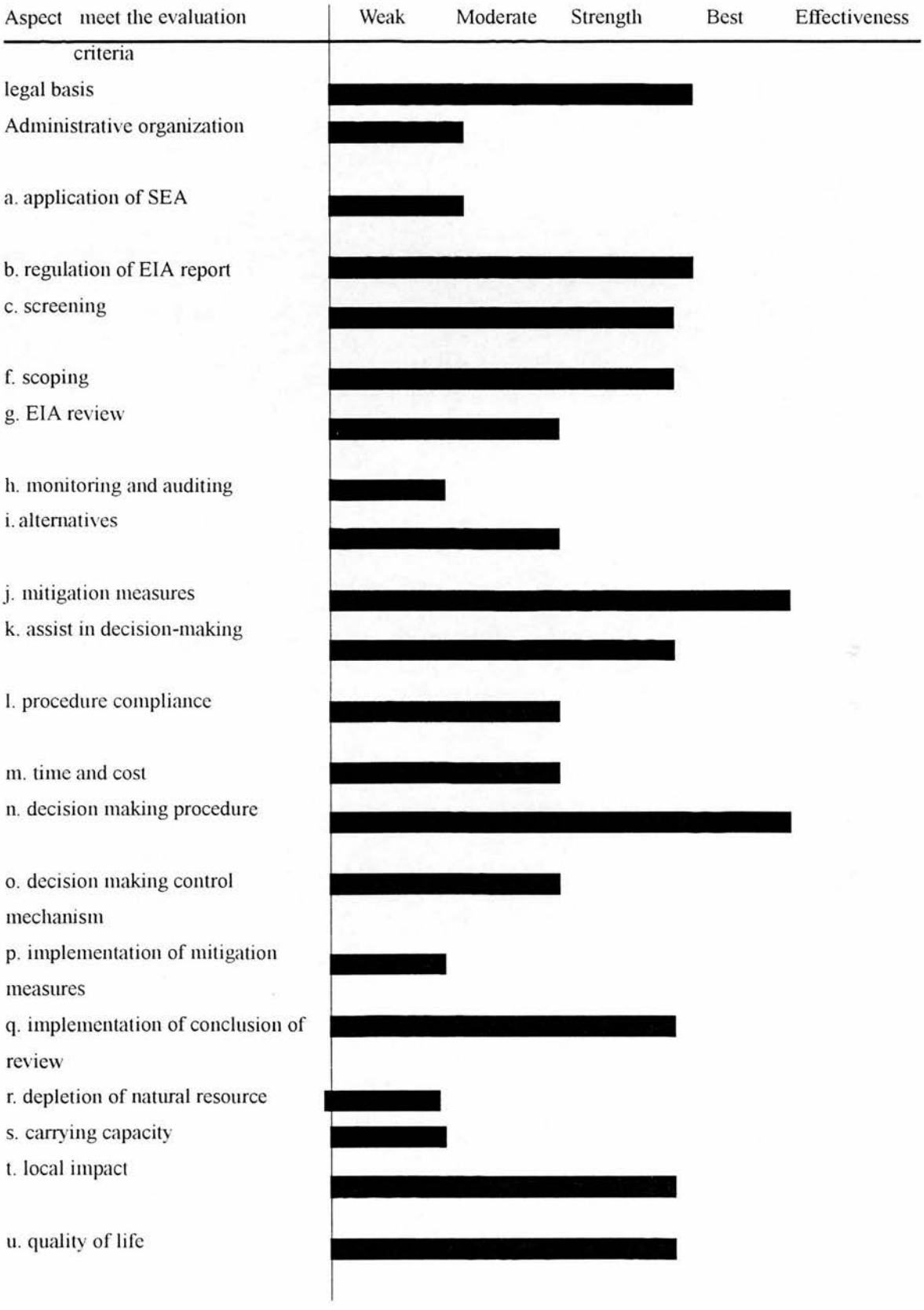


FIG. 14-3: Evaluation of effectiveness EIA system in Taiwan

The third problem tackled by this research was "How can the effectiveness of the EIA system be increased when applied to high-rise buildings?"

Improvements are necessary for those factors with a lower effectiveness as previously discussed. Consequently, the answer to this last question will be described through an effectiveness assessment structure. This section provides principle answers and suggestions for improvement (Section 14-5 for reference).

In the policy aspect, regulations for the SEA have not been established so there is no guidance for the present policy system. Specifications need to be set up immediately as, to date, no SEA cases have been implemented. A further obstacle is that there is no clear division between the intent and responsibility for monitoring and auditing. This results in a shortcoming of surveillance and monitoring after the implementation of an EIA so reducing the benefits of pragmatic practice. The EIA process starts too late and finishes too early. The timing of alternative assessments should be at an earlier planning stage.

From a practice perspective, the timing of the scoping process in the second stage of assessment is too late so an established structure is limited to the conclusions of the first phase. The function of scoping is not fulfilled. Furthermore, control mechanisms during the decision-making process lack general public, judicial, evaluative, and outside agency control mechanisms. Improvement can be achieved by ameliorating the timing of public participation. Thus, the central government needs to establish a set of performance criteria to observe and monitor the competent authority performing the EIA, and to define sanctions to develop the evaluative control function. For the judicial control aspect, the disputed issue of the plaintiff's standing concerning environmental protection should be relaxed so the general public and interested groups can file suits against unsatisfactory EIA decisions. Finally, as there is no specific

organisation or manpower to cope with the implementation of an EIA, no monitoring or surveillance is carried out. This results in low effectiveness of when implementing mitigation measures. Consequently, to ensure effective monitoring adjustments needs to be made to organisation and manpower.

As previously discussed, the sustainability performance for high-rise building is not effective. The major reasons are insufficient assessment items and inadequate building performance criteria. This results in an incomplete assessment of each sustainable development aspect imposed by high-rise buildings. Therefore, it is suggested that key sustainable development issues should be listed as assessment items for high-rise buildings eg. energy consumption, the use of abiotic resources and recycled materials, global warming, acid rain, eutrophication, human toxicity etc. In addition, the pursuit for sustainable development goals should be realised through assessment results by establishing performance criteria.

In summary, the EIA system in Taiwan is effective when applied to high-rise buildings (Table 14-1). However, some aspects still require improvement and specific suggestions are described in Section 14-5.

Table 14-1 : Development & Implementation of EIA System in Taiwan

Strengths	**Opportunities**
• Regulation of EIA report • Enforcement of EIA review conclusion • Decision making procedure • Reduce local impact • Preparing mitigation measures • Experts are increasing involved in integrated EIA • Closer contacts and sometimes partly integrated work between competent authority and environmental agency	• Application of strategic environmental Assessment (SEA) • Application of Life Cycle Environmental Impact Assessment (LEIA) • Increased Environmental awareness • Priority -setting • Extra costs for environmental adaptation and mitigation are often accepted at various stages of proposal • More attention is paid to EIA Act • Broader consultations
Weaknesses	**Threats**
• Lack of public participation • Lack of administration remedy • Weakness in monitoring and auditing • Lack of effective mechanisms for strengthening the EIA influence on decision-making • Weakness in quality of EIA report • Lack of bureaucratic organization for implementation of EIA system • Incomplete or inadequate consideration of alternatives • Lack of performance criteria	• Poor enforcement monitoring • EIA process starts too late and finishes to early • Ambiguity over regulation and definition • Lack of EIA credibility • Incompatibility of system • Lack of completeness and inadequacy of indigenous assessment techniques in assessing impacts • In sufficient and inadequate of scoping • Limitation of environmental issues coverage in the EIA process

14.2 DEVELOPMENT & IMPLEMENTATION OF EIA SYSTEM IN TAIWAN

Development of the EIA System in Taiwan

Over the last fifty years, as a result of the Taiwanese government's economic development and the nation's hardworking attitudes, an "economic miracle" was achieved. Since the 1980s environmental protection has become an issue throughout Taiwanese society with many of the public taking environmental pollution seriously and joining environmental organisations.

In the meantime the EIA system was being set up world-wide becoming a powerful environmental safeguard for the project planning process. The Economic Planning Council (EPC) introduced the American EIA system into Taiwan in 1975. The government ran a series of EIA demonstration projects to amass operational experience before establishing the EIA Act. From a historic perspective, the origin of environmental problems and the development of a corresponding EIA system in Taiwan have undergone four distinct phases since 1969 when the EIA was first established in the US. Table 14-2 shows the evolution of the Taiwanese EIA system highlighting the interrelationship between EIA establishment and national development.

Before 1980	**Development of concept of EIA system**
1980-1990	**Preparatory period of EIA legislation**
1990-1995	**Establishment of formal EIA system**
1995-presenet	**EIA action period**

Table 14-2 : Evolution of the EIA in Taiwan

Phase	EIA system	Social and economic	Environmental problems	Environmental policies	Environmenta legislation
Before 1980	**Concept development**	Economic development priority	Environmental problems emerge	Slow development	Aimed at hygie
1980-1990	**Legislation preparation**	Period of change	Promotion of environmental awareness	Pollution control	Unadaptable environmental laws
1990-1995	**Establishment of law**	Political situation destabilising	Local to global problems	Environmental management	Promulgation enormous law
1995-present	**Period of action**	Period of crisis and change	Environmental loading increasing	Think globally act locally	Delay environmental legislation

Implementation of EIA

The EIA system in Taiwan, operating now for over 20 years, can be divided into four phases. The EIA Act, a two-stage approach, was promulgated and implemented on 30 December 1994. It enforces those development proposals with a significant impact on the environment to carry out an EIA. For proposals with severe environmental impacts, a second-stage EIA process must be conducted.

In addition to assessment at the project level, there is also the tiering assessment concept introduced in the EIA Act of 1994. It means "governmental policies" are incorporated into EIA applications through the strategic environmental assessment (SEA) approach. This promotes EIA targets from the project level up to the 3Ps (policy, planning, and programme).

Since the first Taiwanese EIA project in 1980, the number of cases has increased yearly with 102 in 1998; an annual growth rate of about 20%. Of these EIA cases, high-rise building and new town construction projects make up the greatest (30%) proportion of the total followed by environmental protection projects (accounting for 15%) (Figure 7-5).

The cost of an EIA in Taiwan, which accounts for 0.098% of the total development costs, which is lower than that for other countries (between 0.1% and 1% Table 13-3). EIA costs for a high-rise building is even lower at only 0.06% (Figure 7-6). The average EIA cost is £57,000, and £16,000 for high-rise buildings. This is much lower than for development activities in other categories. The average duration for a case is about 34 weeks (8½ months) compared with 22 weeks in the UK, 80 weeks in Germany, 40 weeks in the Netherlands and between 48 and 72 weeks in the US. The assessment period for high-rise buildings is 18 weeks (4½ months), a little longer than the period for excavation and water supply engineering.

With respect to manpower, each case in Taiwan requires 33 people month. In the EU 40 people month are necessary indicating that employees needed to implement an EIA is insufficient. The highest number of employees in an EIA consulting company is 69, with 37.6% of companies having a workforce of 10 of less. Of these 58% have 5-10 years of experience. This data indicates that employee numbers and experience in Taiwan is low.

The average length of an EIA report in Taiwan is 162 pages. In the UK, 80% of reports are 21-100 pages long, and 65% are 51-150 pages long in Germany. The EIA report review and decision-making period in Taiwan lasts about 30 weeks (7½ months). The equivalent in the UK lasts 23 weeks, and 60 weeks in Germany. Concentrating on the review results, 5% of cases in Taiwan were overruled, which is slightly lower than "unsatisfactory and very unsatisfactory" cases (7%) in the UK and Germany.

In the Taiwanese case studies there was no public comment during the EIA processes, however the rate of no public comment in the UK is 20%, and 60% in Germany. In the UK and Germany respectively, 30% and 38% of cases has 1-10 public comments revealing public participation in Taiwan is low.

In Taiwan, reasons to overrule an EIA review report are mainly due to the carrying capacity of the local environment being exceeded, non-specific soil conservation programmes, insufficient water sources, severe traffic impact, and tremendous potential risks. For non-overruled EIA cases 30% are taken through to the second stage of assessment by the EIA committee. Among these, 47.3% are from the industrial sector followed by new town development. As these project types require extensive areas they impose far-reaching environmental impacts. The EIA committee decides on a second stage assessment when high traffic impacts are expected, or mitigation measures need further analysis.

Conclusions of the EIA review always include conditions for development approval. On average each EIA case has 12½ conditions that mainly deals with reminders and compulsory requirements. Mandatory requirements include raising the level of, and proposing plans for, environmental protection, the prohibition of certain types of development, and increasing monitoring.

The development of the EIA system in Taiwan has been a long process as it took 15 years from the first EIA demonstration project to the promulgation and implementation of the EIA Act. During this period, regulations were compiled for specific construction projects to aid the EIA process. As a result much experience has been accumulated. After the legislation of the EIA Act in 1994 the number of cases significantly increased. Suggestions for improvement are described in Section 14-5.

14.3 SUMMARY OF THE CASE STUDY COMPARISONS OF EIA PRACTICE

The empirical aspect of this research (summarised in Chapter 11) has revealed both similarities and difference between the So-Go and Formosa Buildings with respect to EIA practice.

The So-Go and Formosa Buildings are both private sector investments with 21 and 32 floors respectively.

The So-Go Building has a single use (department store) whereas the Formosa Building has a multi-use function (restaurants, offices, department stores and hotels). The Formosa Building has 149% greater floor area than that of the So-Go Building. In both cases the EIA process was conducted prior to the 1994 EIA Act. However, the Environmental Impact Differential Analysis Report (EIDAR) was used when a change in usage of the Formosa Building was necessary in 1998. With respect to development procedures, the So-Go Building used a gradual up-down (increment) approach. This is a three step process; a change in urban zoning followed by land reclamation and the EIA process which gives permission to build. However, the Formosa Building adopted the adverse approach; the EIA process is carried out first followed by changes in the urban zoning, an application for occupancy and finally an EIA process to cover building use change. The development period for both projects is 8 years, however that for the Formosa Building is more argumentative.

The preparation of the EIA report, for the So-Go Building took four months and 20 people-months. Its cost accounted for 0.083% of the project cost, which is lower than the 0.6% in the UK. However, the Formosa Building took eight months, 32 people-months, and accounted for 0.095% of total costs (slightly higher than for the So-Go Building). Greater human and financial resources were needed for the EIA report preparation for the Formosa Building. On examination of the content of the EIA report, predictions of environmental impact, mitigation measures, and alternatives (accounting for 2.8% of the report) are emphasised for the Formosa Building whereas the So-Go Building focuses on construction plan descriptions with no alternatives. The most important three sections of an EIA report are prediction of environmental impact, alternatives, and mitigation measures; accounting for 41.5% and 46% of the So-Go and Formosa Building reports respectively (and 34% of the EIDAR). These reports do not follow the general structure of EIA reports as over half the reports deal with project descriptions. This indicates that the quality of these reports needs improvement.

Report lengths are over 200 pages, double those produced in the UK and Germany. Although the prediction of environmental impacts cover a number of issues, over 70% are physical environmental impacts. Less emphasis is placed on natural resource depletion and social-economic impacts due to the absence of the scoping process.

The decision-making process for both cases was carried out during the 1993 economic boom. Several large investment projects were being developed in Taichung at the same time with a supportive attitude from the general public. However, the decision-making process for the EIDAR occurred during the Asian economic crisis (1998-1999). The location of the Formosa Building on a main artery, coupled with a deteriorating level of service on the roads, resulted in general public opposition to the project. This is illustrated by an ad hoc meeting held in the city council requiring the EIA to be carried out again. The decision-making process for the So-Go and Formosa Buildings took four and eleven months respectively. Professional and procedural control mechanisms took a leading decision-making role for the So-Go Building whilst public and outside agency control mechanisms were also important for the Formosa Building.

Public participation was limited to public meetings, and held after the completion of the reports. Consequently, public comments are difficult to present. There was no public participation for the EIDAR, which resulted in arguments and conflict during the decision-making period.

The major issue for the So-Go Building is traffic impact; however the change-of-use plan and applied procedures are necessary for the Formosa Building. As the Formosa Building adopts the adverse development approach the EIA process is conducted twice meaning the total EIA process period is 30 months (compared with 11 months for the So-Go Building). The EIA process has not finished despite completion of the Formosa Building in 1998 and acquisition of the occupancy permit. As a third of the

building has not been occupied for over a year the Daimaru department store has been forced to suspend operations and lay off employees due to tremendous financial burdens.

From a performance perspective, minor and moderate modifications to the EIA process are required for both cases. The environmental quality of decision-making for the two projects is better allowing the EIA process to take effect.

14.4 ENVIRONMENTAL IMPACT AT SPECIFIC LIFE-CYCLE STAGES FOR HIGH-RISE BUILDINGS

Environmental Impact during the Life-Cycle of a Building

Environmental impacts caused by the building sector in general are mainly the emission of pollutants, depletion of resources, and physical environmental impact. Greenhouse gases produced during the life-cycle of the building sector are largely CO_2, CH_4 and N_2O. Carbon dioxide has the highest emission rate and accounts for 36.1% of the total CO_2 emissions in Taiwan, higher than Japan (34%), and less than the UK (48.6%). In the life-cycle, the highest emissions are during the occupancy phase (53.3% CO_2 emissions) followed by 45.3% in the manufacturing phase, 0.9% during the transportation phase and 0.4% and 0.1% for the construction and demolition phases respectively. This implies that the use of fossil fuels is greatest during the operation and manufacturing phases. Emissions of total suspended particulates (TSP) is greatest during the manufacturing phase (57.6%). 23.2% is produced during the constructing phase, 12.8%, 6.1% and 0.3% in the transportation, operation, and demolition phases respectively. The main TSP source in the manufacturing phase comes from the production of cement, gravel, brick, steel, glass, and concrete. During the construction phase TSPs originate from floating particulates. The transportation phase produces the greatest volume of carbon monoxide (56.2%) in the building sector with the main source being the energy consumption of heavy duty diesel trucks (HDDT).

During the occupancy phase 23.3% is produced from the use of fossil fuel and vehicular exhausts.

Energy use is the main criterion in resource depletion. Total annual energy consumption for the building sector is 217,204billion Kcal. This accounts for 34.5% of Taiwan's total energy use, which is lower than Japan (36.8%), America (51.7%) and the UK (47%) (Table 14-5). The occupancy phase accounts for 55.3% of energy use in the building sector, followed by the manufacturing phase of 43.4% . The transportation, construction, and demolition phases account for 1.3%.

With respect to global warming potential (GWP), the equivalent CO_2 volume accounts for 36.4% in Taiwan. The occupancy phase produces the highest proportion (53.4%) in the building sector, and 45.1% during the manufacturing phase. The other three phases only account for 1.3%. 27.3% of the acid rain potential (acidification potential (AP)) is produced by the building sector in Taiwan. Again, the operation and manufacturing phases are responsible for the greatest emissions. The photochemical oxidant creation potential (POCP) for the building sector is 32.4% of the total amount produced in Taiwan. The manufacturing phase produces the highest volume, 69.8% of the building sector and 22.5% overall in Taiwan. The main source is proliferated hydrocarbons (HC) from evaporating organic solvents (eg. paint). The building sector accounts for 2.7% of the atmospheric pollution produced in Taiwan, with the greatest emissions occurring during the transportation phase (42.4%) followed by the occupancy phase (25.5%). Most atmospheric pollutants are of CO.

A Case Study for Environmental Impacts during the Life-Cycle Stages of High-Rise Buildings

Environmental impacts at each phase can be assessed using the LEIA concept. From Table 14-8 pollution levels of NO_x, TSP, CO_2, waste water, COD and SS can be determined for each case study. Emission levels during the occupancy phase (annually) are under 50%, which indicates that a significant under-estimation will result if just the occupancy phase is subject to an EIA. Levels of NO_x emissions during

the manufacturing phase are 56% and 52% for the So-Go and Formosa Buildings respectively (and 20% and 21% during the occupancy phase). These results are similar for TSP and CO_2 emissions. Carbon dioxide, a major greenhouse gas, accounts for 39% of the total annual emissions during the occupancy phase for the So-Go and Formosa Buildings. The proportion of waste water at each phase is 64% and 52% for the So-Go and Formosa Buildings during the manufacturing phase, and 34% and 46% in the occupancy phase respectively. Greater quantities of CO, HC, SO_x and Pb are produced, however, during the occupancy phase. CO emissions account for 82% and 85% of the total emissions and SO_x accounts for 79% and 78% (So-Go and Formosa Buildings respectively). This all indicates that the main pollution sources occur in the manufacturing and occupancy phases.

Resource depletion generally refers to energy and abiotic resource depletion, water resource use, use of recycled materials, solid waste disposal, and land-use. On examination of energy depletion, the manufacturing phase for the So-Go and Formosa Buildings accounts for 56% and 54% of the total energy consumption in Taiwan (41% and 42% during the occupancy phase). The So-Go Building consumes 1.477million Kcal of energy per $1m^2$ of floor area against 1.059 million Kcal for the Formosa Building. The manufacturing phase uses the greatest amount of water resources; the So-Go and Formosa Buildings account for 60% and 53% of the total water resource volume; the latter consumes more than the former .

For various environmental impact themes, the So-Go Building emitted 436.99kg per unit floor area of GWP. This is higher than the 295.65kg from the Formosa Building as the former consists of a greater volume of cement and concrete. 58% of the GWP comes from the manufacturing phase. The acidification potential at each phase is identical to the GWP. However, emissions during the transportation phase increased dramatically revealing significant acidifying emissions from trucks. As for solid waste disposal, the Formosa Building produces more for every $1m^2$ of floor area; 0.161 m^2 of landfill compared with 0.145 m^2 for the So-Go Building. The construction phase produces the greatest

quantity of solid waste mainly as waste soil.

A comparison of environmental issues between the So-Go and Formosa Buildings revealed that the energy use, global warming, ozone depletion, eutrophication, acidification, human toxicity and atmospheric pollution impacts are greater with the So-Go Building (Figure 14-4). The main reason being the greater energy consumption at each phase producing higher pollutant levels. The biggest difference between the two buildings was ozone depletion (the Formosa Building emitting just 65% that for the So-Go Building) indicating that the department store has a greater air-conditioning demand. Nevertheless, both buildings are substituting CFC_s with HCFC of a lower ODP so decreasing the ozone layer depletion impact.

The social-economic impact of both buildings arises during the occupancy and construction phases. The impact during the manufacturing phase refers to the construction of building materials, the proportion of secondary industry, and ecological and natural landscape impacts due to the extraction of minerals and aggregates. The social-economic environmental impact during the occupancy and construction phases can be divided into community population, economic environment, public service facilities, traffic impact, community culture, ecology and landscape factors. The primary social-economic impact during construction and demolition phases is traffic.

The sustainability performance for the So-Go and Formosa Buildings is shown in Figure 12-34. Ozone layer depletion, overshadowing of other buildings, community population, and economy indicate better sustainable development.

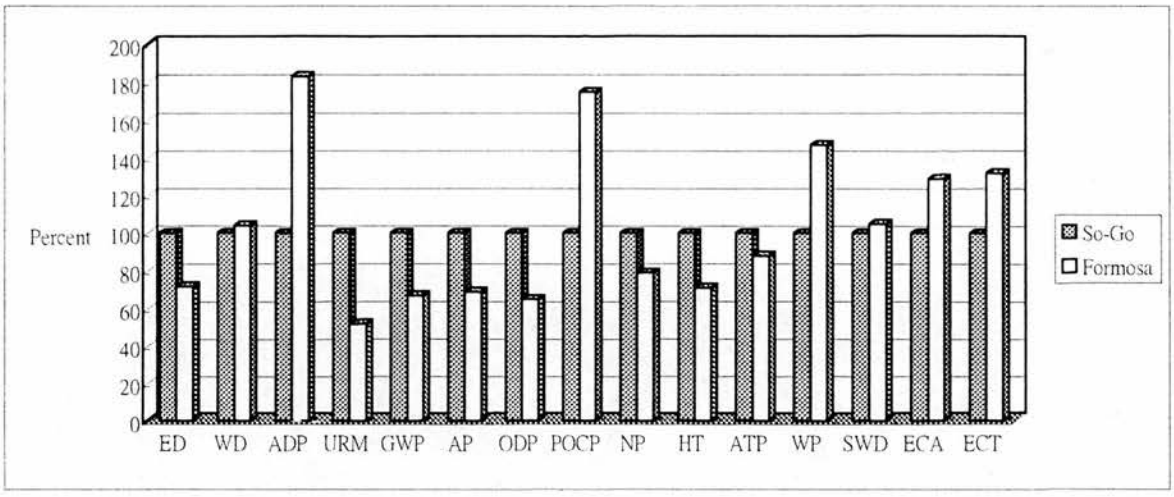


FIG 14-4 : Comparison of Environmental Impact Issues per Unit Floor Area between the So Go and Formosa Buildings

Notes:

a. Assuming the So-Go Building is 100%

b. Abbreviations:

ED: energy depletion; WD: water depletion; ADP: abiotic depletion potential; URM: use of recycled materials; GWP: global warming potential; AP: acidification potential; ODP: ozone depletion potential; POCP: photochemical oxidant creation potential; NP: nutrification potential; HT: human toxicity; ATP: atmospheric pollution; WP: waterborne pollution; SWD: solid waste disposal; ECA: ecotoxicity, aquatic; ECT: ecotoxicity, terrestrial

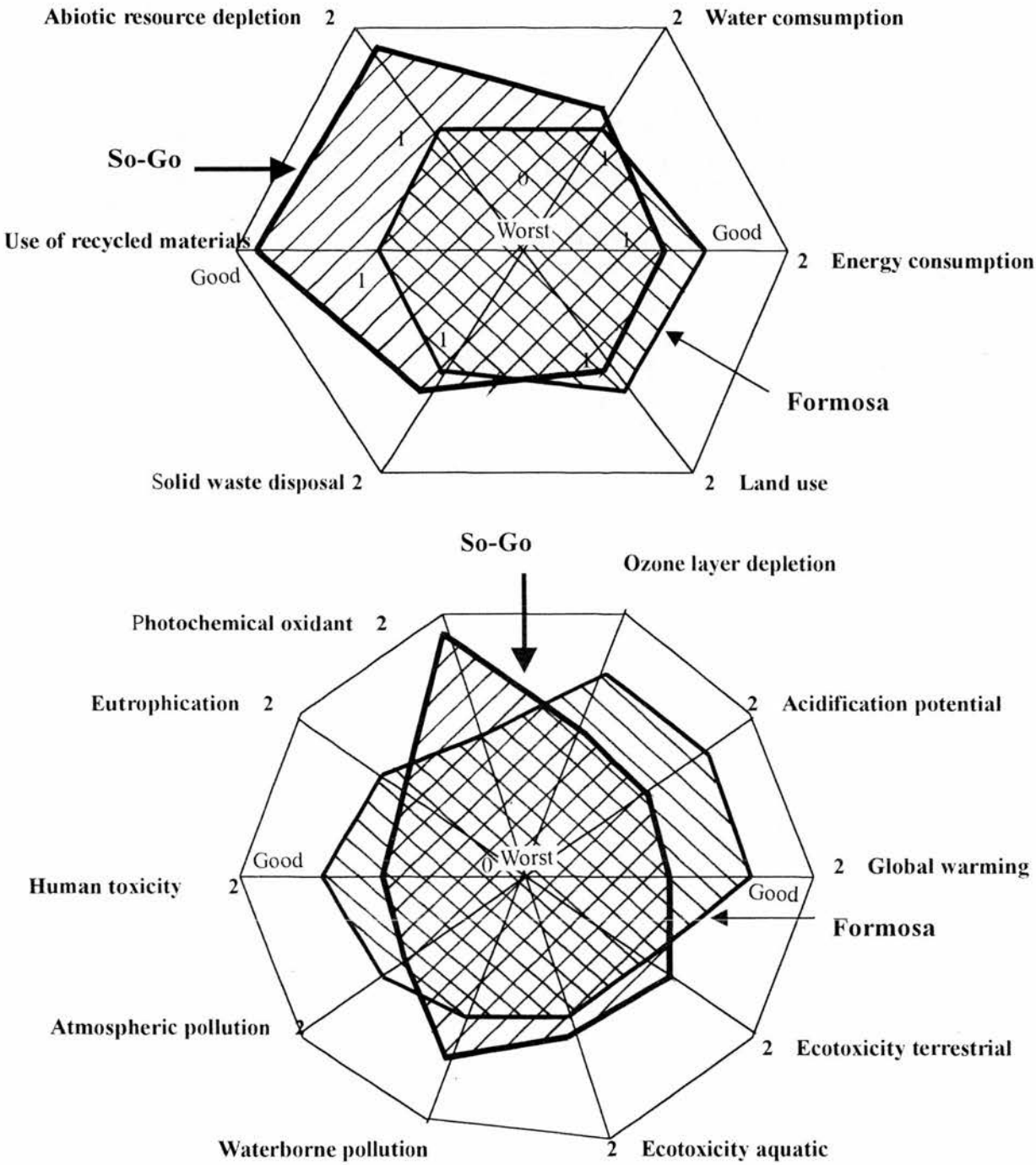


FIG. 14-5: Multidimensional metric of sustainability performance of So-Go and Formosa building (nature resource and carrying capacity)

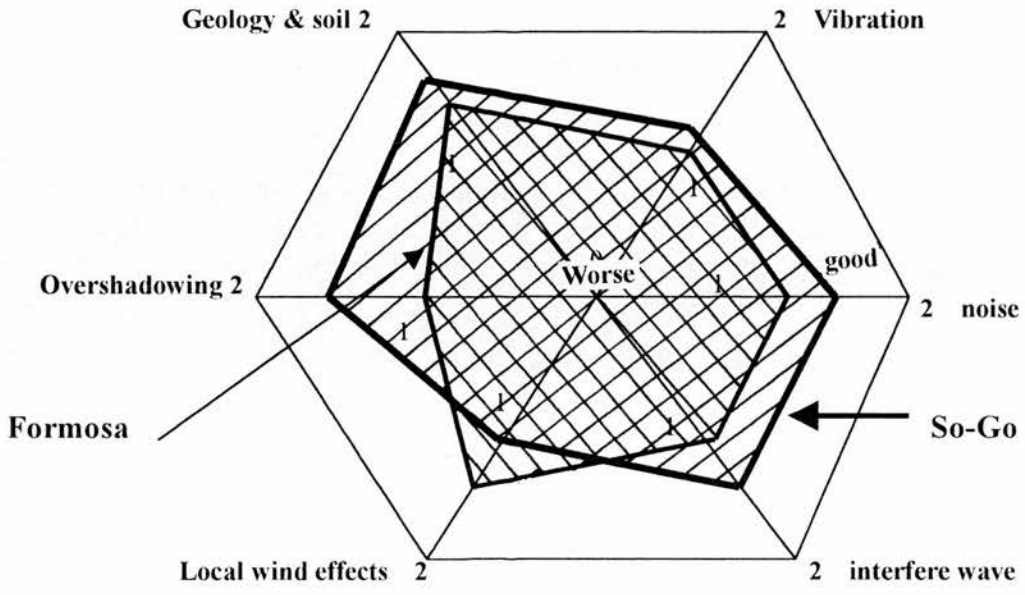


FIG. 14-6: Multidimensional metric of sustainability performance of So-Go and Formosa building (local impact)

14.5 RECOMMENDATIONS TO IMPROVE THE EIA SYSTEM FOR HIGH-RISE BUILDINGS

An assessment of the effectiveness of the EIA system for high-rise buildings in Taiwan has been conducted in Chapter 13. Improvement recommendations from the aspects of policy, practice, and performance are presented in concurrence with the evaluation results.

A. Recommendations for the policy aspect:

The main weaknesses in the current Taiwanese EIA policy is summarised as:

- **Lack of public participation**
- **EIA process starts too late and finishes too early**
- **Lack of regulation for formal SEA requirement**
- **Weakness in integrating EIA committee review conclusions into decision-making process**
- **Lack of administration remedy**
- **Weakness in monitoring and auditing**

A policy is a guideline to the implementation and basis of a system. Opinions to improve the EIA system are:

- **Insufficient public participation at the first stage of an EIA:** There are currently no channels for public participation prior to the EIS review during the first stage of an EIA case aside from the publication of the EIS review conclusions and public meetings after the EIA review. As a result, the timing of public participation is "notification ex-post". This does not meet the public participation principle of "in advance". Only open meetings are held indicating participation

practices are insufficient.

- **Late timing of public participation in the second stage of an EIA:** 70% of EIA cases in Taiwan are not required to enter the second phase. Thus, only 30% of cases are subject to the scoping and public hearing process. The timing for public participation is too late to meet the principle of early participation. In the EIA procedure the professional level in the latter phases is higher and as the modification space gets smaller the possibility for alternatives is lower. It is recommended that procedures should be changed (Figure 14-7) ie. the medium high style of public participation should be adjusted to a reverse triangle, and the unified style of professional (elite) participation to a triangular model (Figure 14-7).
- **NGO and general public opinion not expressed effectively:** Only related agencies and local residents can present their opinions within 15 days of a public hearing. NGOs, scholars, experts and the general public can only express opinions during hearings. Moreover, their suggestions are only for the preparation of the EIR as reference for the developer, who does not need to deal with them, or incorporate them into an EIR.
- **Inadequate paths for appeal:** There are no specific regulations against procedural violation of the EIA Act. Administrative litigation in Taiwan is only confined to legislative review conclusions and is only applicable to the developer, who is a stakeholder in the administrative decision. The general public, as well as NGOs, cannot use judicial channels to sue. Consequently, a third party must be incorporated into EIA litigation.
- **Implementation of SEA system:** Although the SEA is included in the EIA Act, relevant detailed regulations have not yet been completed. Thus, no SEA cases have occurred to date. It is fundamental that details for the implementation of the SEA should be established. There are only nine policies applicable to SEA at the moment. 3Ps with a significant environmental impact should be covered.
- **Unspecific regulations of monitoring and surveillance:** Using the case studies it has been

noted that monitoring has not been performed. Responsibilities are not clearly specified, which not only decreases the use of monitoring, but also influences the performance of the EIA.

- **EIA committee should only have the right to review:** The EIA committee currently has the right to review, makes decisions and veto EIA cases. This takes away the focus of the EIA committee from the review of environmental impacts as they have to consider the balance between economic development and environmental protection. The single primary review function ought to be restored to the committee. The decision-making right should be with the competent authority, and the right to veto modified to "the right of dissidents". Policymakers can combine the goals of economic development and environmental protection for a verdict for any arguments.

B. Recommendations for the practice aspect:

The main weakness in current EIA practice can be summarised as:

- **Lack of effective mechanisms for strengthening the EIA influence on decision-making**
- **Weakness in quality of EIA report**
- **Lack of bureaucratic organisation for implementation of EIA system**
- **Incomplete or inadequate consideration of alternatives**
- **Lack of means for ensuring development project has complied with mitigation measures and conclusion of EIA review**

Effective mechanisms need to be established to achieve policy goals. From the practice perspective, only half meet the effectiveness requirements. The following recommendations are presented to improve the effectiveness of practice:

- **Adjustment of organisational structure and manpower to cope with the implementation of the EIA system:** After promulgation of the EIA Act, human resource levels to cope with the implementation of an EIA were never adjusted. In the EPA there are five staff in charge of an EIA, with one person presently responsible for EIA tasks in each county and city. This understaffing means monitoring and surveillance is not performed thoroughly. Human resources for the environmental and competent authorities need to be adjusted.
- **Increase in quality of the EIA report:** The average length of an EIA report in Taiwan is 162 pages with alternatives only accounting for 1.1%. Currently manpower responsible for EIA projects is low (average 33 people-months per case). Staffing levels in the high-rise building case studies are lower than for general cases. This implies EIA report quality is not good. A system to train evaluation assessors, personnel and principles in order to improve the quality of EIA reports should be established.
- **Set-up evaluative control mechanisms:** The superior agency can monitor its subordinates through evaluation and establishing performance criteria to enhance effectiveness.
- **Policy decisions should not be made prior to the EIA process:** The EIA process for important development projects in Taiwan does not usually start until a decision has made. This overrides the function of an EIA. As a result, the system only serves to lessen environmental pollution and suggest alternatives. Public participation cannot be fully realised. Thus, the decision-making culture of the administrative organisations must be adjusted.
- **Promoting alternatives:** The presentation and assessment of alternatives in the Taiwanese EIA system is almost lost, as proved by the low proportion of alternatives outline in the EIA reports (just 1.1% in on average; 0% for the So-Go Building and 3.7% for the Formosa Building). From the case study analyses, alternatives generally consist of 'no action' measures. Technical, site, goal, time, and solution alternatives are not analysed or evaluated in depth. Therefore, specifications should be established and public participation needs to be reinforced to promote the performance of

alternatives.

C. Recommendations for the performance aspect:

The main weaknesses are:

- **Limitations of environmental issue coverage in the EIA process**
- **Lack of performance criteria**
- **Lack of completeness and adequacy of indigenous techniques in assessing impacts**
- **Weaknesses in assessment timing**

EIA performance refers to the output and practical perspective of assessment. Thus, recommendations are to improve assessment approaches, and to establish performance criteria:

- **EIA items should be expanded:** As the aim of the EIA system is for sustainable development, non-renewable resources should be used optimally, and renewable resources sustainably. However, as the EIA system in Taiwan places greater emphasis on physical environmental impacts. Aside from energy and water resources, natural resource depletion and socio-economic impacts are seldom assessed. Non-assessed items include abiotic resource depletion and the use of recycled materials. Thus, environmental impacts for a project cannot be completely evaluated. To expand the criteria assessed is the only means to accomplish sustainability goals.
- **EIA themes should be in line with critical international environmental issues:** According to the Kyoto Protocol for Global Warming (1997), Taiwan listed CO_2 emissions as an EIA item. Nevertheless, some items are excluded (eg. ozone layer depletion, acid rain and toxicity) that will impose significant global impacts. To fulfil the EIA aims, assessment should be extended to

cover critical global environmental issues.

- **Establishment of the LEIA approach:** An EIA in Taiwan mainly focuses on the occupancy and construction phases. However, environmental impacts result from all phases (eg. manufacturing, transportation, and ultimate disposal). Underestimation will occur if the occupancy phase continues to be the only stage assessed. A "from cradle to the grave" assessment process will reveal environmental impacts effectively.
- **Set-up of building performance criteria:** During the EIA report review process there are few performance criteria. This can result in controversial review conclusions that means the developer is unable to proceed with self-evaluation of the project towards environmental impacts.
- **Development of indigenous assessment techniques:** During the prediction process of an EIA, many foreign assessment models are quoted and introduced. However, as situations differ from country to country, direct application may lead to over- or understatement of environmental impacts. Therefore, a native assessment model must be established to make the EIA system more effective.

The above recommendations are proposed to enhance the effectiveness of the implementation of the EIA system. It aims to make decisions more acceptable, to accomplish sustainable development goals, and to raise environmental awareness.

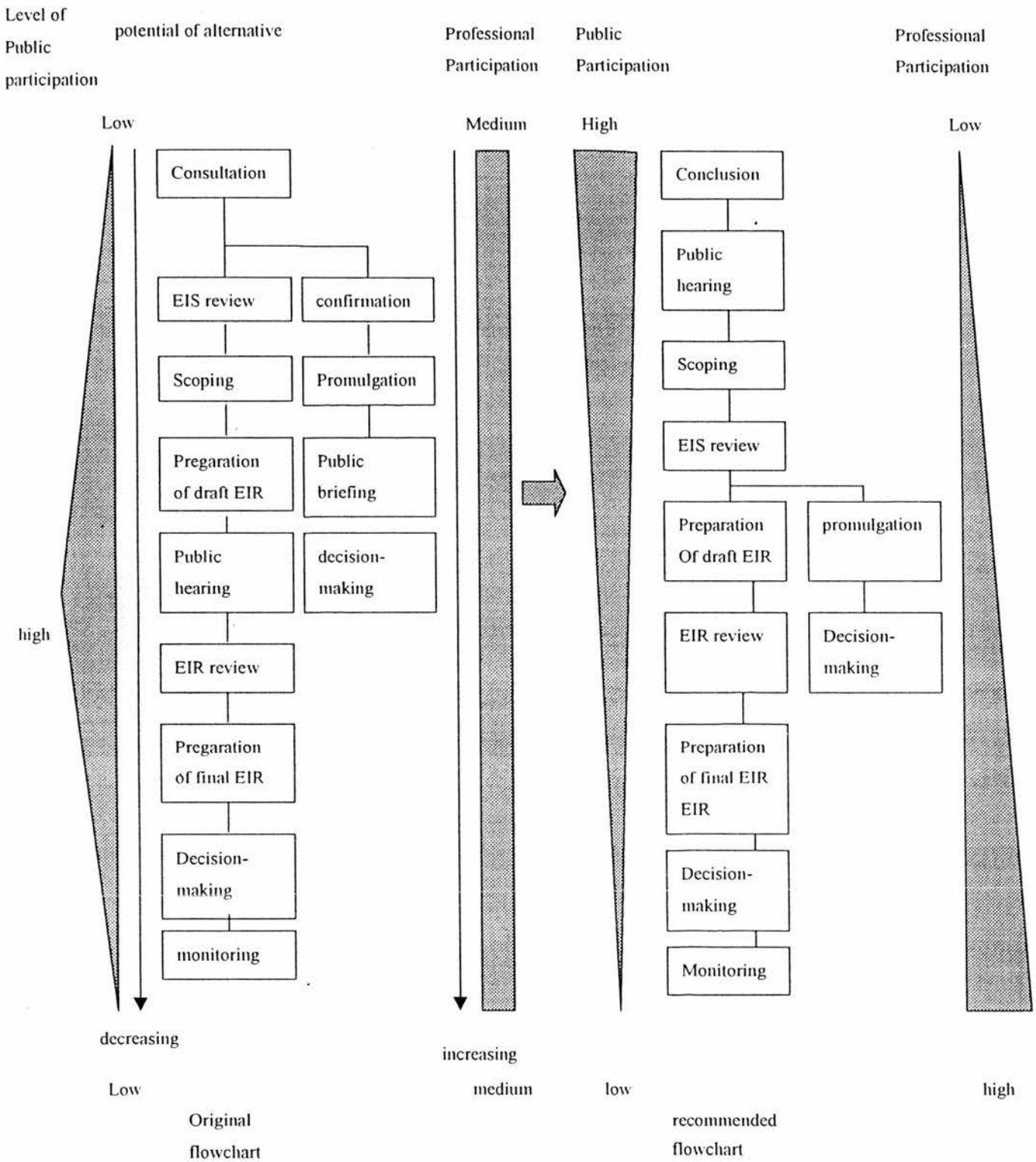


Fig. 14-7:A Concept of EIA Process Recommendations in public participation

14.6. Concluding Remarks

For those who are interested in further research on the EIA, it is suggested that impacts at each stage in the life-cycle of a various project should be assessed. Quantitative analyses should be made from a range of samples to establish performance criteria for each development project. Aside from those taking an interest in base-line research, specific impacts of assessment techniques or specific life-cycle phases could be targeted in order to set up an effective assessment model.

After the discussion of analyses and the aforementioned research, it is worthwhile to note that the EIA system for high-rise buildings in Taiwan has still not achieved all the goals set out in the original system design. Nevertheless, the decision-making process for a project has become more acceptable and sustainable. As the EIA system is vital to environmental management, political factors will undoubtedly become involved. Consequently, no matter how well a system is designed, participating parties and pressure from the general public will always be required to fully develop the function of an EIA system.

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APPENDIX B: TOWARD SUSTAINABLE DEVELOPMENT: IMPLEMENTATION OF THE EIA SYSTEM AND IMPROVED ENVIRONMENTAL DECISION-MAKING IN TAIWAN

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Introduction

The system now known universally as Environmental Impact Assessment (EIA) was first established in the United States. It originated with the US National Environmental Policy Act (NEPA) of 1969 which was implemented in 1970[1]. Many other countries have subsequently set up their own EIA systems. While some countries made special laws to deal with EIA issues others incorporated the essence of the EIA process into existing and related legislation such as environmental protection, land planning and urban development.

In summary, EIA is a process of predicting and assessing a development project's direct and indirect impacts on the environment. The conclusions of an EIA review, expressed as an Environmental Impact Statement (EIS), are used as a tool in decision-making by policy makers. The process aims to prevent environmental degradation by giving decision-makers better information about the consequences that development projects can have on the environment[2] The EIA system provides a key reference point for the overall planning of development projects with

the objective of balancing economical growth with the demands of environmental protection.

In this paper, the processes of change in the Taiwanese political and environmental administration system in response to the challenge of sustainable development is analysed. The paper reviews the historical development of environmental policy and EIA systems in the country and examines the institutional changes brought about by the public implementation of the EIA system.

The Historical Development of the EIA system in Taiwan

In the past fifty years the Taiwan Government's main focus has been on economic development. International reports have frequently cited Taiwan as an example of an "economic miracle"[2]. Though the economy of the country has indeed greatly improved over this period it has not been without cost. Quality of life has not enjoyed the same improvement as gross national product and since the 1980's, the state of the environment has been a matter of growing concern, leading to an active environmental protection movement[3].

Against this background and the emergence worldwide of the EIA system as a powerful environmental safeguard in the project planning process, the Economic Planning Council (EPC) first introduced the US EIA system into Taiwan in1975[4]. The Government began by implementing a series of EIA demonstration projects intended to provide the operational basis for the implementation of an EIA Law[5].

Since the time of these early trials, corresponding to the introduction of the US EIA system in 1969, the development of the EIA system in Taiwan has undergone four distinct phases. Table 1 shows the evolution of the Taiwanese EIA system in this period with indications of the interrelationship between EIA and the key stages of national development.

Table 1: Matrix of the evolution of Environmental Impact Assessment (EIA) in Taiwan

Phase	EIA system	Social & Economic	Environment Problems	Environment Policies	Environment Legislation
Before 1980	Concept germination	Economic development priority	Environmental program emerged	Slow development	Aimed at hygiene
1980-1990	EIA legislation preparation	Era of change	Promotion of Environmental crisis awareness	Pollution control	Unadaptable environmental laws
1990-1995	Establishment of laws	Political Situation became unstable	From local to global programs	Environmental management	Promulgation of Enormous laws
1995-	EIA action	The age of crises and changes	Loading of environment increasing daily	Thinking globally, acting locally	Delay environmental legislation

The "germination phase" - early development in the concept of EIA (pre- 1980)

The phase before 1980 was called colloquially the "EIA concept germination phase". This period saw the emergence of environmental protection as a growing political and legislative issue in Taiwan and the development of corresponding environmental policies. Prior to 1970 there were no laws specifically concerned with environmental protection and with the prevention of pollution[6]. Instead the emphasis was on economic development, as a national priority with a consequential neglect of environmental matters by government and public alike.

Under the economic development policies of this period Taiwan experienced high economic growth, expanding industrialisation and major development. Little regard was paid to the environmental impact of such development with serious consequences in terms of environmental degradation and pollution.

Growing recognition of the need to consider the environmental impacts of economic development[1] and to avoid further pollution at last led to the Economic Planning Council belatedly introducing the US EIA system into Taiwan, and proposing through scientific meetings of the Executive Yuan that the government actively promote EIA as a vital environmental protection

measure. The Government responded by implementing a trial EIA demonstration project.

Preparatory phase for the introduction of EIA legislation (1980-1990)

The second phase, between 1980 and 1990, constituted a preparatory period for incorporating EIA into the legislative system. An early demonstration programme for the development of an Industrial Park on the Northern Coast of Taiwan was trialed in 1980, with the purpose of developing a national EIA system..

Following these early trials, the Environmental Protection Bureau (EPB) of the Public Health Administration was established and was given responsibility for environmental matters including the establishment of EIA legislation. Early progress was discouraging and the first draft of an Environmental Impact Assessment Law presented by the EPB was rejected by the Executive Yuan in July 1983. More preparation and public understanding of the role of EIA was needed was clearly needed. The Enhancement and Promotion of the EIA System Programme was established and fourteen pilot projects were set up through which experience of the EIA process could be gained.

The Environmental Protection Bureau was upgraded to the Environmental Protection Administration (EPA) in 1987 (Huang, 1994), responsible directly to the Executive Yuan. Local environmental agencies were set up at the same time. The EPA issued technical manuals on the application of EIA to various kinds of development and this provided an important reference for the implementation of environmental impact assessment[7]. Large-scale development now became the subject of EIA review by the EPA.

The lack of hard legislation, however, weakened severely the effect of EIA procedures. Development proposals such as the fifth and the sixth light oil refineries were approved without the conduct of a formal EIA review.

The Enhancement and Promotion of EIA System Programme did, however, provide the EPA with essential experience and in 1989 the EIA Law, complying in essential respects with internationally established good practice, was finally presented to the Executive Yuan for approval. The Executive Yuan agreed the draft and submitted it to the Legislative Yuan for review in 1990[8] this marked the end of the preparatory phase.

The most important national change during this period was political reform. Taiwan had been under Martial Law, barring both political parties and free news agency. Martial Law was lifted in 1987 and with the lifting came a greater concern with social reform and environmental protection[9]. The public became increasingly dissatisfied with frequent pollution occurrences associated with major industrial developments, giving support to an effective protest movement and the emergence of Non-Government Organisations (NGOs) dedicated to the protection of a 'beautiful and healthful environment' for Taiwan..

The Establishment of a Formal EIA system (1990-1995)

With the referral of the draft legislation to the Legislation Yuan in 1990 three committees (interior, economic and judiciary) collaborated on reviewing the draft and agreeing amendments as appropriate. As a result of their work over a number of years, the process of EIA review was proposed as a precondition to the approval of development projects and greater openness in the process was introduced to ensure a higher level of public participation. With the passing of the first EIA Law in 1994/95[10] the process of environmental impact assessment was established as a major component of national planning and development.

To understand the full significance of this it is necessary to appreciate the corresponding shifts in social, political, and economic contexts during this period. The economy continued to grow, per capita income levels increased and demands for a good living environment amongst the public increased dramatically.

In the political arena, the parliament (Legislative Yuan) was completely re-elected[11], The result of

the second election meant that the seats held by the ruling party, Kuomintang Party (KMT), were greatly reduced to the benefit of the main opposition party, Democratic Progress Party (DPP) which won 51 seats. A genuine two party system now existed and in 1994, the first provincial and metropolitan city governor elections were held.

With the emergence of a strong democracy and effective opposition the environment became a major political issue in the face of both internal and external pressures to improve pollution control and the protection of wildlife. Following the Rio Earth Summit, threats of trade sanctions and further international isolation engendered a growing imperative for Taiwan to take its environmental responsibilities seriously. In May 1992 a clause that national policy would embrace the economic development and protection of environmental was inserted into the national Constitution. It was the first environmental clause in the constitutional history of Taiwan.

Agencies responsible for the protection of the physical environment had already been established by all local governments in Taiwan. Such agencies were particularly active and this period saw the enactment of a great volume of environmental legislation at a local level. Altogether some 106 new laws were proposed or amended, on average one every three weeks.

Whilst this achievement was substantial, the need for a strong national regulatory system to ensure effective enactment of the laws was essential because of lack of empowerment at the local government level. The EIA system provided this.

The EIA action phase (1995-present)

The fourth and current phase is the most challenging for EIA. In July 1997, the Asian economic crisis began and a financial storm spread from Asia to Western countries. Taiwan was not immune to this crisis and the New Taiwan Dollar underwent devaluation by 20 %. The growth rate of the economy dropped to 5.3 %. A series of emergency strategies were proposed including a programme to increase consumer demand. Under this plan, the Government decided to invest four

billion pounds in major construction programmes such as urban renewal, infrastructure, privately-owned power stations and so on. All have clear environmental significance and impact[12]

As a result of this policy, according to the World Bank's 1998 statistics, Taiwan is now in the top four countries in the world in terms of the global economic growth – an average 8.6 % of growth over the past 35 years[13]. The average GNP per capita has jumped to twenty-third in the world. The government is not only trying to accelerate internal industrial development but actively plans to turn Taiwan into a "technical island" as a means of attracting foreign investment.

In political terms, the first national presidential election was held in 1996. In 1997, the ruling party KMT lost seriously in the elections for mayors and magistrates. They won only eight out of twenty-one counties and cities. As a result, the central and local government now belongs to two different parties, with serious implications for the integration of national and local government legislative programmes[14].

The instability brought about by continuing military threats from the Peoples' Republic of China presents a further major challenge for political and economic development in Taiwan.

Environmentally, the international movement for global environmental protection continues to be a focus of debate in Taiwan. In December 1997, the Kyoto protocol calling for reductions in greenhouse gases emission called into question several important national investments, such as the seventh petrochemical factory. The government finally announced that from 1998 the emission of carbon dioxide would be taken into account in the EIA process. Furthermore, the EIA system is to be strengthened so that it operates to prevent environmental problems not just to identify them after the event. Of special significance here is the introduction by the government of a Strategic Environment Assessment (SEA) system with the focus on policies, plans and programmes, not just on projects.

The current state of Environmental Impact Assessment in Taiwan

When the EIA law was enacted in December 1994, it was believed generally to be an important milestone for environmental protection in Taiwan, raising both hopes and expectations. A review of the experience to date in the operation of the EIA system can reveal whether such expectations have been justified.

Under the present system in Taiwan the environmental impact of a development is assessed in two stages - through an Environmental Impact Statement (EIS) and through an Environmental Impact Report (EIR). Not all development projects need to be assessed by both stages. Only when the EIS concludes that the environment might be seriously impacted is the second report stage of EIA implemented

While based essentially on good international practice, the Taiwanese system has some unique features such as the separation of the EIS and EIR review and the transfer of the reviewing authority to environmental protection agencies from the so-called competent authority that has to take the final decision on the pertinent activity[15]. Under Taiwanese law, the process of EIA review gives the EPA effective power of veto over development projects. If the environmental impact assessment is not passed then the competent authority cannot approve a development project. Under these circumstances the developer can present alternative proposals for review.

The operation of the EIA system allows for the monitoring of environment impact both during the development and post-development phase of a project. The environment protection agencies supervise the implementation of EIS and EIR[16] and, if necessary, can request a developer to present an environment investigation report and to conduct an environmental difference investigation and analysis both before and after development. This repetitive monitoring process provides a significant constraint on the behaviour of developers.

The Structure and Characteristics of the EIA system in Taiwan

The first clause of the EIA Law defines the purpose of implementing the EIA system as the prevention and reduction of the adverse effects caused by development actions. The contents of the EIA Law can be divided into four objectives:

(a) To provide reference for government policy: in the process of government policy-making, economic benefit cannot be the only consideration.

(b) To manage national resources effectively: the EIA system focuses on the management of resources and on environmental protection. Resources can be utilized effectively through impact assessment mitigation measures.

(c) To prevent adverse effects in advance: preventing public pollution and adverse effects are the main points of EIA system. Implementation of mitigation measures are designed to prevent or reduce adverse effects.

(d) To let the public participate in decision-making: the focus of the EIA system is on participatory planning and analysis through which environmental NGOs and the general public can join together to ensure that developments satisfy best environmental practice.

Development projects that are judged not to cause major impact on the environment may start development after the EIS stage has been passed[17].

When the competent authority submits a development proposal for EIA to the EPA for both EIS and EIR review (if the matter is necessary) the proposal is reviewed by an EIA committee which includes more than two-thirds experts and academics. The duration of an EIS is fifty days and an EIR sixty days. The conclusion of the EIA review committee is legally binding. Without EIA approval the competent authority cannot permit the project to go forward.

Eleven kinds of construction come under EIA legislation. Whether these constructions need to be submitted for an EIA procedure depends on the level of environmental impact envisioned, as defined by the legislation.

Public participation

The basic purpose of public participation in the EIA process is to raise the efficiency of the system and public confidence in it.

Overall, the process of public participation includes feed-forward and feedback. Feed-forward means that the Government must transfer information to the people most concerned about the development project. Feedback means that the public must be able to transfer information directly to the government to be taken into account in the decision making process.

In the implementation of the EIA system in Taiwan, interested public groups can be divided to the following categories: the general public, minority races and aborigines, NGOs, experts and academics, other government authorities, and commercial and industrial associations[18]. There is also a vital role for an informed media.

Public participation in the EIA system takes many forms. The most common ways are public announcements, public readings, public briefings, opinion consultation, opinion polls, public hearings and review meetings.

Application of strategic Environment assessment

Since the first EIA trials in 1980, the system has had a positive influence on environmental management and sustainable development in Taiwan. The system, however, has its weaknesses. It fails, for example, to provide comprehensive protection of the environment from cumulative impacts of multiple projects. Improvements are sought through the introduction of a system of Strategic Environment Assessment or SEA.

According to legislator Peng, Pai-hsien[19]:

EIA only includes development ***projects,*** *but according to evidence and examples from many countries some of the government's policies will also have major impacts on the environment. Changes in exhaust discharging standards for cars and motorbikes, alterations of waste water discharging standards for factories, urban planning changes, amendments to national parks legislation and bans on the catching of fish by drift and gillnet, etc. are examples of government policies which may have larger long term impacts on the environment than specific development projects. Such government policies should be included within the scope of EIA.*

The proposal of legislator Peng won majority support amongst members of the legislature. As a result, the SEA system was officially incorporated within EIA law. The amended law applies only to government policies that "might impact upon the environment". There are ten policy areas listed in the SEA Regulations, including industrial development, mining development, water conservancy, land use planning, energy plans, livestock-raising, traffic, waste disposal and radioactive nuclear waste disposal policies.

The SEA system aims at the assessment of what are known as "PPP"s standing for policies, plans and programmes) In comparison with the application of EIA to development projects, SEA policy levels are, as the name makes clear, more strategic than tactical and SEA assessments items do not need to be as detailed and specific as under the EIA system. On the other hand, strategic policies will have influence over the large-scale and over many people. The scope of SEA is therefore greater than EIA and includes concern for the carrying capacity of environment,

the health of natural ecological system, natural resource management and issues covered by international environmental treaty.

Taiwan's SEA system is concerned with following scales:

(a) Regional, requiring assessment of impacts on of geographical areas within Taiwan

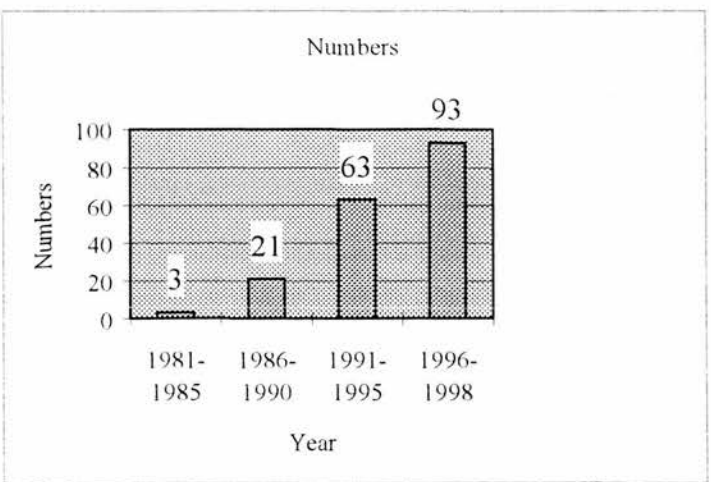
(b) Nation-wide, requiring assessment of impacts on the environmental carrying capacity of Taiwan

(c) Global

The Implementation of EIA

Taiwan has now implemented a system of Environmental Impact Assessment for almost twenty years from the time of the first trials. Since EIA law was first passed at the end of 1994, the number of EIA cases has increased sharply year by year (See Figure 1).

Figure 1 The Situation of conducting EIA case (average annual)



The average cost of an EIA assessment, based on a sample of 581 cases before 1998, 1998b) was £57,000 This is equivalent to around 0.1 per cent of the total engineering budget. This is significantly lower than the corresponding costs in the United Kingdom.

The assessment time of these 581 EIA cases - the time from when assessors start the assessment process until the the time the EIA is completed and submitted to competent authority - varied

from 2.5 months to 18 months. On average this assessment time is 9.9 months, compared to 4.5 months in the UK[20].

The EIA process includes both EIS and EIR. Table 2 provides an analysis of the breakdown between the EIS and EIR processes.

Table 2 analysis of EIS and EIR frequency of review (1997)

Number	Case	Percentage (%)
More than 4 times	7	9.6
3 times	22	30.1
2 times	39	53.4
1 times	5	6.9
Total	73	100

In the 77 cases reviewed in 1997, fifteen were EIR reviews and the rest (62) EIS reviews (EPA, 1998a). In the EIS review, one out of three cases were selected for second stage assessment.

Table 3 : Type of EIA case needing second stage assessment (1997)

Type	Case	Percentage(%)
Industrial park	9	47.3
Cultural & educational Facility	2	10.5
Flood prevention , water Drainage	1	5.3
New town construction	3	15.8
Mass rapid transit	1	5.3
Energy development	2	10.5
Railway (high-speed railway)	1	5.3
Total	19	100
Percentage in total EIA cases		30

Conclusion

Whilst evidence for the full level of effectiveness of the EIA system in Taiwan is still being gathered, it seems clear that Taiwan's system does start to meet the main objectives of EIA, namely:

- The improvement of the quality of decision-making from an environmental perspective
- The identification of ways to avoid or reduce environmental impacts
- The raising of environmental awareness

EIA is seen as an important tool for sustainable development and for environmental management, but it is just that – a tool. How effective it is depends on how well the tool is used and that needs political will and political wisdom. Only time will tell if these are available in sufficient quantity to make a difference.

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[9] Up until the mid-1980's, the opposition party in Taiwan had been banned under Material Law. The DPP started integrating with anti-KMT factions by the late 1970's and emerged as an important political force before it was permitted legally.

[10] Legislative Yuan (1996), *Official Report of session 74* Volume2, Legislative Yuan, Taipei

[11] The so-called congress in Taiwan has two Yuans. One is the Legislative Yuan and the other is the National Assembly. The Legislative Yuan in Taiwan is an organization to legislate laws and a supervising organisation over the Executive Yuan. Its position is more important. In 1992, there was a complete re-election in the Legislative Yuan.

[12] The Central Daily newspaper, International Section, 17th August, 1998,Taiwan.

[13] According to statistics from the World Bank, the highest economic growth over the past 30 years is attributed to Botswana (13%), the second is Oman (9.5%) and the next to South Korea (8.9%) Source is the (Central Daily newspaper, 26th November 1998, International Section).

[14] In August 1998, the central government asked the Taipei City Government to destroy the

Chung-Sun Bridge to prevent flooding. The Taipei city government refused.

[15] Mostert, E. (1996) , *Commissions for Environmental Impact Assessment*, Ph.D. Dissertation , University Delft, Rotterdam,p.27.

[16] EPA (1995), *Guideline of Environmental Impact Assessment for High-rise building* , EPA, Taipei,p.5.

[17] EPA (1998) , *Conclusion of reviewing Environmental Impact Assessment*, EPA, Taipei,p.51.

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[19] When the EIA law was under its Second Reading in the Legislative Yuan, Peng Pai-Hsien proposed to add the SEA regulations and this was agreed by other legislators. See the Official Report of the Legislative Yuan, p72 Volume 2 the 74th Session meeting records.

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APPENDIX C: SUMMARY OF THE BOOK *PLANNING AND ENVIRONMENTAL IMPACT ASSESSMENT*

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Hsiao is recently engaged in research toward a PhD in the Edinburgh Sustainable Architecture Unit (ESAU) of the University of Edinburgh.

1. SUMMARY

This book treats the subject of planning and Environmental Impact Assessment (EIA) - not a new subject, but newer than many may suppose. The issue of spatial planning in Europe has accompanied the historical development of the EU and each of its national economies. In the UK, the integration of planning with the EIA system in 1988 was a milestone in spatial policy development: linking urban and national planning activity with environmental issues is one way in which society seeks to control its surroundings and move towards sustainable development. This book offers an overview of the important issues arising from physical environmental planning in Europe (and most specifically the UK).

Chapter One offers an interdisciplinary and integrated account of environmental issues. It explains four aspects of the context within which contemporary environmental issues arise. The first is the concept of utilitarianism which has distorted the meaning of development by stressing its primacy and, in that process, has changed our perception of the environment. The second is the impact of population and economic development. The third focuses on the distribution of profit and over-exploitation. The fourth presents an account of the depletion of natural resources. The concept of sustainable development is the central keynote throughout this chapter for the term suggests a desire to ensure that economic activities remain compatible with the needs of the environment.

Chapter Two addresses European spatial policy and planning. There is now a substantial body of European Union (EU) policy-making which has specific spatial objectives. While this body of policy has evolved over many years, the 1990s in particular have seen a resurgence of interest in national and supranational spatial planning and in the field of spatial planning studies as a whole. Partly, this resurgence is a response to economic integration and the single market and to new or improved infrastructures. The chapter offers an account of the development of the EU, the introduction of European administrative and legislative systems governing the environment in European countries, planning systems in Europe and the concept of planning and planning policy in Europe today.

Chapter Three examines the UK's administrative system. Throughout, it attempts to present contemporary central and local government in a way that may influence the control of development and environment management. There are four sections in this chapter. The first introduces the development of government, outlining various aspects of the function of the Royal family. The second considers the roles played by the Prime Minister and the Cabinet and outlines the functions of the head of government. The

third looks at the emergence and development of the UK Parliament. The final section deals with the system of local government in the UK, introducing its main current issues and characteristics, including how the 64 new unitary councils have come into being, how Londoners are to vote in a referendum on a new strategic council and how the Lords' Report backs new local powers.

Chapter Four presents the UK's physical planning system and authority. It describes the system that deals with environmental management affairs and development control applications. The first section introduces the development of the UK planning system. The Town and County Planning Act of 1947 (which came into effect in 1948) provides the framework for the legislative system governing planning. After half a century it has come of age as a very important professional activity. The second section looks at the structure of the UK's planning authority. The third deals with the central planning authority, i.e., the Department of the Environment, Transport and Regions (DETR). The final section is concerned with the characteristics of the EPA, one of the main agencies in the planning system. Within district and country councils, planning and development activity is normally controlled by the Planning Committee, which consists of elected councillors selected from the full Council membership.

Chapter Five outlines the legal basis to development control and planning. The first section looks at the area of planning permission which is concerned with the legal definition of development. In the UK, planning permission is required before any land can be developed for economic activities or building projects. The second section focuses on the procedures for applying for planning permission as they are a legal requirement for the granting of a valid planning permit. The next section examines the nature of UK planning permission. The final section looks at how the system is implemented and includes the major issues to arise in controlling development and in the granting or refusal of planning permission.

Chapter Six begins by explaining the origins of the EIA system, an assessment exercise which is important for only a few highly significant applications. A small number of planning applications which have significant environmental impacts are required to undergo an EIA. The second section looks at the concept of the EIA. The final section outlines EIA procedures and themes. Arguably, all development activity has some need for an EIA. Even quite minor proposals need to be assessed by the developer and the EPA to check whether they are likely to have negative environmental effects and whether those impacts can be forestalled or minimised. In the context of this chapter, however, our concern is with large or significant projects. The EIA is a process, part of which consists of making an Environmental Statement (ES) to accompany the planning application. The EPA takes the ES into account when deciding on whether to grant or withhold planning permission.

Chapter Seven presents suggestions on how the UK's experience can be used to guide Taiwan's control over its development activities.

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APPENDIX D : ANALYSIS OF ENVIRONMENTAL IMPACTS OF THE LIFE-CYCLE OF BUILDINGS

Assessing the environmental impact of a high-rise means more than merely examining its effects when occupied. Throughout the various stages of its life-cycle it consumes energy and resources and generates emissions. Its consumption refers to more than its immediate gas and electricity requirements; every item that goes into its construction (including bricks and steel) consumes natural resources and the task of building it and disposing of it consumes energy as well. As a result, a comprehensive assessment of its environmental impact must evaluate its entire life-cycle which we can divide into six stages: the production of building materials, the transportation of materials, the construction phase, the occupancy phase, maintenance and repair, and demolition. The environmental impacts of each stage are listed in Table D- 1.

Table D- 1: Major Environmental Impacts at Specific Life-Cycle Stages of High-Rise Buildings

Life-Cycle	Assessed Item	Environmental Issues
Manufacture of Materials	Pollution, resource	Natural resources depletion Emission of pollution
Transportation of materials	Pollution, traffic, energy	Emission of pollution; Traffic impact
Construction	Ecology, landscape, Social & economic, Cultural, energy, traffic	Terrain, emission of pollution, noises, wastes, landscape, traffic impact, cultural impact, consumption of energy, vibration
Operation	Ecology, landscape, Social & economic, Cultural, traffic, energy	Emission of pollution, noises, micro-climate, interfere waves, ecology, landscape, recreation, energy, land use, social environment, culture, traffic, vibration, wastes disposal.
Maintenance	Material, energy, pollution	Wastes, emission of pollution, application of natural resources
Demolition	Energy, traffic, wastes	Consumption of energy, traffic impact, emission of pollution, disposal, traffic, application of energy, wastes

Figure D-1 identifies the building's inputs and outputs over its life-cycle. Input items include raw materials, energy, natural resources, land etc. and output items include pollutants and waste, and its effects on the local micro-climate, landscape, traffic, etc.

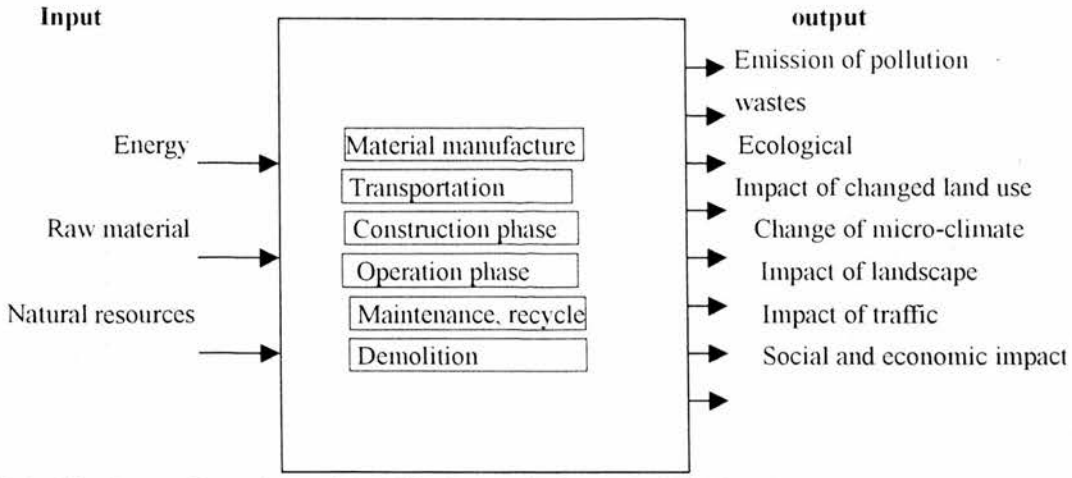

FIG. D-1: The System Boundary of the Life-Cycle of High-Rise Buildings

As a building usually remains in use for decades or longer, its energy and resources requirements during the maintenance and repair stage are less than those found in other stages, so we will focus in this chapter on the five remaining phases.

D.1. ENVIRONMENTAL ISSUES RELATING TO THE PRODUCTION OF BUILDING MATERIALS

The salient environmental issues which feature at this first stage of the life-cycle include energy consumption, raw materials acquisition, pollutants (e.g., CO, CO2, N2O, NOX, TSP and SO2) and waste water. First-stage environmental effects may contribute to global warming, atmospheric pollution, acid rain, photochemical oxidant formation and eutrophication, human toxicity and waterborne pollution since the various building materials used during the manufacturing process each generate their own waste water and exhausts. For example, factories engaged in paper-making, plastics, brick manufacture, glass and the plating of building materials will each emit their own particular mix of heavy metals, waste water and HT pollutants. This section will deal mainly with estimates of the volume and impact of the various pollutants which result from first-stage energy consumption.

D.1.1 Energy Consumption at the Manufacturing Stage

A building consumes a great deal of fossil fuel and energy during the process of its production, e.g., coal, petrol, natural gas and electricity. Over half of Taiwan's power is generated from thermo-electric power stations which take fossil fuels as their energy source. A high-rise building, in particular, requires a large amount of material so its consumption of cement, aggregate reinforcing steel bars, tiles, plate glass, plywood etc. is especially great. As building materials are so various - ranging from the largest steel frames to the smallest screws - we will focus only on the main ones. Table D- 2 lists the types and annual production capacities of building materials in Taiwan.

Table D-2: Production Capacity of Building Materials

Material	Production	Material	Production	Material	Production	Material	Production
Gravel & sand	7618212 (M^3)	Timber	378108 (M^3)	Paper for Publishing	771551 (tonne)	Poly-ammonium	269890 (tonne)
Excavated Stone	9956000 (M^3)	Common Plywood	264407 (M^3)	Paper for Household	156261 (tonne)	Knitting Textile	224910 (tonne)
Reinforcing Steel Bar	8432099 (tonne)	Paper Board	3045500 (tonne)	Paper for Packaging	88484 (tonne)	Paint	473595 (tonne)
Frame Steel	1243398 (tonne)	Pre-mixed Concrete	26121000 (M^3)	Synthetic Resin	325222 (tonne)	Linear Light Tube	83844 (thousand unit)
Steel Plate	2487671 (tonne)	Brick	3808062 (thousand unit)	Polyvinyl Chloride	1113679 (tonne)	Wires & Cables	48401 (tonne)
Cement	22721650 (tonne)	Plastic Pipe	370793 (tonne)	Synthetic Rubber	99198 (tonne)	Wires	280582 (tonne)
Aluminium Door & Window	41430 (tonne)	Plastic Bag	209602 (tonne)	Poly ester-cotton	726258 (tonne)	Window-style Air Conditioner	1487543 (unit)
Plate Glass	1311227 (tonne)	Plastics	895431 (tonne)	Poly ester-silk	1178925 (tonne)	Generator	3180 (unit)
Fibreglass	74975 (tonne)	Pulp	320128 (tonne)	Shuttled Cloth	1801592 (thousand m^2)	Motor	333447 (unit)
Tile	140648 (thousand M^2)	Wooden Furniture	22642100 (thousand dollar)	Cotton Cloth	970344 (thousand m^2)	Electric Motor	6691184 (unit)

Data Source: Yang, 1996, p. 8

As the energy to manufacture building materials mainly comes from fossil fuels and electric power, the total energy consumption of each kind of building material can be obtained if we add together the electric and thermal energy it consumes, as Table D- 3 shows.

Table D- 3: Energy Consumption per Unit Production of Building Materials (Heat Value Unit)

Building Product		Unit	Power	Thermal Energy					
			Consumed Power (kwh)	Consumed Coal (Kg)	Consumed Oil (L)	Consumed Natural Gas (M^3)	Consumed LPG (L)	Consumed Heat Energy (Kcal)	Total Consumed Energy (Kcal)
Gravel	Sand	M^3	1.32	0	0.76	0	0	6992	9868.11
	Stone	M^3	1.56	0	0.92	0	0	8464	11863.04
Steel	Reinforcing Steel Bar	T	498.3	51.84	72.8	2.2	0.096	1021692	2107424.83
	Steel frame	T	512.3	51.84	71.6	2.2	0.096	1010652	2126889.07
	Steel Plate	T	564.1	51.84	51.8	2.2	0.096	828492	2057594.73
Cement	Cement	T	110.25	132.83	0	0	0	850112	1090332.84
Aluminium	Aluminium door & window	T	1497	0	162	0	0	1490400	4752174.14
Glass	Plate Glass	T	249.67	0	209.8	0	0	1930160	2474159.43
	Fibreglass	T	1755.38	0	484.5	0	0	4457400	8282151.56
Porcelain	Tile	M^2	3.083	0	0.682	1.514	0	19749	26466.47
Wood	Timber	M^3	13.54	0	1.73	0	0	15916	45417.95
	Plywood	M^3	132.3	0	0	0	0	0	288265.01
	Wooden Mould Board	M^3	0.229	0	0	0	0	0	498.96
	Wooden Furniture	1000 dollar	7.94	0	0	0	0	0	17300.26
Cement Product	Pre-mixed Concrete	M^3	3.4	0	0	0	0	0	7408.17
Clay	Brick	Unit	0.057	0.021	0.043	0	0	530	654.20
Plastics	PVC Pipe	T	310	0	0	0	0	0	675450.89
	Plastic Bag	T	950	0	0	0	0	0	2069930.15
	Plastic Cloth	T	493	0	78.3	0	0	720360	1794544.80
Paper	Pulp	T	462	0	181.3	0	0	1667960	2674599.71
	Paperboard	T	338.9	150.4	58.6	0	0	1501680	2240100.34
	Paper for Publishing	T	582.6	158.9	120.1	0	0	2121880	3391291.90
	Paper for Household	T	891.8	4	216.4	0	0	2016480	3959599.69
	Paper for Packaging	T	539.2	23	134.4	0	0	1383680	2558528.77
Plastics	Synthetic Resin	T	840.3	0	108.7	0	0	1000040	2830947.69
	PVC	T	352	0	43	0	0	395600	1162563.59
	Synthetic Rubber	T	1033.6	0	35.5	0	0	326600	2578684.00
Artificial Textile	Polyester-cotton	T	520	93	148	0	0	1956800	3089814.40
	Polyester-silk	T	680	28	115	0	0	1237200	2718834.21
	Poly-ammonium	T	2300	0	220	0	0	2024000	7035409.83

Building Product		Unit	Power	Thermal Energy					
			Consumed Power (kwh)	Consumed Coal (Kg)	Consumed Oil (L)	Consumed Natural Gas (M^3)	Consumed LPG (L)	Consumed Heat Energy (Kcal)	Total Consumed Energy (Kcal)
Textile	Cotton Cloth	1000 M^2	382.3	0	0	0	0	0	832983.47
	Shuttled Cloth	1000 M^2	242	0	191	0	0	1757200	2284487.47
	Knitting Cloth	T	1250	0	829	0	0	7626800	10350392.3
Paint	Paint	Kg	1.17	0	0.042	0.001	0	395.3	2944.58
Lighting Appliance	Linear Light Tube	1000 unit	218	0	0	28.5	0	253650	728644.50
Electrical	Wire & Cable	T	1324	0	0	0	0	0	2884828.96
	Electric Wire	T	660	0	0	0	0	0	1438056.73
	Window-style Air Conditioner	Set	25	0	0	0	0	0	54471.85
	Generator	Set	300	0	0	0	0	0	653662.15
	Motor	Set	5	0	0	0	0	0	10894.37
	Electric Starter	Set	44	0	0	0	0	0	95870.45

Data Source : Yang, 1996, p.7

According to the data in Table D-2 and D-3, the total energy consumption of building materials manufacture is 10,521 thousand kilolitres oil equivalent, or 15.95% of Taiwan's annual energy consumption.[1]. Of the various kinds of building material, the energy consumed by the steel frame production industry was the highest in 1994 (27% of the total) while cement production came a close second (26.2%). The industries producing aluminium doors and windows, glass and tiles are also high energy consumers[2] because of the extreme processing that goes into the manufacture of these items.

There can be no doubt of the significance of the building materials industries to Taiwan's national energy use. What is more, as economic development has increased demand for new construction, the total energy consumption of building materials production in 1994 had increased by 16% as compared with 1990 consumption rates. Thus, the industries associated with the manufacture of building materials are a prime target for energy-saving strategies. It is clear that energy-saving improvements to building materials' manufacturing processes would help matters, as would the choice of low energy consumption materials for specific building projects. Together, these would decrease the energy consumption levels associated with the first stage of the building life-cycle.

D.1.2 Raw Material Consumption at the Manufacturing Stage

In addition to using a great deal of energy, the building materials industries also consume a tremendous amount of raw materials, e.g., gravel, timber, aluminium, steel, iron, non-metal materials, etc. As we saw in Table D- 2, they annually consume 7.6 million m3 of gravel, 10 million m3 of stone, 12 million tonnes of steel and 41,430 tonnes of aluminium. As a large building requires a great deal of materials, this particular project requirement needs to be evaluated prior to conducting the assessment of impacts

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[1] The total energy consumption of this sector is found by multiplying Tables 2 and 3. In 1994, gross national energy consumption was 65,956.2 thousand kilolitres oil equivalent. See Yang, 1996, p. 6.

[2] Ibid., pp. 6-7.

during the manufacturing stage.

To facilitate the assessment of material requirements, the project will generally be categorised into segments such as foundation engineering, structural engineering, interior finish, exterior decoration, lifts and miscellaneous engineering which follow the order in which those segments are built. Each engineering segment can then be sub-divided into smaller units; for example, structural engineering may encompass moulding work, concrete work and reinforcing steel bar work. After that, the requirements for construction materials can be estimated according to each detailed item.

Materials requirements relate mainly to the structure, height and proposed use of the building. Table D-4 lists data on the various material needs of different types of structure. Steel framed reinforced concrete (SRC) creates the greatest demand for reinforced concrete; every square metre of the total floor area needs 0.58 m3 of it. In contrast, SRC creates the least demand for steel bars; in SRC for housing, every square metre of the total floor area only needs 0.047 tonnes of it whereas a six-floor office block with a RC structure requires 0.064 tonnes.

Table D- 4: Major Building Materials Requirements for Different Types and Height of Building

Building Type	**Office**								**flat**	
		RC						SRC	RC	SRC
Item		bungalow	2 floors	3 floors	3 floors	4 floors	5-6 floors	B1, 4F-6F	B1-B2, 7F-9F	5 floors	11 floors
Concrete	M^3	0.153	0.098	0.061	0.043	0.035	0.028	0.023	0.025	0.005	0.004
Reinforced Concrete	M^3	0.560	0.640	0.530	0.480	0.470	0.470	0.550	0.580	0.450	0.500
Mould Board	M^3	4.900	4.800	4.100	3.800	3.900	3.900	4.000	3.500	4.000	4.200
Steel Bar	T	0.062	0.056	0.056	0.054	0.056	0.056	0.064	0.056	0.038	0.047
Steel Frame	T								0.052		0.014
Wood	M^3	0.023	0.025	0.020	0.015	0.015	0.019	0.017	0.013	0.038	0.028
Wooden Door and Window	M^3	0.187	0.112	0.072	0.088	0.088	0.084	0.068	0.052	0.420	0.270
Metal Door & Window	M^3	0.280	0.300	0.250	0.260	0.260	0.200	0.250	0.220	0.230	0.170
Glass	M^3	0.330	0.310	0.240	0.250	0.250	0.220	0.170	0.140	0.210	0.190
Paint	M^3	2.600	1.700	1.500	2.100	2.100	1.700	1.700	1.300	0.840	1.900

Data Source: Lu et al, 1998, p. 171

Table D-5 reveals that the different uses to which buildings are put also creates huge variety in their materials requirements. This Table D-5 only compares three materials, chosen here because they are in wide demand and they are high energy consumers. Banks generate the greatest demand for concrete; every square metre of the total floor area of a bank requires 0.82 m3 of concrete while only 0.54 m3 is required for domestic housing. Freezer warehouses create the most demand for steel bars; every square metre of their total floor area takes 0.077 tonnes compared with only 0.042 tonnes for housing.

Table D- 5: Major Building Materials Requirements for Different Types of Building

	Requirement for 1 m2 of Total Floor Area		
Building	**Concrete**	**Mould Board**	**Steel bar**
Residence	0.66	4.94	0.059
Apartment	0.54	5.36	0.042
Hotel	0.54	4.91	0.055
Office	0.67	4.36	0.064
Agency	0.66	4.20	0.074
Bank	0.82	5.58	0.074
School	0.58	4.15	0.058
Hospital	0.63	4.46	0.058
Theatre	0.74	4.65	0.072
Warehouse	0.64	3.81	0.057
Freezer warehouse	0.79	4.35	0.077
Average	0.62	4.53	0.062

Data Source: as the Table D- 4, p. 160

The differing heights of buildings also influence materials requirements as Table D-6 shows. For example, the higher the building, the greater the demand for steel bars. For 15-storey buildings or over, every square metre of total floor area needs 0.156 tonnes of steel bars whereas only 0.057 tonnes are needed for buildings of less than five floors. As for concrete, we find little difference between buildings above seven storeys as their outer walls are all made of RC. However, demand greatly decreases for buildings lower than five floors because their outer walls are made of brick.

To assess the environmental impact of a building over its life-cycle, the first step is to estimate the various materials required for the development project and then use the building materials analysis to consider the detail of each material item. For instance, after estimating the concrete requirement for a project, the investigation can then turn to examine the detailed requirement for cement, sand, stone and water.

D.1.3 Effects on Global Warming at the Manufacturing Stage

The global warming effect mainly results from the exhaust of greenhouse gases from the burning of fossil fuel. Greenhouse gases primarily refer to carbon dioxide (CO2), methane (CH4) and dinitrogen oxide (N2O). This section will estimate emission volumes from these three gases and will quantify them in terms of their global warming potential (GWP) as we saw in Table D-2 of Chapter Ten. GWP is relative to 1kg CO2.

The level of CO2 emissions can be obtained by multiplying the figure for product unit energy consumption of building materials in terms of the thermal values of coal, oil and natural gas with their respective carbon emission coefficients which are 25.8, 21.1 and 15.3 tonne/1012 joule, along with the fractions of oxidised carbon. As for electric power, we will only calculate the CO2 emissions from thermo-electric power generation because there are no CO2 emissions from nuclear and hydro-power generation. In 1996, coal-generated power accounted for 35.44% of total power capacity, oil/fuel for 21.42% and gas for 4.5%. Table D-7 summarises the CO2 emissions per unit of each major building material according to the electricity and fossil fuel consumption of its manufacture.

Table D-7: Greenhouse Gas Emissions from Building Materials Manufacture

Building material		Unit	Total Consumed Energy (Kcal)	CO_2 Emission (Kg)	CH_4 Emission (Kg)	N_2O Emission (Kg)	GWP amount(kg)
Gravel	Sand	M^3	9868.11	2.86	7.74E-06	8.33E-05	2.88
	Stone	M^3	11863.04	3.44	9.29E-06	9.99E-05	3.47
Steel	Reinforced Steel Bar	T	2107424.83	579.75	2.24E-03	2.28E-02	586.41
	Frame Steel	T	2126889.07	582.71	2.27E-03	2.31E-02	589.45
	Steel Board	T	2057594.73	548.36	2.24E-03	2.31E-02	555.10
Cement	Cement	T	1090332.84	381.18	2.10E-03	1.67E-02	386.07
Aluminium	Aluminium door & window	T	4752174.14	1173.31	4.14E-03	4.83E-02	1187.40
Glass	Plate Glass	T	2474159.43	734.94	1.90E-03	2.01E-02	740.81
	Fibreglass	T	8282151.56	2244.79	6.81E-03	7.61E-02	2266.99
Porcelain	Tile	M^2	26466.47	6.59	1.78E-05	1.56E-04	6.64
Wood	Timber	M^3	45417.95	11.39	3.92E-05	4.54E-04	11.53
	Plywood	M^3	288265.01	61.45	2.71E-04	3.32E-03	62.42
	Wooden Mould Board	M^3	498.96	0.11	4.70E-07	5.75E-06	0.11
	Wooden Furniture	$000	17300.26	3.69	1.63E-05	1.99E-04	3.75
Cement Product	Pre-mixed Concrete	M^3	7408.17	1.58	6.97E-06	8.54E-05	1.60
Clay	Red Brick	Unit	654.20	0.21	6.97E-07	6.47E-06	0.21
Plastics	PVC Pipe	T	675450.89	144.00	6.36E-04	7.79E-03	146.27
	Plastic Bag	T	2069930.15	441.28	1.95E-03	2.39E-02	448.24
	Plastic Cloth	T	1794544.80	460.01	1.53E-03	1.76E-02	465.13
Paper	Pulp	T	2674599.71	749.48	2.15E-03	2.36E-02	756.36
	Paper board	T	2240100.34	703.92	3.20E-03	2.82E-02	712.16
	Paper for Publishing	T	3391291.90	1019.68	4.23E-03	3.92E-02	1031.15
	Paper for Household	T	3959599.69	1060.62	3.32E-03	3.71E-02	1073.45
	Paper for Packaging	T	2558528.77	704.11	2.32E-03	2.48E-02	711.36
Plastic	synthetic Resin	T	2830947.69	711.02	2.44E-03	2.83E-02	719.27
	PVC	T	1162563.59	290.37	1.01E-03	1.17E-02	293.78
Artificial Textile	Polyester-cotton	T	3089814.40	909.21	3.36E-03	3.26E-02	918.73
	Polyester-silk	T	2718834.21	724.70	2.55E-03	2.76E-02	732.76
	Polyester-ammonium	T	7035409.83	1717.43	6.18E-03	7.23E-02	1738.52
Textile	Cotton Cloth	Thou-Sand M^2	832983.47	177.58	7.84E-04	9.60E-03	180.38
	Shuttled Cloth	Thou-Sand M^2	2284487.47	675.91	1.76E-03	1.87E-02	681.36

Building material		Unit	Total Consumed Energy (Kcal)	CO_2 Emission (Kg)	CH_4 Emission (Kg)	N_2O Emission (Kg)	GWP amount(kg)
	Knitting Cloth	T	10350392.3	3026.40	8.06E-03	8.61E-02	3051.54
Paint	Paint	Kg	2944.58	0.67	2.68E-06	3.22E-05	0.68
Lighting Appliance	Linear Light Tube	Thou-Sand Unit	728644.50	160.54	5.79E-04	6.11E-03	162.33
Electrical	Wire & Cable	T	2884828.96	615.01	2.72E-03	3.33E-02	624.71
	Electric Wire	T	1438056.73	306.58	1.35E-03	1.66E-02	311.41
	Window Air Conditioner	Set	54471.85	11.61	5.13E-05	6.28E-04	11.80
	Generator	Set	653662.15	139.35	6.15E-04	7.54E-03	141.55
	Motor	Set	10894.37	2.32	1.03E-05	1.26E-04	2.36
	Electric Starter	Set	95870.45	20.44	9.03E-05	1.11E-03	20.76

Note: GWP relative to emission of carbon dioxide

Data Source: main data comply with Yang, 1996, p. 7

If we multiply the unit emission level of each kind of building material with national output capacity (see Table D-2), we discover that total CO2 emissions during the manufacture of building materials is 27,950 tonnes or 16.4% of Taiwan's annual CO2 emissions. In addition, during this stage of building materials manufacture, the energy used by these industries accounts for 15.95% of Taiwan's total energy consumption. The CO2 emission volume of 16.4 % of the national total indicates that the manufacture of building materials is not only a major energy consumer but also an industrial sector which produces a significant proportion of Taiwan's CO2 emissions.[3].

As fossil fuel is required for specific life-cycle stages of buildings and incomplete burning results in CH4, we can see that the higher the burning efficiency, the less CH4 is generated. To estimate CH4 emissions, we first present the energy consumption of various fuels in terms of a thermal value unit (Kcal) and then multiply the Kcal of each type of energy with its CH4 emission potential. Table D-8 shows that annual CH4 emissions from the manufacture of building materials come to 109,225 tonnes

emissions, we first present the energy consumption of various fuels in terms of a thermal value unit (Kcal) and then multiply the Kcal of each type of energy with its CH4 emission potential. Table D-8 shows that annual CH4 emissions from the manufacture of building materials come to 109,225 tonnes or 0.52% of Taiwan's total. Among building materials, cement products generate the most emissions (47.7175 tonnes or 44.66% of the total emissions from building materials manufacture). The manufacture of steel products (including bars, frames and plates) generates 27.2827 tonnes (25.64%). Figure D-2 shows that although cement and steel product manufacture account for the largest proportion of CH4 emissions in this industrial sector, paper-making and artificial fibre manufacture are also significant (accounting for 7.1% each).

Table D-8: CH_4 Emissions at the Manufacturing Stage

Building Material	**CH_4 Emission (tonne/year)**	**building Material**	**CH_4 Emission (tonne/year)**	**Building Material**	**CH_4 Emission (tonne/year)**	**Building Material**	**CH_4 Emission (tonne/year)**
Gravel	0.0589	Timber	0.0148	Paper for Publishing	3.2636	Poly-ammonium	1.6679
Excavated Stone	0.0921	Plywood	0.0716	Paper for Household	0.5187	Knitting Textile	1.8127
Steel Bar	18.8879	Paper Board	2.4563	Paper for Packaging	0.2052	Paint	0.0012
Frame Steel	2.8225	Pre-mixed Concrete	0.1820	Synthetic Resin	0.7935	Linear Light Tube	0.0485
Steel Plate	5.5723	Brick	2.654	Polyvinyl Chloride	1.1248	Wires & Cables	0.1316
Cement	47.7154	PVC Tube	0.2358	Synthetic Rubber	0.2341	Wires	0.3787
Aluminium Door & Window	0.1715	Plastic Bag	0.4087	Poly-cotton	2.4402	Window-style Air Conditioner	0.0763
Flat Glass	2.4913	Plastic Cloth	1.0745	Poly-silk	3.0062	Generator	0.0019
Fibreglass	0.5105	Pulp	0.6882	Shuttled Cloth	3.1708	Motor	0.0034
Tile	2.5035	Wooden Furniture	0.3690	Cotton Cloth	0.7607	Electric Motor	0.6042
Total:	109.225						

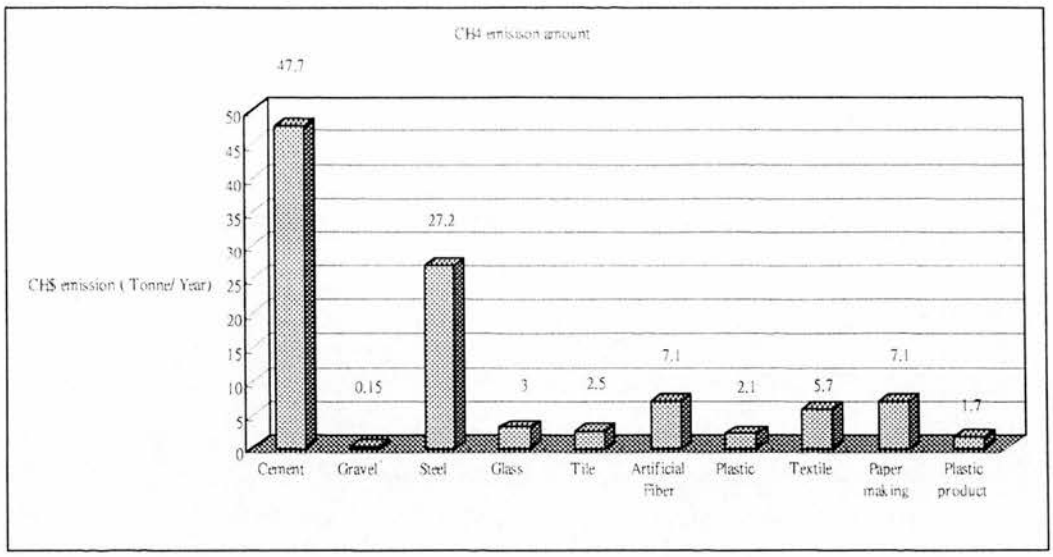

FIG. D-2: CH_4 Emissions from the Manufacture of Main Building Materials

N2O emissions mainly stem from the burning of fossil fuel. To estimate the level of N2O emission we first calculate NOx emissions which can be obtained by multiplying the energy used to manufacture building materials or the vehicle kilometre traveled(VKT) with their NOx emission factor. The N2O emission volume can then be calculated by multiplying the NOx emissions of each type of energy with the transformation rate of 0.01[4]. The N2O emissions from manufacturing each building material is listed in Table D-9. From this table, we know that the annual N2O emission from this sector is 1,180.3802 tonnes and Nox emission is 118,038.02 tonnes (18.3% of Taiwan's total). Again, cement and steel production are the major agents. The manufacture of cement products accounts for 32.75% of the total emissions from this sector and 5.87% of Taiwan's total while steel production accounts for 4.3%. Figure D-3 shows the N2O emissions from the manufacture of each building material.

[4] See Yang Hsuan Chao, 1996, p. 10

Table D-9: N_2O Emissions from Building Materials Manufacture

Building Material	N_2O Emission (tonne/year)	Building Material	N_2O Emission (tonne/year)	Building Material	N_2O Emission (tonne/year)	Building Material	N_2O Emission (tonne/year)
Gravel	0.6345	Timber	0.1716	Paper for Publishing	30.2447	Poly-ammonium	19.5130
Excavated Stone	0.9946	Plywood	0.8778	Paper for Household	5.7972	Knitting Textile	19.3647
Reinforcing Steel Bar	192.2518	Paper Board	85.8831	Paper for Packaging	2.1944	Paint	0.0152
frame Steel	28.7224	Pre-mixed Concrete	2.2307	Synthetic Resin	9.2037	Linear Light Tube	0.5122
Steel Plate	57.4652	Brick	24.6381	Polyvinyl Chloride	13.0300	Wires & Cables	1.6117
Cement	379.4515	PVC Tube	2.8884	Synthetic Rubber	2.8073	Wires	4.6576
Aluminium Door & Window	2.0010	Plastic Bag	5.0094	Poly-cotton	23.6760	Window-style Air Conditioner	0.9341
Flat Glass	26.3556	Plastic Cloth	15.7595	Poly-silk	32.5383	Generator	0.0239
Fibreglass	5.7055	Pulp	7.5550	Shuttled Cloth	33.6897	Motor	0.0420
Tile	21.94	Wooden Furniture	4.5057	Cotton Cloth	9.3153	Electric Motor	8.2442
Total:	1180.3802						

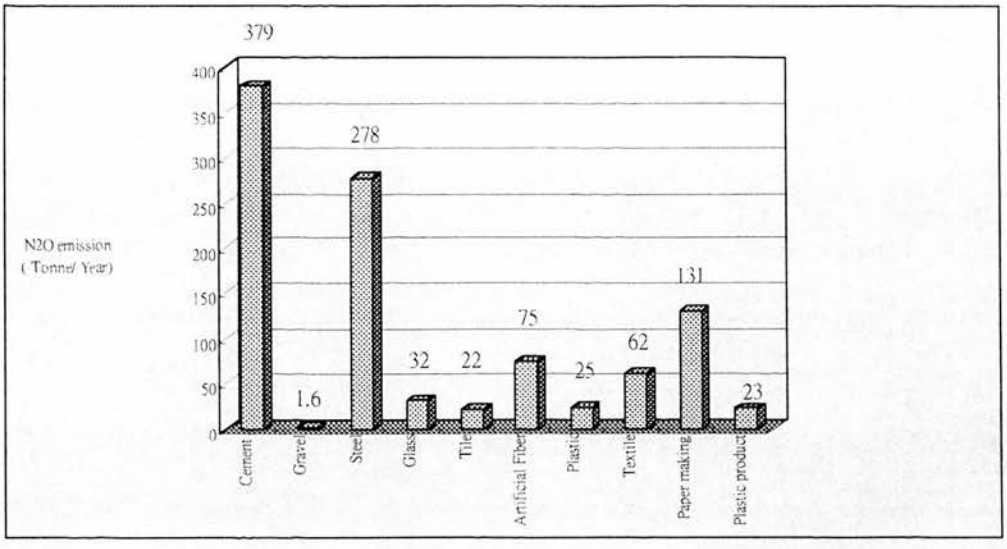

FIG. D-3: N_2O Emissions from the Manufacture of the Major Building Materials

According to the results presented above, carbon dioxide emissions from building materials manufacture come to 27.95 million tonnes; methane 109.225 tonnes and dinitrogen oxide 1,180.3802 tonnes. The exhaust level of GWP is 28.27 million tonnes - 1.15% more than that of carbon dioxide emissions. We can conclude that the carbon dioxide emitted from the manufacture of building materials is the greenhouse gas from this sector which most contributes to the global warming effect.

D.1.4 Effects on Acid Precipitation at the Manufacturing Stage

Acid rain comes from the mix of acidifying pollutants with rainfall. Apart from the acid materials produced naturally such as the sulphides which erupt from volcanoes, human activities generate large amounts of sulphur dioxide (SOx) and nitrogen oxides (NOx). The NOx emissions from the manufacture of building materials were discussed in the previous section (118,038.02 tonnes) so in this section we will deal with SOx.

The total emission of SOx in Taiwan in 1995 was 445,460 tonnes. Stationary pollution sources accounted for 94.2% of this figure, mobile sources only 5.8%. Among the Stationary pollution

sources, the greatest proportion of Sox emission emanated from the power generating stations (226,000 tonnes annually or 50.8% of the fixed sources). The fuel-burning industries accounted for 24.5% while industrial manufacturing only generated 11.3% of the fixed total (EPA, 1997). What this reveals is that over 80% of SOx emission emanates from fuel burning and energy consumption (see Figure D-5). For this reason, our estimate of the SOx emitted as a consequence of the manufacture of building materials will focus on the pollutants generated from energy consumption (see Table D-10).

Table D-10: SO_2 Emissions at the Manufacturing Stage

Construction Material	SO_2 Emission Volume (tonne/year)	Construction Material	SO_2 Emission Volume (tonne/year)	Construction Material	SO_2 Emission Volume (tonne/year)	Construction Material	SO_2 Emission Volume (tonne/year)
Gravel	6.64	Timber	0.79	Paper for Publishing	252.29	Poly-ammonium	73.41
Excavated Stone	10.55	Plywood	0.33	Paper for Household	39.84	Knitting Textile	215.01
Reinforcing Steel Bar	1247.95	Paper Board	746.14	Paper for Packaging	13.98	Paint	0.03
Formed Steel	182.77	Pre-mixed Concrete	0.85	Synthetic Resin	66.34	Linear Light Tube	0.17
Steel Plate	310.95	Brick	281.79	Polyvinyl Chloride	58.24	Wires & Cables	0.61
Cement	3544.57	PVC Tube	1.10	Synthetic Rubber	4.98	Wires	1.77
Aluminium Door & Window	8.20	Plastic Bag	1.90	Poly-cotton	203.35	Window-style Air Conditioner	0.35
Flat Glass	316.00	Plastic Cloth	84.08	Poly-silk	198.05	Generator	0.01
Fibreglass	42.50	Pulp	67.54	Shuttled Cloth	396.35	Motor	0.02
Tile	115.33	Wooden Furniture	1.72	Cotton Cloth	3.55	Electric Motor	2.81
Total:	8502.89						

Of the major building materials, cement production emits the greatest level of SOx (41.6%) while steel production accounts for 20.4%, as shown in Fig D-4. These two kinds of construction material are energy and power consumers. The calculations show that SOx emission is 8,502.89 tonnes and Nox 118,038.02 tonnes. The Acid Potential (AP) is 91,129 tonnes, Nox accounting for 90.7% of total AP emissions.

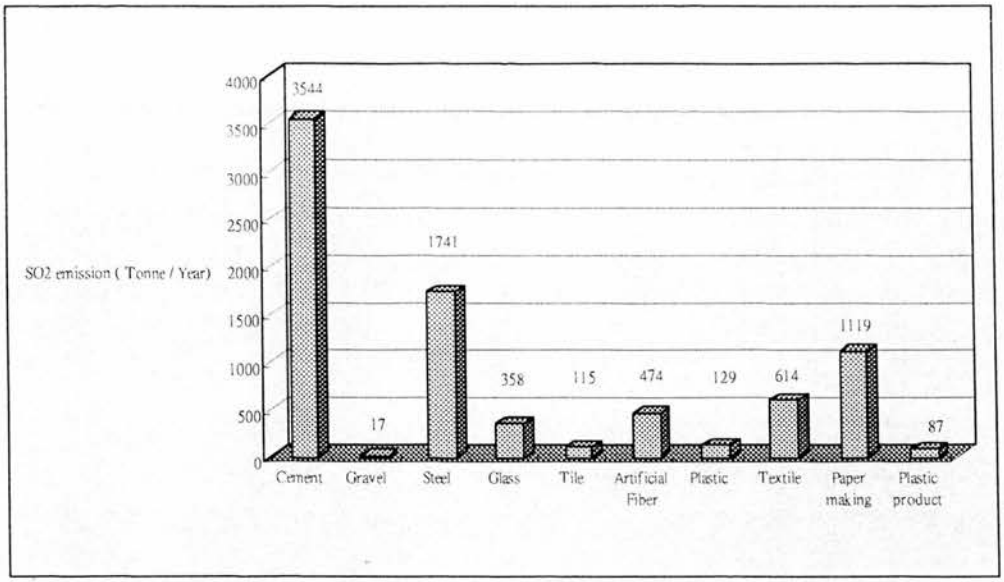

FIG. D-4: SO_2 Emissions from the Manufacture of Major Building Materials

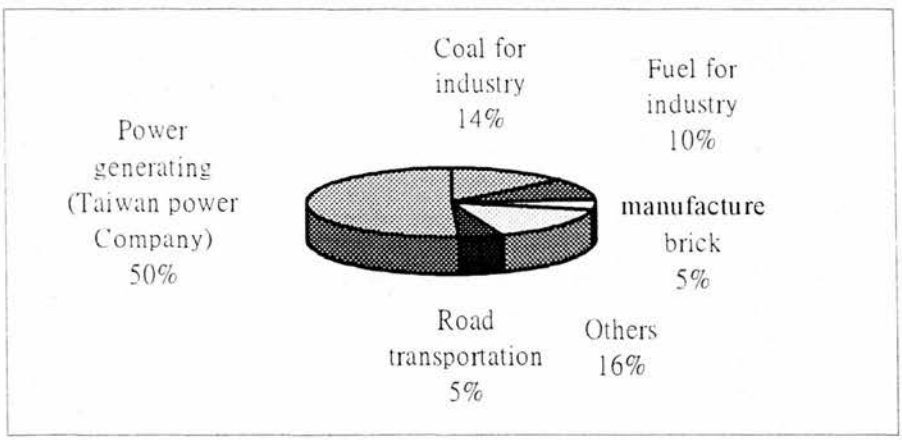

FIG. D-5: Proportion of SO_x Pollution Sources in Taiwan

Data Source: EPA, 1997, pp. 53-56

D.1.5 Photochemical Oxidant Formation and Eutrophication at the Manufacturing Stage

The main substances which contribute to photochemical oxidant formation are methane (CH4), hydrocarbons (CxHy), n-hexane (C6H14), acetylene and benzene. To assess their environmental impact, each substance has to be transformed into equivalent ethylene using an equivalency factor.

Hydrocarbon (HC) emissions come from burning fossil fuel. Estimates of HC emissions from building materials manufacture can be obtained by multiplying the amount of each material manufactured with its HC emission factor. We find that this industrial sector emits 141,468 tonnes, or 22.5% of Taiwan's total. Amongst building materials, steel production accounts for the highest proportion (65.35%).

CH4 emissions amount to 109.225 tonnes and, as we just saw, HC 141,468 tonnes. Thus, the level of POCP (equivalent ethylene) is 53,334 tonnes. This figure shows that building materials manufacture contributes significantly to photochemical oxidant formation.

Thirty per cent of Taiwan's water for agriculture, industry and daily living comes from reservoirs. Over-development of forestry, agriculture and dairy farming coupled with the holiday resort development boom has led to a flow of pollutants into lakes and dams. When coupled in specific ways with environmental variables (such as water temperature, pH value, insolation and water level) self-sustainable organisms or algae may either abnormally multiply or decrease their population levels. This is eutrophication and it plays a critical role in altering the water quality and ecology of lakes. Its level depends on the quantity of nutrients in the water (classified as high, medium or low). According to the EPA's survey, six reservoirs (30% of Taiwan's total) displayed the eutrophication phenomenon in 1996.

Eutrophication is mainly a consequence of the presence of ammonia (NH3), ammonium (NH4+), chemical oxygen demand (COD), nitrogen (N), nitrogen oxide (NOx) and phosphate ($PO4^{3-}$) in the water. An estimate of the level of COD effluent from the manufacture of building materials can be obtained by calculating the COD emitted from each kind of material with its effluent factor. COD effluent from this sector comes to 38.153 tonnes (stone production accounting for the highest proportion at 61.89%). As large amounts of COD and NOx are generated from building materials

manufacture, the emission volume of NP (equivalent PO4) can be found by multiplying the emission volumes of NOx and COD with the nutrification potential, i.e., 16,184 tonnes.

D.1.6 Effects on Human Toxicity at the Manufacturing Stage

Most building material production processes emit poisonous substances such as lead(Pb), mercury (Hg) and carbon monoxide (CO). This section only deals with those human toxicity (HT) substances which are emitted as a consequence of energy consumption so CO, Pb, NOx and SOx are the major poisons under discussion - CO being released by building materials manufacture as a result of the burning of natural gas, coal and fuel.

An estimate of the CO emissions from building materials manufacture can be obtained by multiplying annual output with the types of energy used and their emission factors. We arrive at a figure of 2,650 tonnes (0.177% of Taiwan's total). Amongst building materials, cement production generates the greatest CO volume (997 tonnes or 37.6%), followed by reinforced steel bar production at 942 tonnes or 35.5%. The Pb emissions from building materials manufacture only come to 0.5 tonnes (0.2 % of Taiwan's total Pb emissions).

While assessing the human toxicity of every substance, the HT potential first has to be transformed into the volume relative to 1kg of the human body. The HT potential (equivalency factor) of every substance was listed in Table 10-2 of Chapter Ten. NOx is 0.78; SO2 and SOx both 1.2; CO 0.012; and Pb 160. The HT from this sector comes to 102,384 tonnes with NOx generating the greatest HT volume of 92,069 tonnes (89.9% of the total).

D.1.7 Atmospheric Pollution at the Manufacturing Stage

The manufacture of building materials produces atmospheric pollutants, the main ones being total

suspended particulates (TSP), SOx, Nox, CO, CH4, HC and Pb. In 1995, TSP emissions in Taiwan amounted to 650,688 tonnes. Dust raised by vehicles in motion accounted for the highest proportion (37.23%) while earthwork construction came next at 17.94% (EPA 1997, p.55). The cement and pre-mixed concrete industry alone accounted for 8.08%, indicating that there is a close relationship between the building sector and the national level of TSP emissions. To estimate the TSP emissions of each kind of construction material, we multiply the required energy volume of each material with its emission factor, as Table D-11 shows.

Table D-11: Pollution from Energy Consumed in Manufacture of Building Materials

Product Related to Construction		Unit	Pollution Emission Factor		
			NO_x (Kg)	TSP (Kg)	SO_2 (Kg)
Gravel	Sand	M^3	8.33×10^{-3}	3.25×10^{-4}	8.72×10^{-4}
	Stone	M^3	9.99×10^{-3}	3.91×10^{-4}	1.06×10^{-3}
Steel	Reinforced Steel Bar	T	2.28	8.02×10^{-2}	1.48×10^{-1}
	Steel frame	T	2.31	7.86×10^{-2}	1.47×10^{-1}
	Steel Board	T	2.31	7.19×10^{-2}	1.25×10^{-1}
Cement	Cement	T	1.67	1.05×10^{-1}	1.56×10^{-1}
Aluminium	Aluminium door & window	T	4.83	9.46×10^{-2}	1.98×10^{-1}
Glass	Plate Glass	T	2.01	8.73×10^{-2}	2.41×10^{-1}
	Product Related to Construction	Unit	Pollution Emission factor	2.25×10^{-1}	5.68×10^{-1}
Porcelain	Tile	M^2	1.56×10^{-2}	3.28×10^{-4}	8.2×10^{-4}
Wood	Timber	M^3	4.54×10^{-2}	9.51×10^{-4}	2.10×10^{-3}
	Plywood	M^3	3.32×10^{-1}	2.65×10^{-3}	1.26×10^{-3}
	Wooden Mould Board	M^3	5.75×10^{-4}	4.61×10^{-6}	2.19×10^{-6}
Cement Product	Pre-mixed Concrete	M^3	8.54×10^{-3}	6.83×10^{-5}	3.25×10^{-5}
Clay	Brick	Unit	6.47×10^{-4}	3.41×10^{-5}	7.40×10^{-5}
Plastic	PVC Pipe	T	7.79×10^{-1}	6.23×10^{-3}	2.97×10^{-3}
	Plastic Bag	T	2.39	1.91×10^{-2}	9.10×10^{-3}
	Plastic Leather	T	1.37	3.34×10^{-2}	7.91×10^{-2}
Paper	Pulp	T	2.36	8.14×10^{-2}	2.11×10^{-1}
	Paper for Publishing	T	3.92	1.81×10^{-1}	3.27×10^{-1}
	Paper for Household	T	3.71	1.03×10^{-1}	2.55×10^{-1}
	Paper for Packaging	T	2.48	6.35×10^{-2}	1.58×10^{-1}
Plastic	Synthetic Resin	T	2.83	5.95×10^{-2}	2.04×10^{-1}
	PVC	T	1.17	2.39×10^{-2}	5.23×10^{-2}
	Synthetic Rubber	T	2.83	3.46×10^{-2}	5.03×10^{-2}
Artificial Textile	Polyester-cotton	T	3.26	1.40×10^{-1}	2.80×10^{-1}
	Polyester-silk	T	2.76	8.05×10^{-2}	1.68×10^{-1}
	Poly-ammonium	T	7.23	1.32×10^{-1}	2.72×10^{-1}
Textile	Cotton Cloth	,000 M^2	9.60×10^{-1}	7.68×10^{-3}	3.66×10^{-3}
	Shuttled Cloth	,000 M^2	1.87	8.25×10^{-2}	2.20×10^{-1}
	Knitting Cloth	T	8.61	3.50×10^{-1}	9.56×10^{-1}
Paint	Paint	Kg	3.22×10^{-3}	3.99×10^{-5}	5.90×10^{-5}
Lighting Appliance	Linear Light Tube	,000 Unit	6.11×10^{-1}	5.80×10^{-3}	2.08×10^{-3}
Electrical	Wire & Cable	T	3.33	2.66×10^{-2}	1.26×10^{-2}
	Electric Wire	T	1.66	1.32×10^{-2}	6.32×10^{-3}
	Window-style Air Conditioner	Set	6.28×10^{-2}	5.03×10^{-4}	2.39×10^{-4}
	Generator	Set	7.54×10^{-1}	6.03×10^{-3}	2.87×10^{-3}
	Motor	Set	1.26×10^{-2}	1.01×10^{-4}	4.79×10^{-5}
	Electric Starter	Set	1.11×10^{-1}	8.84×10^{-4}	4.21×10^{-4}

Though some building materials emit TSPs because of their energy use, in general it is the manufacture

of building materials which generates the greatest amount. As a result, the TSP emission volume for each unit of production can be obtained by dividing the annual statistical data on TSPs (provided by the EPA) with the annual production volume of each construction material, as Table D-12 shows.

Table D-12: TSP Emissions Factor of Major from Building Materials Manufacture

Construction Material	Unit	TSP Emission Factor
Tile	Kg/Thousand m^2	0.086
Brick	Kg/Thousand pieces	0.003
Glass	Kg/Tonne	1.030
Gravel	Kg/Tonne	0.960
Steel	Kg/Tonne	0.760
Pre-mixed Concrete (including cement)	Kg/M^3	2.010
Timber	M^3	0.630

Table D-13 shows that the total annual TSP emissions from the manufacture of building materials is 96,878 tonnes, or 14.8% of Taiwan's total. Amongst building materials, cement and pre-mixed concrete production raises the most (52,635 tonnes) which accounts for 54.3% of the TSP emissions from this sector and 8.08% of Taiwan's total. Concrete aggregate production follows, accounting for 12.46% of the sector's TSP emissions. Figure D-6 illustrates the volume of TSPs emitted as a consequence of the manufacture of the major building materials.

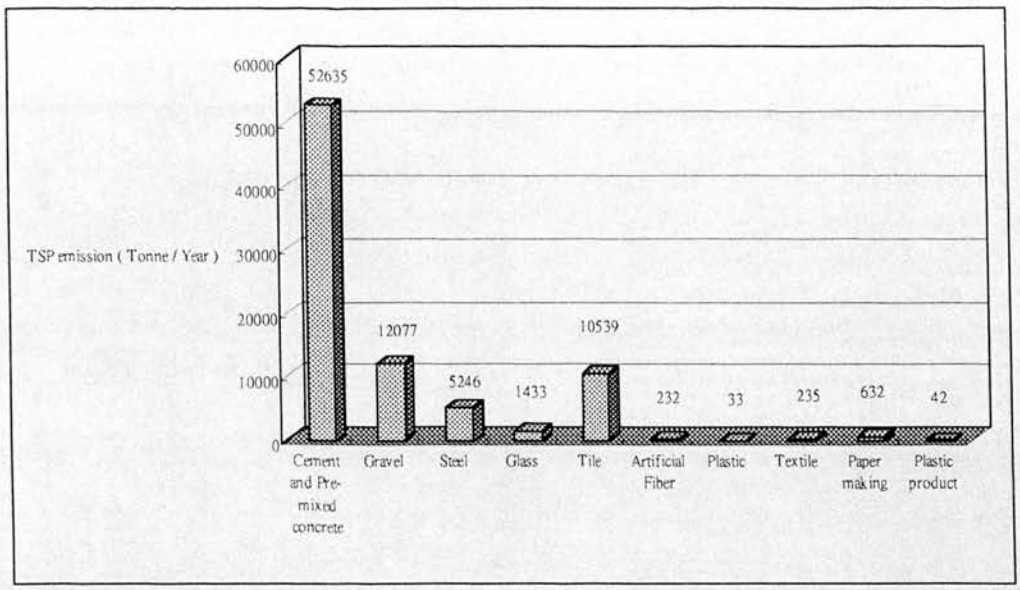

FIG. D-6: TSP Emissions from the Manufacture of Major Building Materials

Table D-13: TSP Emissions from the Manufacturing Stage

Building Material	TSP Emission tonne/year	Building Material	TSP Emission tonne/year	Building Material	TSP Emission tonne/year	Building Material	TSP Emission tonne/year
Tile	10539	PVC Tube	2.31	Synthetic Rubber	3.43	Wires	3.70
Brick	13751	Plastic Bag	4.01	Poly-cotton	101.67	Window-style AirConditioner	0.07
Gravel	12077	Plastic Cloth	36.35	Poly-silk	94.90	Generator	0.02
Steel	5246	Pulp	26.05	Shuttled Cloth	148.63	Motor	0.03
Glass	1433	Wooden Furniture	3.60	Cotton Cloth	7.45	Electric Motor	5.91
Pre-mixed Concrete (including cement)	52635	Paper for Publishing	139.65	Poly-Ammonium	35.62	Paper Board	444.64
Aluminium Door & Window	3.91	Paper for Household	16.09	Knitting Textile	78.71	PVC	26.61
Timber	0.35	Paper for Packaging	5.61	Paint for Cement	0.02	Total:	96878.72
Plywood	0.70	Synthetic Resin	5.90	Linear Light Tube	0.49		

According to the critical dilution volume (CDV) formulation, the CDV of equivalent SO2 (CDVA) is 313,042 tonnes. The level of the various air pollutants emitted from the manufacture of building

materials is shown in Table D-14. HC, at 22.5%, accounts for the highest proportion and NOx, at 18.26%, comes next.

Table D-14: Emissions of Various Atmospheric Pollutants at the Manufacturing Stage

Material	Emission Volume (tonnes)	Rate of Total Emission Volume in Taiwan (%)
CO_2	27950000	16.4
CH_4	109	0.52
N_2O	1180	17.92
SO_2	8503	1.90
NO_x	118038	18.26
CO	2650	0.18
TSP	56878	14.80
HC	141468	22.5%
Pb	0.5	0.2%

D.1.8 Solid Waste at the Manufacturing Stage

The waste that results from building materials manufacture depends on which type of material is under discussion. Table D-15 lists the different kinds of waste and the contribution the manufacture of various building materials makes to them. The Table D- 15 makes it clear that ore production generates the most waste (6,395 tonnes per day); its main source is the metal refining industry which includes the manufacture of reinforced steel bars, steel plates and parts, etc. The next largest waste category is non-organic sludge (4,286 tonnes per day) and its main source is electroplating, metal surface treatment and pulp. Third comes waste metal (4,043 tonnes per day) from the manufacture of metal products. Waste sawdust is another category which the building materials sector makes a large contribution to (1,467 tonnes per day); its main source is timber processing.

Table D-15: Total Waste Relating to Building Materials Manufacture

Waste	Total (kg/day)	hazardous rate (%)	Source
Organic Sludge	2,166,238	0.48	Floating remains of paint & latex manufacture
Non-organic Sludge	4,286,439	2.80	Sludge from pulp & metal during electroplate or metal surface treatment process
Waste Solvent	146,867	26.25	Surface treatment of metals, paint manufacture & the production of electric equipment
Waste Oil	261,690	0.00	Waste lubricatant & grease oil
Waste Liquid	294,645	13.95	Waste liquid from electroplating
Waste Acid	392,797	68.80	Acid solvent for steel processing, non-metal processing & metal surface treatment
Waste Alkali	313,461	88.37	Metal surface treatment
Dust	1,228,594	7.18	Dust from mine melting pot, metal melting pot & dust collector of burning pot
Ash	893,546	1.27	Remains in the pot, coal ashes
Ore Remains	6,395,492	2.14	Remains of steel making
Asbestos	14,652	76.96	Manufacture of asbestos
Waste Plastic	848,162	0.20	Waste plastic products
Waste Rubber	525,725	0.00	Rubber remains
Glass or Porcelain	421,945	0.01	Remains of glass, gypsum, red brick, porcelain, pottery & cement products
Metal	4,043,434	3.05	Manufacture of metal parts
Waste Paper	879,130	0.20	Manufacture of paper box & wall paper
Waste Wood Dust	1,467,760	0.00	Processing of wood material
Fibre	409,616	0.00	Waste cloth, fibre remains

Data Source: EPA, 1997, pp. 486-496

Of the waste relating to building materials manufacture, some is hazardous as Table D-15 also shows. For example, waste alkali and asbestos carry a hazardous rating of 88.37% and 76.96% respectively. Consequently, in addition to consuming a deal of energy, building materials manufacture also generates large amounts of waste, which may endanger living things (perhaps even people) if it is not taken care of properly.

D.1.9 Waterborne Waste at the Manufacturing Stage

Waste water is produced from the manufacture of building materials which results in water pollution. In urban areas, water pollution not only affects aquatic ecology by its contamination of rivers but also obstructs the adjustment function of the sewers. In rural districts, water pollution not only compromises drinking and irrigation water sources but also damages breeding fisheries. In Taiwan,

58.3% of water comes from ground surfaces and 35.84% of that is polluted to some degree (EPA 1997, p.101). When polluted rivers are an irrigation source, crops may be directly affected which may cause withering or reduced crop yield. Worse, farm land may become unviable because of contaminated soil which may lead to the accumulation of poisonous materials; a drop in crop quality; the waste of irrigation facilities; and an increase in the cost of maintenance and management.

The process of treating metal surfaces or electroplating metal products generates waste water containing heavy metals such as zinc, lead and cadmium which might result in soil pollution. There are 80,225 factories in Taiwan, 2,290 of them manufacturing products for the building trade (Liu 1994, p.26). In 1995, the manufacture of building materials generated 5,854 million tonnes of waste water with a BOD_5 emission volume of about 7,514 tonnes per year, as Table D-16 shows. COD emission is 37,493 tonnes and SS 50,742 tonnes so the CDV of equivalent BOD (CDVW) at this manufacturing stage is 28,290 tonnes.

Table D-16: Effluent from the Manufacture of Major Building Materials

Material	Waste water tonnes (million tonnes)	COD effluent (Tonnes)	BOD effluent (tonnes)	SS effluent (tonnes)
Gravel	506.99	23,616	3,573	35,714
Excavated stone	18.46	946		7,626
Steel	21.04	1,788	341	268
Aluminium door & window	0.07	13		268
Tile	5.49	281		1,829
Paint	33.36	10,849	3,600	5,294
Total	585.41	37,493	7,514	50,742

D.1.10 Effects on Landscape and Ecology at the Manufacturing Stage

Acquiring raw materials to make building products often adversely affects the natural ecology and landscape. Because of their greater production output, cement, gravel, glass and clay products have a greater environmental impact than other materials. Cement is the most commonly used material for

building. It is the raw material for concrete and mortar and is mainly manufactured from limestone, clay and shale. A power shovel is used to extract these raw materials from the hillside. They are then sent to factories with mine crushers/breakers to be broken into stones of less than 2.5cm and placed in storage warehouses before being further refined by grinding. The initial hillside quarrying destroys the natural landscape and ecology.

In 1950, Taiwan's total output of cement was only 390,000 tonnes. By 1994, 13 companies owning 18 cement factories with 38 production lines were producing 22.7 million tonnes annually (as we saw in Table D-2) - 58.2 times the output figure of 1950[5]. The distribution of cement factories is illustrated in Figure D-7. Most are situated near limestone excavation sites and some of those mining areas are even in national parks. We can see that the limestone sites are mostly located in the mountains or near urban areas (e.g., Pan Ping Shan near Kaohsiung), affecting both natural and urban landscapes. [6]

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[5] In 1950, the Taiwan Cement Company had an annual output of 390,000 tonnes. Annual output reached 1 million tonnes in 1958 with 8 cement companies in business. By 1990, there were 13 cement companies with an annual output of 18.1 million tonnes. See Tsai Te Shih et al., *Materials of Engineering*, pp. 18-20, Taipei, 1997

[6] Pan Ping Shan is near downtown Kaohsiung. A flood of soil and stone occurred after excavation in 1995 which damaged the city. The mining field of the Central Mountains in Hualien is situated inside Troko National Park which, because of its influence on the region's ecology, has several times been a target of the environmental NGOs. In 1998, there was a dispute between the Construction & Planning Administration (CPA) and the Bureau of Mining Affairs over the excavation approval given to this site.

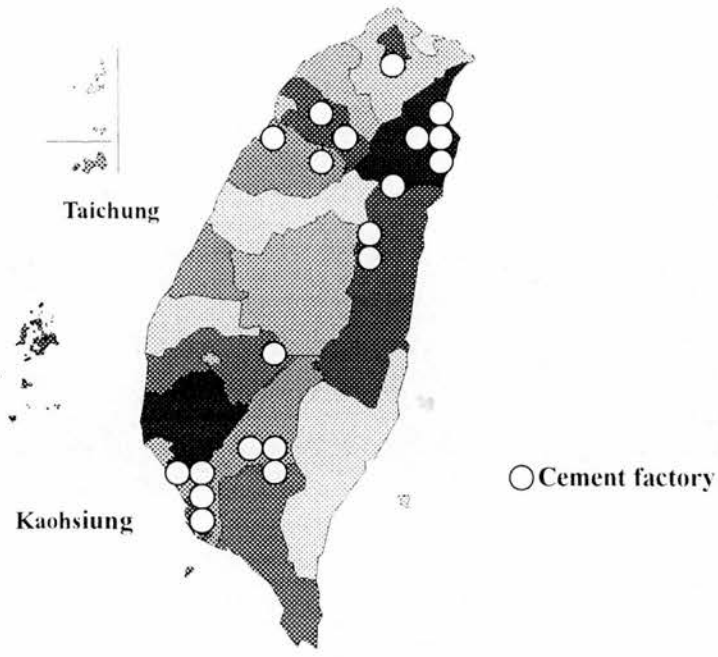

FIG. D-7: Distribution of Cement Factories in Taiwan

Table D-2 showed that about 26.1 million m^3 of pre-mixed concrete is produced in Taiwan every year. As 66%-78% of the components of concrete come from gravel etc.[7], this means that 17.6 million m^3 of aggregate is required per year as Table D-2 also shows. Gravel for building comes from rivers, land and seas (though as it extremely expensive to mine gravel from the sea and gravel from this source also contains salt, it is the least used source). For land and river gravel excavation, rock strata, stones, big pebbles and natural gravel are first taken from the site and then shipped to a processing plant for treatment (i.e., being crushed into different sizes and stored) before being made available for building materials manufacture. Excavation using explosives changes the ecology and landscape of river beds; hillside terrain is also altered radically since the process involves removing surface ground before excavation can begin. This baring of the ground erodes soil and increases the level of drainage water on the hills.

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[7] See Lin, *Construction Evaluation*, 1979, p. 173, Taipei, 1979

Taiwan's annual output of glass is 1.3 million tonnes. Glass is made either from a mix of acidic oxide and alkaline oxide or solely from one of those elements. After melting (at temperatures of 1400-1500°C) the glass is cooled, solidified and formed[8]. The materials that go into making glass also need to be mined. Two excavation methods are used in Taiwan, open and underground, the former being more common. There are currently more than 50 open excavation sites in Taiwan and these have a severe impact on the natural landscape.

Tiles and bricks are the most commonly used clay-based building materials, with an annual total output of 7.1 million cubic metres[9]. Clay is mainly found in the north and east of Taiwan. The noise and floating dust which result from excavating and calcimining clay also adversely affect the environment.

D.2 ENVIRONMENTAL ISSUES RELATING TO THE TRANSPORTATION OF BUILDING MATERIALS

Various pollutants are generated from the transportation of building materials. The major sources of input and output pollutants from this second stage of the building's life-cycle include the energy consumed, emissions (such as CO_2, CH_4, NO_X, TSP, SO_X, CO, Pb and HC), noise and traffic. Thus, we can group the environmental issues associated with this stage into the themes of energy consumption, raw material depletion, global warming, photochemical oxidant formation and eutrophication, acid precipitation, atmospheric pollution, noise, vibration and traffic.

Significant levels of pollutant are generated in this stage as a result of burning fossil fuel.

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[8] See Tsai, Materials of Engineering, p. 228, Taipei, 1997

[9] Annual output is converted into a dimensional total output in compliance with the data of tiles and red bricks shown in Table D-2.

Consequently, this section will mainly focus on estimating the emission volume of pollutants from the burning of petrol and diesel and the EPA's data on TSP emissions will also be considered.

D.2.1 Energy Consumption at the Transportation Stage

There are four ways of transporting building materials; by road, rail, sea and air. Currently, most are transported in Taiwan via road and rail. In December 1995, the daily freight tonnage on roads was 765,360 tonnes (88.65% of total inland freight tonnage) and 98,100 tonnes by rail (11.35% of the total). It is clear that roads constitute the main form of inland transportation of building materials[10]. A survey conducted by the Ministry of Communications in 1990 revealed that gravel dump trucks accounted for the greatest proportion of total freight tonnage (73.91 million tonnes or 15.01% of the total). Next came various containers at 14.57%. Pre-mixed concrete cargoes accounted for 3.12% and various types of cement cargo 3.05%[11]. This data indicates that the transportation of building materials accounts for a significant proportion of Taiwan's total freight tonnage.

Table D-17 lists the freight mileage, tonnage and fuel consumption of vehicles transporting building materials by road. In 1994, the annual energy consumption of this activity came to 202.35 thousand kilolitres of oil equivalent oil, 0.31% of Taiwan's total energy consumption and 1.74% of the energy used by the transport sector. Figure D-8 illustrates that the transport of aggregate for construction consumes the most energy amongst building materials transportation (15.5%), followed by steel products (8.13%) and pre-mixed concrete (7.09%).[12]

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[10] According to Liu (1994, p. 47), road transport accounts for 99.76% of the energy used to carry building materials while rail transport only accounts for 0.24%.

[11] See Liu, 1994, p. 41

[12] See Yang, 1996, p. 12

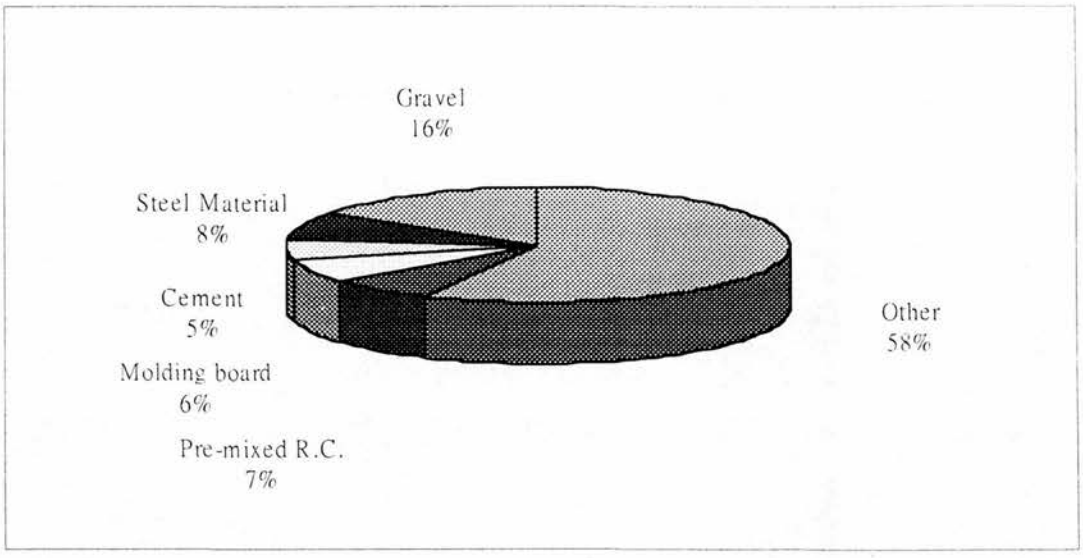


FIG. D-8: Proportion of Energy Consumed by the Inland Transportation of Various Building Materials

Table D-17: Freight Mileage, Tonnage & Fuel Consumption for Transportation by Road of Building Materials

Products Related to Construction		Freight Mileage (Km)	Freight Tonnage (T)	Total Oil Consumption (L)	Fuel Consumption (L)	Diesel Consumption (L)
Gravel	Gravel	224300936	72245336.97	32134804.58	868508.232	31266296.35
Steel	steel prototype	1737635	975482.388	248944.8424	6728.23898	242216.6034
	Steel bar	26387047	3993615.546	3780379.226	102172.412	3678206.815
	Steel frame	31755051	3793337.56	4549434.241	122957.682	4426476.559
	Steel plate	58008128	5444627.87	8310620.057	224611.353	8086008.704
Cement	cement	77429160	11063781.4	11093002.87	299810.888	10793191.98
Aluminium	Aluminium tablet	10142081	854655.975	1453020.201	39270.8162	1413749.384
	Door & window	27958006	1738479.8	4005444.986	108255.27	3897189.716
Glass	Glass plate	19866032	1320916.651	2846136.39	76922.6051	2769213.785
	Fibreglass	5849014	296493.946	837967.6218	22647.7736	815319.8482
Pottery	Kiln products	28956319	2434824.071	4148469.771	112120.805	4036348.966
	Porcelain	22700887	2147321.049	3252276.074	87899.3534	3164376.721
Wood	Timber	60194392	4857767.168	8623838.395	233076.713	8390761.682
	Plywood	20941565	2038350.909	3000224.212	81087.1409	2919137.071
	Processed plywood	40328576	3286530.187	5777732.951	156154.945	5621578.007
	Furniture	55415494	2398150.317	7939182.521	214572.501	7724610.021
	moulding board	93764478	5208983.141	13433306.3	363062.333	13070243.97
Cement Product	concrete	102434991	66067400.04	14675500.14	396635.139	14278865
	cement products	22629967	2886009.391	3242115.616	87624.7464	3154490.87
Clay Product	Brick	24605501	4700622.993	3525143.41	95274.1462	3429869.264
Plastic Product	Plastic tube	31298317	1854395.628	4483999.57	121189.178	4362810.393
	Plastic leather	12519326	829722.77	1793599.713	48475.6679	1745124.046
	Plastic cloth	20865544	1029805.9	2989332.951	80792.7825	2908540.169
Paper-making	Pulp	6156060	391854.422	881957.0201	23836.6762	858120.3438
	Paper	86550735	5559672.804	12399818.77	335130.237	12064688.53
plastic	PVC	6343671	522728.31	908835.3868	24563.1186	884272.2683
	Artificial resin	11418607	796419.46	1635903.582	44213.6103	1591689.971
	Artificial rubber	2595137	206214.38	371796.1318	10048.5441	361747.5877
Artificial Fibre	Artificial fibre textile	16396522	805898.432	2349071.92	63488.4303	2285583.49
Textile	Mixed cotton	8611923	645740.516	1233799.857	33345.9421	1200453.915
Paint	Paint	34426459	1355738.841	4932157.45	133301.553	4798855.897
Lighting Appliance	Lighting equipment	25628677	696235.392	3671730.229	99235.9521	3572494.277

Products Related to Construction		Freight Mileage (Km)	Freight Tonnage (T)	Total Oil Consumption (L)	Fuel Consumption (L)	Diesel Consumption (L)
Paint	Paint	34426459	1355738.841	4932157.45	133301.553	4798855.897
Lighting Appliance	Lighting equipment	25628677	696235.392	3671730.229	99235.9521	3572494.277
Electric Machinery	Air conditioner	19647361	1314375.34	2814808.166	76075.8964	2738732.27
	wire	45479226	1975319.593	6515648.424	176098.606	6339549.818
	Electromechanic	36277808	2235677.54	5197393.696	140470.1	5056923.596
Others	Other non-metal materials	129353312	1886553.529	18531993.12	500864.679	18031128.44

Data Source: Yang, 1996, p. 13

Table D-18 shows that the transportation of lighting appliances as measured per unit weight consumes the most energy amongst building materials, and items like paint, wooden furniture, artificial fibre textiles and plastic cloth are also significant consumers. Since energy consumption depends on the average distance the building material travels, the greater the distance the higher the consumption rate. Besides, the unit weight of building materials, together with the difficulties involved in moving them, influence their per unit energy consumption. For instance, lighting appliances are not heavy per unit volume, resulting in more energy being used per tonne to transport them.

Table D-18: Energy Consumption and Greenhouse Gas Emissions at the Transportation Stage

Products Related to Construction		Energy Consumption Vol. For Unit Transportation (Kcal/T)	CO_2 Emission Vol. For Unit Transportation (Kg/Kg)	CH_4 Emission Vol. For Unit Transportation (Kg/Kg)	N_2O Emission Vol. For Unit Transportation (Kg/Kg)	CO_2^* Emission Vol. For Unit Transportation (Kg/Kg)
Gravel	Gravel	3902.228	0.0012	1.0954E-06	6.27E-07	0.0014
Steel	steel prototype	2238.878	0.0007	6.2850E-07	3.60E-07	0.0008
	Steel bar	8304.546	0.0025	2.3313E-06	1.33E-06	0.0030
	Steel frame	10521.622	0.0032	2.9536E-06	1.69E-06	0.0038
	Steel plate	13390.969	0.0041	3.7591E-06	2.15E-06	0.0048
Cement	cement	8796.144	0.0027	2.4693E-06	1.41E-06	0.0032
Aluminium	Aluminium tablet	14915.132	0.0046	4.1870E-06	2.40E-06	0.0054
	Aluminium window	20212.867	0.0062	5.6742E-06	3.25E-06	0.0073
Glass	Glass plate	18902.841	0.0058	5.3064E-06	3.04E-06	0.0068
	Fibreglass	24794.662	0.0076	6.9604E-06	3.99E-06	0.0089
Pottery	Kiln products	14947.451	0.0046	4.1961E-06	2.40E-06	0.0054

Products Related to Construction		Energy Consumption Vol. For Unit Transportation (Kcal/T)	CO_2 Emission Vol. For Unit Transportation (Kg/Kg)	CH_4 Emission Vol. For Unit Transportation (Kg/Kg)	N_2O Emission Vol. For Unit Transportation (Kg/Kg)	CO_2^* Emission Vol. For Unit Transportation (Kg/Kg)
	Plywood	12912.834	0.0040	3.6249E-06	2.08E-06	0.0046
	Processed plywood	15422.921	0.0047	4.3295E-06	2.48E-06	0.0055
	Furniture	29043.314	0.0089	8.1535E-06	4.67E-06	0.0104
	moulding board	22624.384	0.0069	6.3511E-06	3.64E-06	0.0081
Cement Product	Pre-mixed concrete	1948.734	0.0006	5.4705E-07	3.13E-07	0.0007
	cement products	9855.475	0.0030	2.7666E-06	1.58E-06	0.0035
Clay Product	brick	6579.125	0.0020	1.8469E-06	1.06E-06	0.0024
Plastic Product	Plastic tube	21213.384	0.0065	5.9550E-06	3.41E-06	0.0076
	Plastic leather	18964.409	0.0058	5.3237E-06	3.05E-06	0.0068
	Plastic cloth	25466.291	0.0078	7.1489E-06	4.09E-06	0.0091
Paper-making	Pulp	19745.560	0.0061	5.5430E-06	3.17E-06	0.0071
	Paper	19566.489	0.0060	5.4927E-06	3.15E-06	0.0070
plastic	PVC	15253.026	0.0047	4.2818E-06	2.45E-06	0.0055
	artificial resin	18020.326	0.0055	5.0587E-06	2.90E-06	0.0065
	Artificial rubber	15817.313	0.0048	4.4403E-06	2.54E-06	0.0057
Artificial Fibre	Artificial fibre textile	25571.888	0.0078	7.1786E-06	4.11E-06	0.0092
Textile	Mixed cotton	16762.295	0.0051	4.7055E-06	2.69E-06	0.0060
Paint	Paint	31915.943	0.0098	8.9595E-06	5.13E-06	0.0115
Lighting Appliance	Lighting equipment	46265.947	0.0142	1.2988E-05	7.44E-06	0.0166
Electric Machinery	Air conditioner	18787.811	0.0058	5.2741E-06	3.02E-06	0.0067
	wire	28937.903	0.0089	8.1235E-06	4.65E-06	0.0104
	Electric-mechanic	20394.978	0.0063	5.7235E-06	3.28E-06	0.0073
others	Other non-metal mineral materials	86178.670	0.0264	2.4192E-05	1.39E-05	0.0309

Data Source: Yang, 1997, p. 14

D.2.2 Effects on Global Warming at the Transportation Stage

The prime contributor to global warming is the greenhouse gases emitted from the burning of fossil fuel (e.g., CO_2, CH_4, N_2O and CFCs), including that burned by vehicles. Quantified data on the global warming effect can be obtained by calculating how much petrol and diesel is consumed in relation to their emission factors, emission of CFCs and the equivalency factor of global warming.

Vehicles carrying building materials use petrol and diesel.[13] The level of carbon emissions can be obtained by first converting the amount of fuel used into a thermal value and then multiplying the respective carbon emission potential. The level of CO_2 emissions can be acquired by multiplying the total volume of carbon emissions with the carbon-oxidising rate and 44/12 (the weight ratio of CO_2 vs. carbon).[14] Table D-18 above lists per unit CO_2 emissions associated with transporting every building material. Annual CO_2 emissions from this activity come to 558,266 tonnes (0.37% of Taiwan's total CO_2 emissions and 2.01% of the total of the transportation sector).[15]

Table D-19: CH_4 Emissions at the Transportation Stage

Building Material	CH_4 Emission Volume ton/year	Construction Material	CH_4 Emission ton/year
Gravel	79.14	Paper-making	32.70
Steel	41.59	Plastic	7.19
Cement	27.32	Artificial Fibre Textile	5.79
Aluminium Products	13.44	Textile	3.04
Glass	9.07	Paint	12.15
Porcelain	18.22	Lighting Appliances	9.04
Timber	95.49	Electric Machinery	35.78
Concrete Products	44.12	Others	45.64
Brick	8.68		
Plastic Products	22.82	Total	511.22

[13] The consumption ratio between petrol and diesel is 1:36. See Yang, 1997, p.15

[14] Ibid, p. 15

[15] Ibid, p. 15

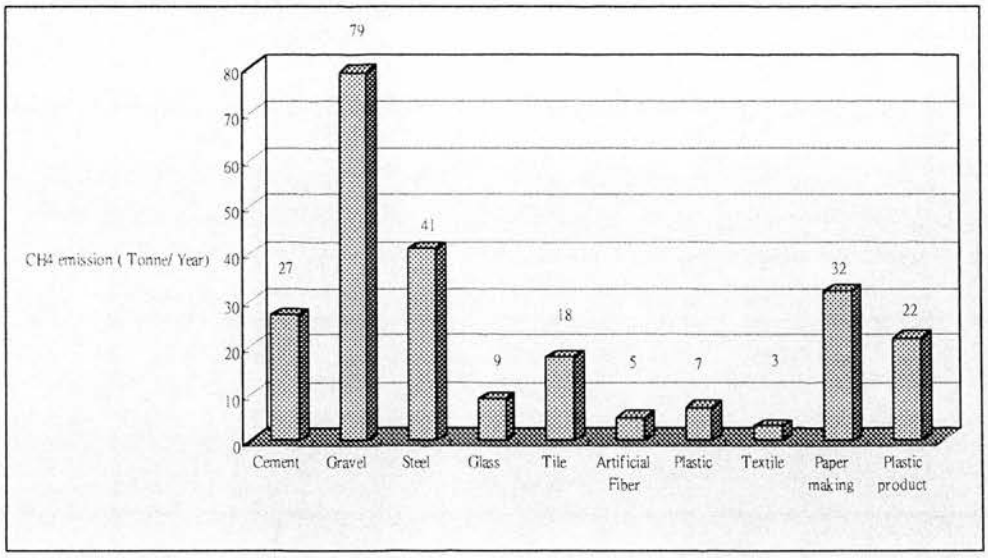


FIG. D-9: CH_4 Emissions from the Transport of Various Building Materials

The NO_x produced from transporting building materials is a mobile source of pollution. Taiwan's NO_x emissions in 1995 came from both stationary (42.6%) and mobile (57.4%) pollution sources. The main stationary source is fuel burning, power generation accounting for 21.5% of that. As for mobile pollution sources, diesel cars account for 45.0% (their emissions come to 280,400 tonnes per year) and cars 11%, as Figure D-10 shows.

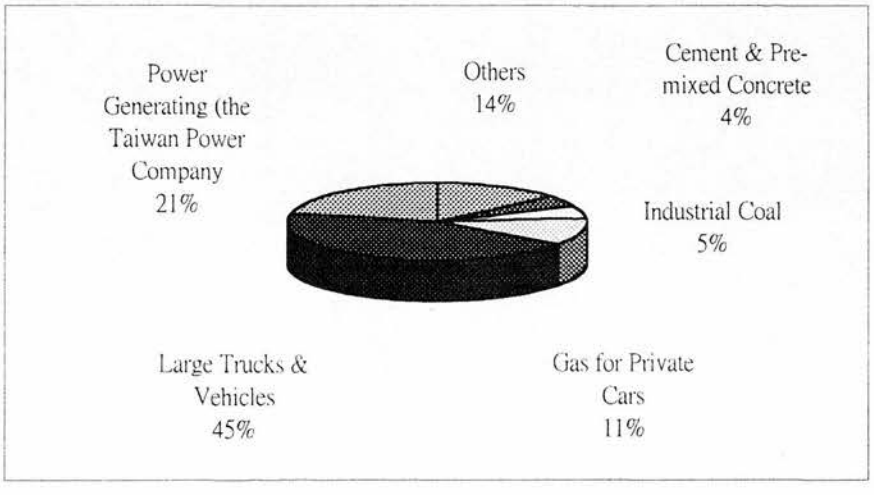


FIG. D-10: NO_x Emission Rates in Taiwan

To estimate the level of NO_x produced from the transport of building materials we multiply the mileage of the various relevant transport trucks with the emission factor of dump trucks and vehicles to get the No_x and NO_2 emission volumes as Tables D-20 show. The transport of building materials produces 29,276.18 tonnes of No_x which is 4.53% of Taiwan's total NO_x emissions and 7.90% of mobile pollution sources. Amongst building materials, the transportation of timber accounts for the largest proportion (5,469.48 tonnes or 18.68% of this activity's total) and second highest is gravel (4,529.78 tonnes).

Table D- 20: NO_x Emissions at the Transportation Stage

Construction Material	NO_x Emissions (tonne/year)	Construction Material	NO_x Emissions (tonne/year)
Gravel	4529.78	Paper-making	1875.51
Steel	2377.92	Plastic	411.4
Cement	1559.99	Artificial Fibre Textile	331.22
Aluminium Products	770.11	Textile	173.70
Glass	519.89	Paint	695.49
Porcelain/ Pottery	1043.87	Lighting Appliances	517.99
Timber	5469.48	Electric Machinery	2048.76
Concrete Products	2523.89	Others	2622.30
Red Brick	498.27	Total	29276.18
Plastic Products	1306.61		

The emissions of CFC_{11} and CFC_{12} come to 3.6 tonnes and 11.5 tonnes respectively (EPA, 1998). Following the GWP formula ($GWP = 1* CO_2 + 9 * CH_4 + 190*N_2O + 1500*CFC_{11} + 4500*CFC_{12}$), the GWP emission (equivalent CO_2) is 675,641 tonnes.

D.2.3 Effects on Acid Precipitation at the Transportation Stage

Acid rain is the result of acidifying substances mixing with rain. It refers to the various processes by

which man-made emissions of sulphur dioxide and nitrogen oxides come to be deposited on land and water, often at long distances from the source of pollution. Two major acidifying pollutants (SOx and Nox, whose acidification potential is 1.0 and 0.7 respectively) are associated with vehicle exhausts.

To estimate SO_x emissions from the transport of building materials we multiply the average SO_x emission factor of dump trucks with the mileage traveled in carrying each building material, as Table D-21 shows. The volume of emissions from transporting building materials per unit (kg) can be obtained by dividing the emission figure with the freight tonnage of each building material, as Table D-22 shows.

Table D- 21: SOx Emissions from Transporting Various Building Materials

Building Material	**SOx Emission (tonne/year)**	**Building Material**	**SOx Emission (tonne/year)**	**Building Material**	**SOx Emission (tonne/year)**	**Building Material**	**SOx Emission (tonne/year)**
Gravel	575.10	Timber	693.92	Artificial Fibre Textile	42.04	Porcelain	132.45
Steel	302.27	Concrete Products	318.66	Textile	22.08	Plastic	52.20
Cement	198.53	Brick	63.08	Paint	88.27	Others	331.66
Aluminium Products	97.68	Plastic Products	165.84	Lighting Appliances	65.71		
Glass	65.94	Paper-making	237.70	Electric Machinery	260.00	Total	3713.13

Table D- 22: Pollutant Emissions Per Unit (kg) at the Transportation Stage (Unit: kg/kg)

Material		NO_x Emission	TSP Emission	SO_x Emission	CO Emission	Pb Emission	HC Emission
Gravel	Gravel	6.67E-05	9.31E-06	7.96E-06	3.46E-05	1.52E-09	1.08E-05
Steel	steel prototype	3.60E-05	5.34E-06	4.56E-06	1.98E-05	8.76E-10	6.24E-06
	Steel bar	1.33E-04	1.98E-05	1.69E-05	7.36E-05	3.25E-09	2.32E-05
	Steel frame	1.69E-04	2.51E-05	2.15E-05	9.32E-05	4.11E-09	2.93E-05
	Steel plate	2.15E-04	3.20E-05	2.73E-05	1.19E-04	5.24E-09	3.73E-05
Cement	cement	1.41E-04	2.10E-05	1.79E-05	7.79E-05	3.44E-09	2.45E-05
Aluminium	Aluminium tablet	2.40E-04	3.56E-05	3.04E-05	1.32E-04	5.83E-09	4.16E-05
	Aluminium window	3.25E-04	4.82E-05	4.12E-05	1.79E-04	7.91E-09	5.64E-05
Glass	Glass plate	3.04E-04	4.51E-05	3.86E-05	1.67E-04	7.40E-09	5.27E-05
	Fibreglass	3.99E-04	5.92E-05	5.06E-05	2.19E-04	9.71E-09	6.91E-05
Pottery	Kiln products (tile, cored tile)	2.40E-04	3.57E-05	3.05E-05	1.32E-04	5.85E-09	4.17E-05
	Porcelain materials	2.14E-04	3.17E-05	2.71E-05	1.17E-04	5.20E-09	3.70E-05
Wood	Timber	2.50E-04	3.72E-05	3.18E-05	1.38E-04	6.10E-09	4.34E-05
	Plywood	2.08E-04	3.08E-05	2.63E-05	1.14E-04	5.05E-09	3.60E-05
	Processed Plywood	2.48E-04	3.68E-05	3.15E-05	1.37E-04	6.03E-09	4.30E-05
	Furniture	4.67E-04	6.93E-05	5.92E-05	2.57E-04	1.14E-08	8.10E-05
	moulding board	3.64E-04	5.40E-05	4.62E-05	2.01E-04	8.86E-09	6.31E-05
Cement Product	concrete	3.13E-05	4.65E-06	3.97E-06	1.72E-05	7.62E-10	5.43E-06
	cement products	1.58E-04	2.35E-05	2.01E-05	8.7E-05	3.86E-09	2.75E-05
Clay Product	Brick	1.06E-04	1.57E-05	1.34E-05	5.83E-05	2.57E-09	1.83E-05
Plastic Product	Plastic tube	3.41E-04	5.06E-05	4.33E-05	1.88E-04	8.30E-09	5.91E-05
	Plastic leather	3.05E-04	4.53E-05	3.87E-05	1.68E-04	7.42E-09	5.29E-05
	Plastic cloth	4.09E-04	6.08E-05	5.20E-05	2.26E-04	9.97E-09	7.10E-05
Paper-making	Pulp	3.17E-04	4.71E-05	4.03E-05	1.75E-04	7.73E-09	5.50E-05
	Paper	3.15E-04	4.67E-05	3.99E-05	1.73E-04	7.66E-09	5.45E-05
plastic	PVC	2.45E-04	3.64E-05	3.11E-05	1.35E-04	5.97E-09	4.25E-05
	artificial resin	2.90E-04	4.30E-05	3.68E-05	1.60E-04	7.05E-09	5.02E-05
	Artificial rubber	2.54E-04	3.78E-05	3.23E-05	1.40E-04	6.19E-09	4.41E-05
Artificial Fibre	Artificial fibre textile	4.11E-04	6.10E-05	5.22E-05	2.27E-04	1.00E-08	7.13E-05
Textile	Mixed cotton	2.09E-04	4.00E-05	3.42E-05	1.49E-04	6.56E-09	4.67E-05
Paint	Paint	5.13E-04	7.62E-05	6.51E-05	2.83E-04	1.25E-08	8.90E-05
Lighting Appliance	Lighting equipment	7.44E-04	1.10E-04	9.44E-05	4.10E-04	1.81E-08	1.29E-04
Electric Machinery	Air conditioner	3.02E-04	4.48E-05	3.83E-05	1.66E-04	7.35E-09	5.24E-05
	Wire	4.65E-04	6.91E-05	5.90E-05	2.56E-04	1.13E-08	8.07E-05
	Electric-mechanic	3.28E-04	4.87E-05	4.16E-05	1.81E-04	7.98E-09	5.69E-05
others	Other non-metal mineral	1.39E-03	2.06E-04	1.75E-04	7.64E-04	3.37E-08	2.40E-04

The transportation stage of the building life-cycle emits 3,713.13 tonnes of SO_x (0.84% of Taiwan's

total). Amongst building materials, transporting timber generates the largest proportion of emissions (693.92 tonnes or 18.66% of the SO_x emissions from this activity), while the transportation of gravel comes next at 575.10 tonnes (see Figure D-11). As the emission of Nox is 29,276 tonnes and SOx 3,713.13 tonnes, the emission of equivalent SO_2 (AP) is 24,206.33 tonnes. Nox accounts for 84.6% of the total AP emission figure since the heavy vehicles used to transport building materials have a high Nox emission factor.

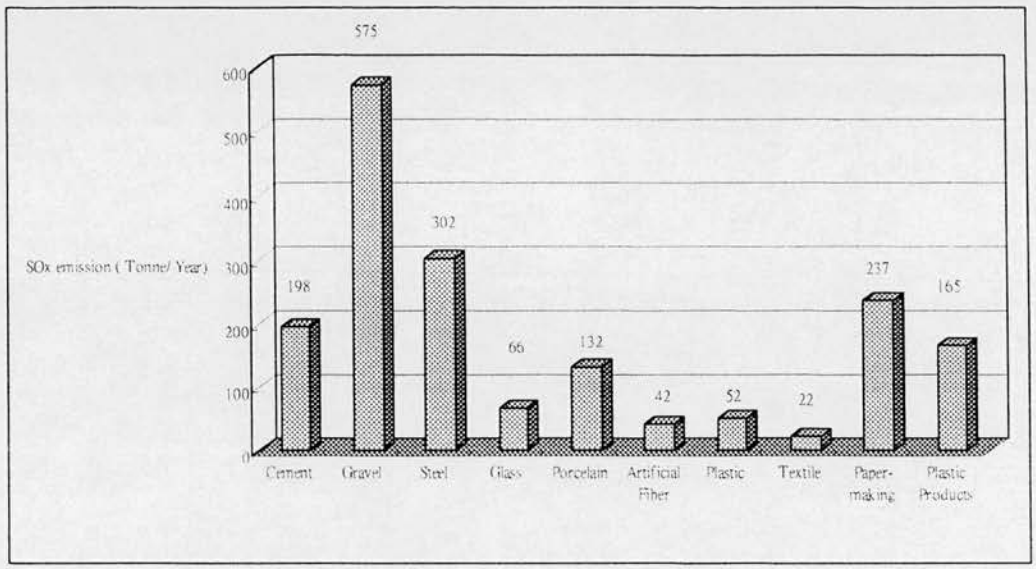


Fig. D-11: SO_x Emissions from Transporting Major Building Materials

D.2.4 Effects on Photochemical Oxidant Formation and Eutrophication at the Transportation Stage

The main substances which contribute to photochemical oxidant formation at the transportation stage are CH4 and hydrocarbon (HC). Table D-19 shows that CH4 emissions amount to 511.22 tonnes. The HC emissions from transporting building materials can be obtained by multiplying the average emission factor of HDDT with the freight mileage involved in transporting each building material. In 1995, Taiwan's HC emissions came to 628,081 tonnes, of which 32.46% stemmed from mobile pollution sources. Table D-23 shows that the HC emissions from transporting building materials come to 5,077.15 tonnes, 0.81% of Taiwan's total and 3.39% of the total of the road transportation sector.

Table D-23: HC Emissions at the Transportation Stage (Unit: tonnes/year)

Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)	Building Material	HC Emission (tonne/year)
Gravel	785.95	Timber	948.34	Artificial Fibre Textile	57.45	Porcelain	181.00
Steel	413.08	Concrete Products	438.22	Textile	30.17	Plastic	71.32
Cement	271.31	Brick	86.21	Paint	120.63	Others	453.25
Aluminium Products	133.51	Plastic Products	226.65	Lighting Appliances	89.80		
Glass	90.11	Paper-making	324.84	Electric Machinery	355.31	Total	5077.15

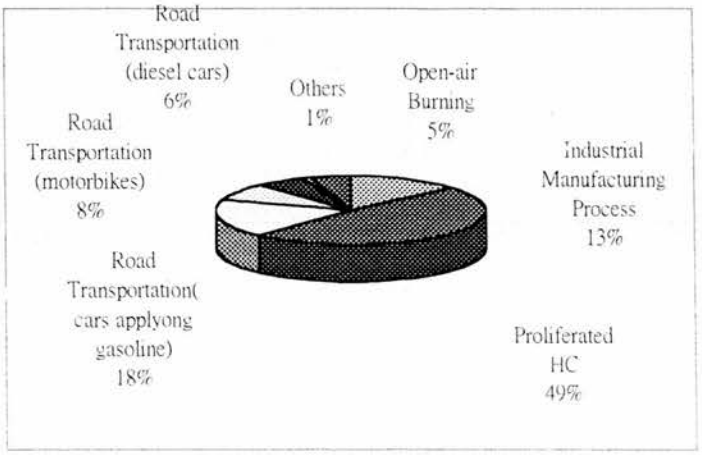


FIG. D-12: HC Emissions in Taiwan

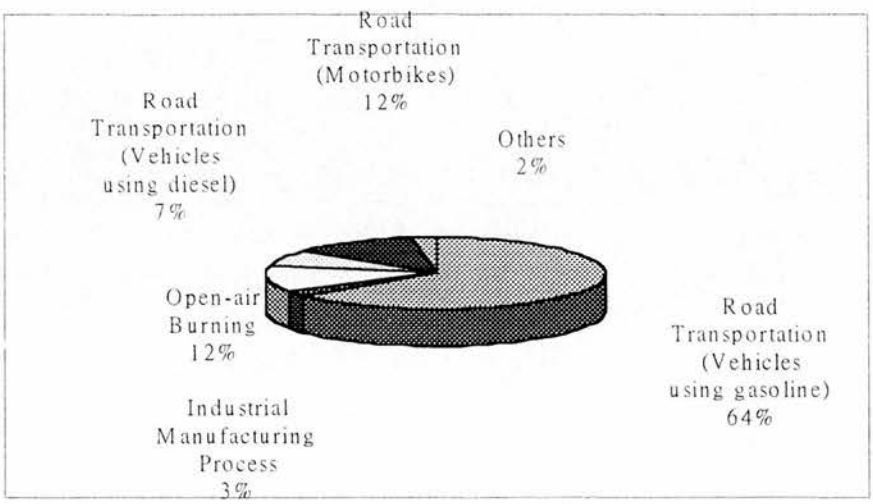
Amongst building materials, the transportation of timber generates the highest volume of HC emissions (948.34 tonnes or 18.68% of the total for this activity), followed by gravel (785.95 tonnes or 15.49%). The equivalent ethylene (POCP) is 1,918 tonnes and HC emissions account for 99% of this.

While assessing the impact of this second stage on eutrophication, the equivalent phosphate (PO4) must first be converted and then accumulated. Nox is associated with eutrophication. As we saw above, Nox emissions from this stage come to 29,276 tonnes and as this Nutrification Potential (NP) is 0.13, the equivalent PO4 (NP) is 3,806 tonnes.

D.2.5 Effects on Human Toxicity at the Transportation Stage

The transportation of building materials causes various toxic substances to be released including carbon monoxide (CO), lead (Pb), nitrogen oxide (Nox) and sulphur dioxide (Sox). To assess the toxic impact of these substances, the human toxicity potential (HT) has to be transformed and accumulated. We have already seen that Nox emissions amount to 29,276 tonnes and SOx emissions to 3,713.13 tonnes. In this section we will look at CO and Pb emission levels.

Taiwan's total CO emissions in 1995 came to 1,489,543 tonnes. Petrol-driven cars and vans were the source of 64.06% (954,157 tonnes) of this total (954,157 tonnes); motorcycles 11.82% (176,004 tonnes); and diesel lorries 6.87%, as Figure D-13 shows. From this figure, we see that CO emissions largely come from mobile pollution sources (83.2% of the total). Stationary pollution sources only account for 16.8% of the total, and 12.4% of it results from open-air burning.



Data Source: EPA, 1997, p. 60

FIG. D-13: Proportion of CO Emissions in Taiwan in terms of Main Pollution Sources

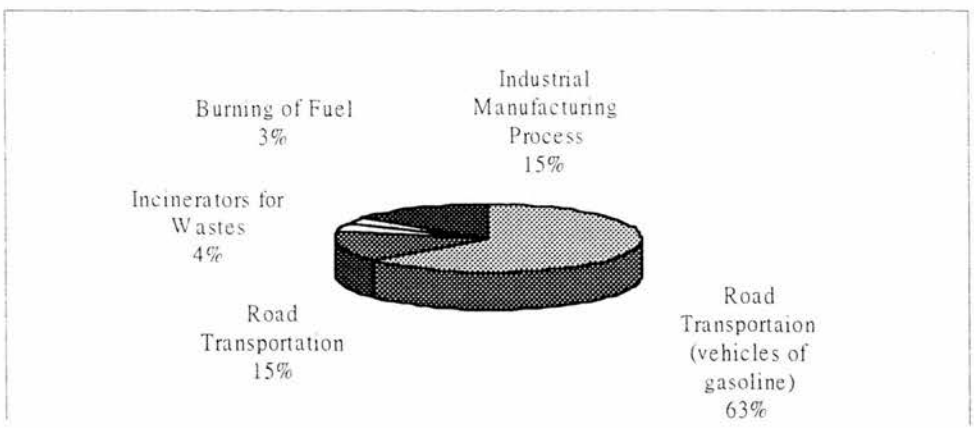
To estimate the CO emissions generated from the transportation of building materials, we multiply

To estimate the CO emissions generated from the transportation of building materials, we multiply 11.1367 g/km - the average CO emission factor of big trucks - with the transportation mileage for each building material, as Table D-24 shows. The total figure comes to 16,135.79 tonnes (1.09% of Taiwan's total CO emissions). The transportation of timber accounts for the highest proportion (3,013.10 tonnes or 18.67% of the total emissions from transportation activities), followed by gravel (2,497.97 tonnes or 15.48%).

Table D- 24: CO Emissions at the Transportation Stage (Unit: tonnes/year)

Building Material	CO Emission (tonne/year)	Building Material	CO Emission (tonne/year)	Building Material	CO Emission (tonne/year)	Building Material	CO Emission (tonne/year)
Gravel	2497.97	Timber	3013.10	Artificial Fibre Textile	182.60	Porcelain/ Pottery	575.29
Steel	1312.88	Concrete Products	1392.80	Textile	95.91	Plastic	226.72
Cement	862.31	Brick	274.02	Paint	383.39	Others	1440.57
Aluminium Products	424.31	Plastic Products	720.35	Lighting Appliances	285.42		
Glass	286.38	Paper-making	1032.45	Electric Machinery	1129.32	Total	16135.79

In 1995, 6% of Taiwan's air failed to meet the environmental quality standard on Pb (lead). Of Taiwan's total lead emissions (319 tonnes), industrial manufacturing accounted for 15.4% while petrol-driven cars and vans accounted for 63.22%. The ratio of each main pollution source is shown in Figure D-14.



Data Source: EPA, 1997a, pp. 53-56

FIG. D-14: Proportionate Sources of Pb Emissions in Taiwan

We can establish the level of Pb emissions from the transportation of building materials by multiplying the average Pb emission factor of transportation vehicles with the freight mileage for each material as shown in Table D-25.

Table D- 25: Pb Emissions at the Transportation Stage (Unit: tonnes/year)

Building Material	Pb Emission (tonne/year)	Building Material	Pb Emission (tonne/year)	Building Material	Pb Emission (tonne/year)	Building Material	Pb Emission (tonne/year)
Gravel	0.1104	Timber	0.1332	Artificial Fibre Textile	0.0081	Porcelain	0.0254
Steel	0.0580	Concrete Products	0.0615	Textile	0.0042	Plastic	0.0100
Cement	0.0381	Red Brick	0.0121	Paint	0.0169	Others	0.0636
Aluminium Products	0.0188	Plastic Products	0.0318	Lighting Appliances	0.0126		
Glass	0.0127	Paper-making	0.0456	Electric Machinery	0.0499	Total	0.7129

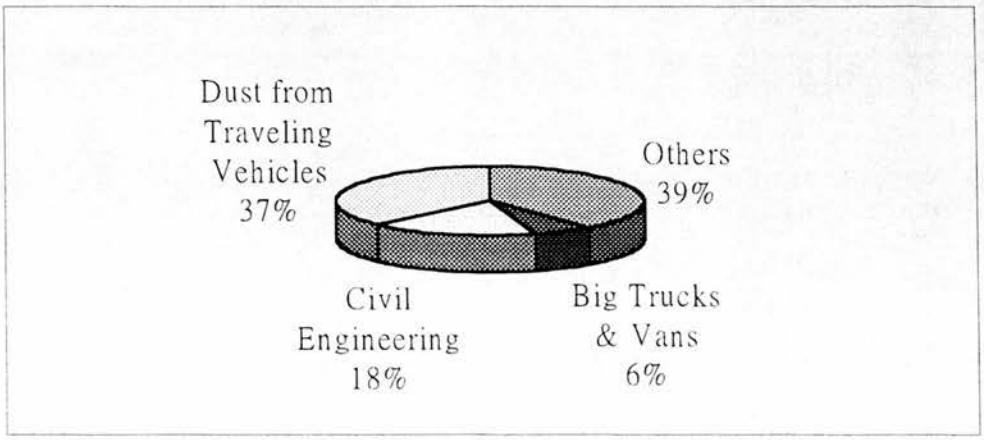
The Pb emissions from this second stage of buildings come to 0.7129 tonnes (0.22% of Taiwan's total). Again, the transportation of timber produces the greatest proportion within this building-related activity (0.1332 tonnes or 18.68%), followed by the transportation of gravel (0.1104 tonnes or 15.49%). The Pb emissions from transporting other kinds of building material are also listed in Table D- 25. In terms of the Pb emissions from transporting each unit of construction material, a non-metal mineral material (rock cotton) comes highest followed by lighting appliances.

The emission of substances toxic to human beings has been assessed above. Total HT emissions amount to 27,598.7 tonnes; NOx accounts for 82.7% of this total while Sox accounts for 16.1%.

D.2.6 Atmospheric Pollution at the Transportation Stage

Vehicles carrying building materials generate pollutants such as CO2, CH4, N2O, Nox, Sox, CO, P_b, HC and TSP from their burning of fossil fuel. The emission levels of most of these pollutants have already been calculated and discussed, so this section will focus on TSP emissions.

According to EPA data, the TSPs generated from road use (a mobile pollution source) came to 61,651 tonnes in 1995 (9.47% of Taiwan's total). In addition, fine particles set aloft from moving vehicles came to 242,280 tonnes (37.23%) as Figure D-15 shows.



Data Source: EPA, 1997, pp. 53-56

FIG. D-15: Proportionate Sources of TSP Emissions in Taiwan

To estimate the TSP emissions generated from the transportation of building materials, we multiply the average TSP emission factor of big trucks with the transportation mileage for each building material. The figure comes to 4,347.72 tonnes - 7.05% of TSPs emitted by the road transport sector - though it does not include the fine floating particles thrown up by the movement of vehicles. This latter kind of emission comes to 17,080.74 tonnes (see Table D-26). Hence, the total amount of TSPs emitted in this second stage is 21,428.46 tonnes (3.3% of Taiwan's total).

Table D- 26: TSP Emissions at the Transportation Stage

Building Material	TSP Emission (tonne/year)	Building Material	TSP Emission (tonne/year)	Building Material	TSP Emission (tonne/year)	Building Material	TSP Emission (tonne/year)
Gravel	672.90	Timber	811.93	Artificial Fibre Textile	49.19	Plastic	61.08
Steel	353.56	Concrete Products	376.09	Textile	25.84	Porcelain/ Pottery	154.97
Cement	232.29	Brick	73.82	Paint	103.27	Others	388.06
Aluminium	114.3	Plastic Products	194.05	Lighting Appliances	76.89	Particles from traveling vehicle	17080.74
Glass	77.15	Paper-making	278.12	Electric Machinery	304.21	Total	21428.46

Table D- 27 lists the volume of each air pollutant. Nitrogen oxide (NO_x) has the highest rate (4.53% of Taiwan's total NO_x emissions); dinitrogen oxide (N_2O) accounts for 4.43% of Taiwan's total N_2O emissions; and TSPs account for 3.3% of Taiwan's total TSP emissions.

Table D- 27: Emissions of Atmospheric Pollutants at the Transportation Stage

Substance	Emission (tonnes)	Rate of Total Emission in Taiwan (%)
CO_2	558266	0.37
CH_4	511	3.00
N_2O	292	4.43
SO_x	3713	0.84
NO_x	29276	4.53
CO	16136	1.09
Pb	0.71	0.22
TSP	21428	3.30
HC	5077	0.81

The CDV model can be applied to assess the effect of the second stage on atmospheric pollution. Using the CDV formula, we find that the CDV of equivalent SO2 at this stage is 643,348 tonnes, about twice as much as that found at the first stage the building life-cycle.

D.2.7 Noise Pollution at the Transportation Stage

Vehicles transporting building materials are noisy, especially when traveling through city centres. In

D.2.7 Noise Pollution at the Transportation Stage

Vehicles transporting building materials are noisy, especially when traveling through city centres. In 1995, 17,772 petitions against noise were raised in Taiwan, an increase of 3.37% over the 1994 figure. Factories are the greatest source of noise and they are the cause of most complaints (33.62%). Table D-28 shows that there were 115 petitions raised against the traffic noise of transportation vehicles (0.61% of the total).

Table D-28: Petitions Raised against Noise in Taiwan

Noise Source: Case Number & %		factory	Entertainment Place	Construction Site	Amplification Equipment	Neighbourhood Noise	Traffic Noise	Military	Total
Taipei	Petition	1065	2148	2004	1137	1217	84	0	7615
	Percent	13.98	28.2	26.31	14.93	15.98	0.58	0	100
Kaohsiung	Petition	659	8930	216	256	55	4	1	2111
	Percent	31.21	39.3	10.23	12.12	2.6	0.19	0.04	100
Taiwan Province	Petition	1251	1957	596	602	552	67	13	8646
	Percent	53.83	23.34	7.48	7.48	6.93	0.83	0.16	100
Taiwan Areas	Petition	5975	4927	2706	1995	1830	115	14	17772
	Percent	33.62	28.78	16.35	11.22	10.29	0.61	0.07	100

Data Source: EPA, 1997a, p. 93

Noise levels are most likely to be complained about if the noise level is high during the day. Table D-29 shows that this time slot accounted for 82.6% of the petitions raised. Night-time noise accounted for 10.7%, while early morning noise (5am-7am) only caused 61 petitions to be raised (0.24% of the total).

Table D- 29: Time Slots of Noise Petitions Raised in Taiwan

Control Area Time Zone Case Number Area	Group I Control Area				Group II Control Area				Group III Control Area				Group IV Control Area				Total			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Taipei City	2	74	2	8	8	5388	518	400	2	743	151	164	0	1127	6	4	12	7332	677	576
Kaohsiung City	0	0	0	0	2	141	12	6	9	141	234	156	2	36	5	7	13	318	251	169
Taiwan Province	0	0	0	1	14	8525	1134	604	20	4582	636	272	2	189	22	8	36	13296	1792	885
Taiwan Area	2	74	2	9	12	7322	881	532	93	6745	1027	613	4	401	33	19	61 (0.24%)	20926 (82.6%)	2720 (10.7%)	1630 (6.46%)

Notes: (1) early morning: AM 5:00~7:00; (2) day: AM 7:00~PM 8:00; (3) night: PM 8:00~PM

The noise hearers experience is influenced by three factors: the components of noise; the transmission path from the noise source to the receiver (i.e., direct sound, reflected sound and ground-borne vibrations); and the hearers themselves. Noise decreases with distance and increases by the increment of the noise source. Generally speaking, a doubling of the intensity of a sound leads to an increase of 3dB(A). An increase of 10dB(A) is usually heard by the human ear as a doubling of sound, while an increase of below 3dB is barely detectable[16].

Table D-30 shows levels of noise pollution. Noise increase of less than 3dB is acceptable while increases of between 3-5dB have only a minor impact. Noise increase of over 5dB has moderately adverse impacts and requires that some mitigation measures be put in place. However, the environmental impact of traffic noise varies depending on location. For instance, regulations against noise pollution are more strict in the vicinity of hospitals and schools than they are in business districts. As the transportation of building materials involves a daily mileage of 3,696,791km, we can see that the noise of this activity is indeed significant.

Table D-30: Noise Significance Criteria

Criterion	Construction Noise	Traffic noise
Severe adverse	Noise above traffic noise insulation thresholds for > 8 weeks; insulation or permanent rehousing required	> 15 dB increase
Major adverse	Noise above traffic noise insulation thresholds for < 8 weeks; insulation or temporary rehousing required	10-15 dB increase
Moderate adverse	Noise above ambient levels for > 8 weeks, but below traffic noise insulation thresholds	5-10 dB increase
Minor adverse	Noise above ambient levels for < 8 weeks, but below traffic noise insulation thresholds	3-5 dB increase
None	Noise at or below ambient levels	< 3 dB increase

[16] See Morris, et al., 1995, pp. 51-54

Data source: Morris, P. et al., 1995, P. 60.

More stable levels of noise - such as traffic - can have long-term and chronic effects on people. This kind of noise has different characteristics from the suddenly greater noise of passing planes and trains. Generally speaking, the public will not be grossly aware of the noise of passing traffic and so will not have an extreme response to it, as can be seen from the relatively few petitions raised against it (only 0.61% of the annual total of petitions). Nevertheless, this does not imply that traffic noise is negligible. The increasing volume of traffic on roads and the extensive distribution of the road network suggest that traffic noise is a chronic source of stress.

Most of the vehicles which transport building materials are lorries with large loading capacities and noisy exhausts. They make a great deal of noise especially when accelerating. In addition, some materials (e.g., gravel, bricks and cement) are routinely delivered to the construction site before the builders start work, meaning that the transportation time slot for these items occurs between 5 a.m. and 8 a.m. This early morning heavy traffic has a tremendous impact on residents living close to the site.

Traffic noise varies according to distance from the source. In the distant sound field, if the source is open and there is no reflected sound field, the distance doubles and the sound level decreases by 6dB. In general, the distance parameter of traffic noise on the road is considered to be the linear distance between the hearer and the centre of the road. However, when the road is wide and has several lanes, then the level of noise between the slow and fast lanes will be significantly different. For this reason, the formula for the single-lane equivalent distance is usually applied.[17]

$$D_E = (D_N \cdot D_F)^{1/2}$$

D_E: the distance between the centre of the single-lane equivalent and the hearer

D_N: the distance between the centre of the nearest lane and the hearer

D_F: the distance between the centre of the furthest lane and the hearer

In practice, noise not only influences our ability to hear but also our feeling state; anger is not an uncommon response to the stress of chronic noise. The transportation of building materials, with its heavy trucks and high annual mileage, generates a relatively high level of chronically-stressful traffic noise which affects near-roadside residents to differing extents.

D.2.8 Traffic Impacts at the Transportation Stage

Building materials are mainly carried by road, and trucks are the vehicles most commonly used. The transportation of building materials accounts for a quarter of all the freight tonnage transportation in Taiwan - about 190,000 freight tonnes per day, i.e., each truck has a capacity of c.10 tonnes and there are about 19,000 of them moving on the roads each day.

Taiwan's traffic volume increases each year; the annual growth rate is around 8% (e.g., in 1996, it was 8.12%). Table D-31 shows the road area available for each car in Taiwan between 1991 and 1996. In 1991, each car occupied an average of 23.72m^2 of road space but by 1996 this had decreased to 22.42m^2 per car. As traffic congestion becomes more common, there are not only more traffic jams and accidents but more energy is consumed too.

[17] See Shih et al. 1984, pp. 45-47

Table D- 31: Proportion of Road Area to Vehicles in Taiwan (1991-1996)

Year	Road Area (,000 m^2)	Number of Vehicle (car)	Road Area for Each Car (m^2/car)
1991	251,649	10,611,037	23.72
1992	270,310	11,268,253	23.98
1993	283,408	11,856,528	23.90
1994	296,707	12,377,084	23.97
1995	310,139	13,201,471	23.49
1996	319,757	14,273,465	22.40

The assessment of traffic impacts is usually based on level of service (LOS) (grouped in six categories) which shows the degree of congestion as well as the capacity of roads.[18] As the pace of business activity quickens in Taiwan, the demand for transport also increases, resulting in greater traffic volumes on every road. For example, Taichung (Taiwan's third largest city) has 38 traffic arteries but 19 of those are classified as having a LOS below "Class D" (see Table D-32). With 50% of its main roads ranked below "D", we can see that Taichung's routes are overloaded.

Table D-32: Level of Service on Taichung's Traffic Arteries

Level of Service	V/C	Definition	Number of Road	Rate
A	>=0.80	steady traffic flow	3	7.9%
B	>=0.95	no congestion	9	23.7%
C	>=1.00	congested and inconvenient	7	18.4%
D	>=1.20	Traffic is overloaded with serious congestion	7	18.4%
E	>=1.35	Traffic is overloaded with deteriorating congestion	8	21.1%
F	>=1.35	Traffic is overloaded and vehicles can move	4	10.5%

Data Source: Taichung City Government, 1993 p.22 and Shih et al, 1984, p.39

From Table D-33 we see that the average road space per person is less in Taiwanese cities than it is in US or European cities; Taipei offers only 7.01m^2 of road per person and Taichung only 14.18m^2. New York (at 33.49m^2), Berlin (at 21.42m^2) and Paris (at 15.80m^2) all possess more road space per person

[18] Each road has an ideal capacity under specific conditions and this ideal may be adjusted in relation to its conditions in practice to show actual capacity (C). Factors which influence capacity include parallel parking and temporary parking to pick up passengers, etc.

than do the large Taiwanese cities. What this shows is that Taiwan's city road networks are less extensive than US and European counterparts. That, coupled with the inadequacies of Taiwanese cities' mass transit systems, ensures that traffic jams occur everywhere and at every time of day in the major cities. By making a sizable contribution to the number of (large) vehicles on the road, the transportation of building materials plays a lead role in exacerbating traffic problems.

Table D-33: Average Road Space and Road Rate per Person in Major Cities

City	Averaged Road Area for a Person (m2/person)	Road Rate (%)
New York	33.49	15.18
Berlin	21.42	9.77
Paris	15.80	6.24
Hamburg	12.59	3.11
Kyoto	11.37	2.60
Tokyo	8.74	4.81
Osaka	7.40	11.33
Taipei	7.01	6.70
Taichung	14.18	7.60
Kaohsiung	8.39	7.83

Data Source: abstracted from Shih et al., 1984, p.38

To assess the traffic impact of the second stage of the building life-cycle, we must evaluate the number of transportation vehicles involved; the time slots within which they are on the move (e.g., early morning, day or night); the length of their journeys; and the routes they take. This data must then be coupled with our information about prevailing traffic flows and road capacities. The assessment findings can be measured in terms of LOS, which will show changes in traffic conditions pre- and post-transportation stage as well as the extent of the second stage's impact on traffic.

11.3 ENVIRONMENTAL ISSUES RELATING TO THE CONSTRUCTION STAGE

During the third phase of the building life-cycle - the construction process - building work consumes

energy (e.g. through the use of power machinery) and natural resources (e.g., water) and emits several kinds of pollutants. In addition, the construction process impacts on the surrounding environment with its noise, vibration and alteration of underground water courses. This section will analyse the main environmental issues associated with this third stage: energy depletion, consumption of water resources, global warming, acid precipitation, photochemical oxidant formation and eutrophication, human toxicity, atmospheric pollution, waterborne pollution, solid waste disposal, traffic, noise and vibration and socio-economic impacts.

D.3.1 Energy Consumption at the Construction Stage

According to data provided by the Energy Committee, the construction industry consumes 217,000 kilolitres of oil equivalent oil per year (0.4% of Taiwan's total energy consumption). Fuel oil accounts for the highest proportion (44.5%), followed by diesel (37.4%), electric power (15.6%) and petrol (2.5%). Liquid energy is the primary form of energy consumed in the construction stage, accounting for 84.4% of the total energy consumed by the building trade; the movement and installation of building materials and equipment on-site are mostly powered by liquid fuel, as are the earthwork machines. Though temporary electric power is also needed, the requirement is quite modest.

During construction, energy is used for building and civil engineering. Their respective rates of power and fossil fuel use are 30.89% and 69.11%. Thus, the amount of energy it takes to construct buildings is 67031kilolitres oil equivalent or 603282 million kcal. During the construction stage, the energy consumed per unit floor area annually is 15,186.5 Kcal (equal to 1.69 litres/m^2 of equivalent oil).[19]

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[19] The energy costs of construction are £53.78m and civil engineering £120.32m, 30.89% and 69.11% respectively. See Yang, 1996, p. 12

D.3.2 Water Consumption at the Construction Stage

During the construction process, water is needed for mixing reinforced concrete, sprinkling the site, washing cars and for various kinds of concrete engineering. According to data provided by the Water Resource Council of the Ministry of Economic Affairs, Taiwan's total average amount of reserved water (i.e., rainfall minus evaporation) in 1983 was 710 hundred million m^3. The amount of water consumed annually came to 27% of the total water reserve; 16% of it from rivers, 5% from reservoirs and 6% from the withdrawal of underground water. The amount of underground water which was withdrawn was so great that a layer of coastal ground actually sank.[20]

Taiwan's water demands increase annually. In 1993, the total volume consumed was about 17.1 billion m^3. Agriculture took 12.6 billion m^3 (74%) followed by domestic use at 2.7 billion m^3 (16%) and industry at 1.7 billion m^3 (10%) (EPA, 1997). According to estimates from the Ministry of Economic Affairs, by 2001 the total volume of water needed for various applications in Taiwan will come to about 20.6 billion m^3. Agriculture will still need 73% (15 billion m^3), domestic requirements 17% (3.3 m^3) and industry 10% (2.2 billion m^3) (EPA, 1997).

During the construction stage, the amount of water needed for concrete mixing is about 180kg/m^3 and for concrete curing about 220kg/m^3. The mixing of cement mortar per m^3 requires 270kg of water[21]. It is estimated that the volume of water needed in the construction stage in 1996 was 102.5 million m^3 (0.51% of Taiwan's total water consumption).

D.3.3 Effects on Global Warming at the Construction Stage

The burning of fossil fuel generates greenhouse gases such as CO_2, CH_4 and N_2O. CO_2 in particular is

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[20] See. Hsiao et al., 1993, p. 24

a major greenhouse gas. CO_2 emissions at the construction stage can be converted into a thermal value unit using the energy consumption and then multiplied by the carbon emission factor and the oxidation rate of carbon to give us the level of carbon emissions. According to Yang (1996), the CO_2 emissions of a unit floor area during the construction stage is 4.48 (kg/m^2).[22]

Table D-34 shows the level of CO_2 emissions from construction work, and its proportion of Taiwan's total (i.e., around 0.11%-0.17%) from 1990 to 1996. In 1990, CO_2 emissions from the construction process came to 140,094 tonnes (0.12% of Taiwan's total) but by 1996, this had increased to 204,778 tonnes - an increase of 46.17% over the figure in 1990. Despite this, CO_2 emissions from construction work that year only accounted for 0.12% of Taiwan's total exhaust volume. What this reveals is that national CO_2 emissions are greatly increasing and that the rate of increase nationally is higher than the rate found in the building sector.

Table D- 34: CO_2 Emissions at the Construction Stage

Year	Number of buildings	Total Floor Area (m^2)	CO_2 Emission (tonne)	Total CO_2 Emissions in Taiwan (thousand tonne)	Percentage of total emission in Taiwan(%)
1990	52856	31271059	140094	118,522	0.12
1991	50146	31995034	143337	127,987	0.11
1992	61919	36922351	165412	136,076	0.12
1993	72872	47542986	212992	147,078	0.15
1994	68494	58159322	260553	154,835	0.17
1995	60854	55262803	247577	165,394	0.15
1996	47994	45709423	204778	171,054,000	0.12

Construction work generates CH_4 emissions as a consequence of the energy it consumes. According to Yang (1996), the construction stage produces 1.542×10^{-1} kg/m^2 of CH_4 emissions per unit floor area.[23]. As Table D- 36 shows, the annual exhaust comes to 7.05 tonnes (0.041% of Taiwan's total).

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[21] Estimated from data provided by Mr. Hsiao Chia Ching

[22] See Yang, 1996, p. 16

Table D- 35: CH_4 Emissions at the Construction Stage

Year	Number Of building	Total Floor Area (m^2)	CH_4 Emission (tonne)	Growth Rate (%)
1990	52856	31271059	4.83	
1991	50146	31995034	4.93	2.1
1992	61919	36922351	5.69	15.4
1993	72872	47542986	7.33	28.8
1994	68494	58159322	8.97	22.4
1995	60854	55262803	8.52	-5.0
1996	47994	45709423	7.05	-17.3

The figure in 1990 was only 4.83 tonnes but, by 1994, this had increased to 8.97 tonnes - an annual growth rate of 21.4% between 1990 and 1994. After 1995, when the construction industry in Taiwan became bearish, CH4 emissions also decreased. By 1996, 7.05 tonnes were emitted, a decrease of 17.3% on the previous year. The average annual growth rate from 1990 to 1996 was around 7.6%, indicating that CH4 emissions from construction work is still on the increase despite the peculiarities of the market in the mid '90s.

According to Yang (1996), the construction process generates about 1.26×10^{-4} kg/m^2 of N2O emissions per unit floor area,[24] which means that NO_X emissions amount to 1.26×10^{-2} kg/m^2. Table D-36 lists NO_X emissions from the construction process from 1990 to 1996. The figure in 1990 was 394.01 tonnes, increasing to 732.81 tonnes in 1994. After that, NO_X emissions began to decrease; by 1996, they amounted to 575.94 tonnes (0.09% of Taiwan's total).

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[23] See Ibid., 1996, p. 16

[24] See Ibid, 1996, p. 17

Table D-36: NO_X Emissions at the Construction Stage

Year	Number Of building	Total Floor Area (m^2)	NO_X Emission (tonne)	Total Emission in Taiwan (tonne)	Proportion of total emission in Taiwan (%)
1990	52856	31271059	394.01	597565	0.07
1991	50146	31995034	403.13	598959	0.07
1992	61919	36922351	465.22	624837	0.07
1993	72872	47542986	599.04	641081	0.09
1994	68494	58159322	732.81	637680	0.12
1995	60854	55262803	696.31	646103	0.11
1996	47994	45709423	575.94	639754	0.09

The global warming potential (GWP) is related to 1kg of CO_2. Accordingly, the GWP of CO_2 is 1; CH_4 is 9; and H_2O is 190. As a result, the GWP at the construction stage is 205,981 tonnes and CO_2 accounts for 99% of that. It is clear that CO_2 is the dominant contributor to the global warming effect, far outstripping CH_4 and N_2O.

D.3.4 Effects on Acid Precipitation at the Construction Stage

As mentioned earlier, acid rain is produced by the mix of acidifying substances with rain. These substances mainly refer to SOx and Nox and also ammonia (NH_3). Once SO_2 (SOx) and Nox get into the atmosphere, they are influenced by the climate (wind velocity and direction, temperature, radiation, etc.) and react with other chemicals producing particulates such as SO4 and nitrate. These particulates remain suspended in the air, acidifying the clouds, only to fall finally to earth in the rain, affecting water courses, forests, soil, crops, etc. and ultimately affecting human health. To assess the impact of the acidification potential (AP) at the construction stage we first calculate the level of SOx and NOx emissions and then convert them into equivalent SO2 with AP.

factor. According to EPA data, construction machinery in Taiwan, used across all sectors, generates 284 tonnes of SO_X emissions. Construction machinery specifically related to the building trade generates 88 tonnes (0.02% of Taiwan's total SOx emissions).

SOx emissions also come from the exhausts of transportation vehicles. At the construction stage, residual soil comes to 30,090,932 cubic metres.[25] If the loading capacity of dump trucks is $10m^3$ and the distance traveled is 30km (60km for a round trip) then the SOx emission is 463 tonnes.

The analysis above shows that SO_X emissions from the construction stage amount to 551 tonnes annually (0.124% of Taiwan's total) which means that each unit (m^2) of floor area generates 9.97×10^{-3} kg of SO_X. The AP (equivalent SO2) comes to 954.4 tonnes, SOx accounting for 58.8% of that. We can see from this analysis that the construction stage does not significantly contribute to the acid rain effect.

D.3.4 Photochemical Oxidant Formation and Eutrophication at the Construction Stage

The primary substances which contribute to photochemical oxidant formation are CH_4 and hydrocarbons (HC). We have already estimated that CH_4 emissions from the construction stage come to 7 tonnes. Hydrocarbon emissions from construction work stem mainly from the evaporation of organic solvents (such as paint) and also from the operation of construction machinery and vehicles.

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[25] To estimate the volume of earthwork, we multiply the number of excavated floors including all basements as per the data supplied by the Construction & Planning Administration with the excavated area. If there is one underground floor, the excavation depth is five metres; two underground floors, six metres; three, 11 metres; four or more, 15 metres. The excavated area is 20% of the total floor area. Buildings without basements are excavated to a depth of 1.5 metres and the excavated area is one third of the total floor area.

According to EPA statistics (1997), the painting of buildings generates 54,121 tonnes of hydrocarbon emissions (8.617% of Taiwan's total); per unit of floor area (m^2) the average comes to 0.979 kg/m^2. The hydrocarbons emitted as a consequence of using construction machinery (from all sectors in Taiwan) amount to 349 tonnes, and 30.8% of these (108 tonnes) are accounted for by building-related construction machinery. The hydrocarbon emissions from transportation vehicles can be obtained by multiplying the mileage of those vehicles with the average emission factor (3.504 g/km), giving us a figure of 633 tonnes. Accordingly, we find that hydrocarbon emissions from the construction stage come to a total of 54,862 tonnes. Paint work accounts for almost all of this (98%) and, on average, $1m^2$ of floor area generates $0.99kg/m^2$ of hydrocarbons. Consequently, the photochemical oxidant creation potential (equivalent ethylene) is 20,682 tonnes per year with hydrocarbon emissions accounting for 99.9% of it.

Eutrophication is caused by the effluence of pollutants into lochs and reservoirs. To assess the impact of this stage on eutrophication, the NP can be obtained by transforming Nox emissions into equivalent phosphate giving us a figure of 74.88 tonnes - only 0.46% of that produced in the first stage and 1.97% of the second. This shows that the construction stage has less impact on eutrophicatlon than the first two stages of the building life-cycle.

D.3.5 Effects on Human Toxicity at the Construction Stage

The pollutants toxic to humans which are emitted at the construction stage are mainly Nox, SOx (or SO_2) and CO. We have already looked at Nox and SOx emissions, so we will now discuss CO. The major source of CO pollution from construction work is the exhausts of plant machinery and construction vehicles. Thus, the emission volume from each must first be calculated separately prior to establishing a total volume.

CO emissions from the operation of construction machinery can be obtained by multiplying the duration each machine is used with its emission factor. According to EPA statistics, CO emissions from all types of construction machinery in Taiwan is 3,647 tonnes, 1,127 tonnes of that emanating from building work. The CO emissions of vehicle exhausts can be obtained by multiplying the emission factor with mileage. The number of trips needed to transport soil comes to 3,009,093 so the CO emissions amount to 2,011 tonnes. Based on these estimates, total CO emissions from the construction stage come to 3,138 tonnes (0.21% of Taiwan's total) and each $1m^2$ of floor area generates 0.057kg of CO on average.

Thus, the HT from this stage is 1,148 tonnes; SOx accounts for 57.6% of it and Nox 39.1%. Comparatively, the impact of the construction stage on the human toxicity effect is much less than that of the first two stages.

D.3.6 Atmospheric Pollution at the Construction Stage

Various air pollutants are released during the construction stage from the operation of machinery and vehicles and from the clearance of the surface of the construction site, the most important being TSP, SOx, Nox, CO and HC. We will focus in this section on TSP emissions as the others have already been considered in previous sections.

There are three sources of TSP from the construction process: floating dust from building activities; construction machinery exhausts; and dust raised by construction vehicles in motion. In addition to particulate pollutants, exhausts from construction machinery also emit CO, HC, NO_X and SO_X. Transportation also generates various air pollutants. This section will deal first with the level of TSP emissions found in the third stage of the building life-cycle.

D.3.6.1 Floating Dust from the Construction Process

Each of the four stages of building construction produce TSPs: removal and clearance procedures; earthwork excavation; on-site surface baring; and construction engineering. The emission factors associated with each procedure are listed in Table D-37. The level of floating dust from construction can be calculated in accordance with the area of the development site, the duration of the construction process and the emission factors.

Table D- 37: Floating Dust Emission Factors from Construction Work

Category	Emission Factor
Removal Procedures	0.1901 kg/m^2
Earthwork Excavation (including foundation, soil blocking & water drainage engineering)	0.1206 kg/m^3
Baring of surface of the ground on-site	$4.265 \times 10^{-4} kg/m^2/day$
Construction (house) Engineering Building (structure of steel frame)	0.506 $kg/m^2/month$
residual soils & placement of materials	$4.257 \times 10^{-4} kg/m^2/day$

Data Source: You-Jiuh company, 1997, p.7-11

According to EPA statistics, total TSP emissions in 1995 came to 650,688 tonnes (EPA, 1997). The TSPs which stemmed from floating dust from building construction amounted to 36,074 tonnes (5.54% of Taiwan's total).

D.3.6.2 Particulate Pollutants Exhausted by Construction Machinery

Various types of construction machine generate particulate pollutants; the emission factors associated with each type are listed in Table D-38. The machinery most used for building work are power shovels and dump trucks. In 1995, the total volume of particulate pollutants exhausted by construction machinery in Taiwan was 245 tonnes (EPA, 1997); 73 tonnes of this was directly associated with building work (0.011% of Taiwan's total).

Table D-38: Emission Factor of Air Pollutants from Diesel-Powered Construction Machinery

Construction Machinery	Emission factor (g/hr)				
	CO	HC	NO_X	SO_X	Particulate
Scraper	157.01	55.06	570.70	62.30	50.70
Wheeled Tractor	1,622.77	85.26	575.84	40.91	61.50
Bulldozer	816.81	86.84	1,889.16	158.00	75.00
Power Shovel	568.19	128.15	1,740.74	210.00	184.00
Motorgrader	68.46	18.07	324.43	39.00	27.70
Loader with Wheels	259.58	113.17	858.19	82.50	77.90
Loader with Belt	91.15	44.55	375.22	34.40	26.40
Dump Truck	816.81	86.84	1,889.16	206.00	116.00
Roller	137.97	30.58	392.90	30.50	22.70
Miscellaneous	306.37	69.35	767.30	64.70	63.20

Data Source: You-Jiuh company, 1997, p. 7-12

D.3.6.3 Vehicle Exhausts and Floated Dust from Vehicles in Motion

As the transportation vehicles we considered in Section 2 exclude earthworkers, we will consider them here. Using the emission factors, the formula for calculating their TSP emissions is as follows:

$$Q = (Q1 + Q2) \times V$$

Q1 refers to suspended particulates of vehicle exhausts. (3.0 g/km)

Q2 refers to other sources, including dust on the vehicles and roads.

$$\text{The formula is } Q2 = (3 \times 10^{-6}) \text{ S.L.W.}$$

S refers to the volume of mud on the surface of the vehicle (5%)

L refers to the volume of dust on the surface of the road (150 lb/mile)

W refers to the vehicle's weight. It is estimated that Q2 comes to 12.8g/km per trip.

If we multiply our estimate of 3,009,093 trips made to transport residual soil with a journey distance of 30km (60km for a round trip), then TSP emissions will come to 2,853 tonnes (1.17% of Taiwan's total floating dust emissions from vehicles in motion).

Using the 1995 data we have already mentioned, we find that TSP emissions from the construction

stage amount to 39,000 tonnes (6.0% of Taiwan's total) and each unit of floor area generates 0.706kg of TSPs on average. Table D-39 lists the emission volumes of the various pollutants associated with the construction stage. Construction-related HC emissions account for the highest proportion (from the construction stage) of Taiwan's total HC volume (8.7%) followed by TSP emissions from this stage which account for 6% of Taiwan's total TSP emissions. The CDV is obtained by dividing the emission volume of the various atmospheric pollutants with the emission standard(g/vol.), giving a CDV of equivalent SOx of 170,039 tonnes.

Table D-39: Emissions of Various Atmospheric Pollutants at the Construction Stage

Substance	Emission (tonnes)	Rate of Total Emission amount in Taiwan (%)
CO_2.	204778	0.20
CH_4	7	0.04
N_2O	6	0.09
SO_x	551	0.12
NO_x	576	0.09
CO	3138	0.21
TSP	39000	6.00
HC	54862	8.70

D.3.7 Waterborne Pollution at the Construction Stage

The main sources of waste water at the construction stage are from workers' sewage, site cleaning, car washing and concrete works. The greatest volume stems from the first two of these sources: the construction process generates 215,973 CMD of waste water from workers' needs and 401 CMD from cleaning. As the major component in the waste water that comes from cleaning is muddy sand, a precipitation pool is usually installed for recycling purposes. Construction workers living on-site produce 40g of BOD_5 per person per day while commuting workers produce 30g of BOD_5. As a result, the daily effluence volume of BOD_5 is 21.6 tonnes whose annual BOD5 emissions come to 7,883 tonnes.

Annual emissions of COD and SS from workers' waste water amount to 15,766 tonnes and 7,883 tonnes with respective emission concentrations of 200mg/l and 100mg/l. As for waste water from

cleaning, BOD emissions come to 14.6 tonnes; COD 29.2 tonnes; and SS 14.6 tonnes. The total CDV of equivalent BOD is 16,111 tonnes.

D.3.8 Solid Waste Disposal at the Construction Stage

The sold waste from construction work can be grouped into two types: residual materials (e.g., moulding boards, mortar, tiles, glass, wood, bricks and reinforced steel bars) and general waste (e.g., packaging and the various detritus of the staff). Some of this waste can be recycled (e.g. reinforced steel bars) but other types end up as rubbish. Table D-40 lists the wastage rates from residual construction materials. Of the 1,830,654 tonnes of residual waste, 898,464 tonnes of it is waste moulding boards; 183,020 tonnes waste mortar; 379,046 tonnes waste tiles; 3,016 tonnes waste glass; 39,515 tonnes waste timber; 238,003 tonnes waste bricks; and 89,590 tonnes waste reinforced steel bars.

Table D-40: Wastage Rates of Residual Construction Materials

Name	Rate (%)	Remarks
Moulding Boards	36%	moulding boards can be used three times
Mortar	6.5%	3-1 %, 6.5 the norm
Tiles	3.5%	2-5%, 3.5% the norm
Glass	4%	3-5%, 4% the norm
Wood	6.5%	5-8%, 6.5% the norm
Bricks	2.5%	2-3%, 2.5% the norm
Steel Bars	3.5%	2-5%, 3.5% the norm

Data Source: Lin, 1997, pp. 116, 120, 138, 250, 257, 336, 352 & 425

Staff's waste is set at 1kg per worker per day, giving 719,910 tonnes daily of this kind of rubbish at the construction stage. In 1996, the construction stage generated 2,550,564 tonnes of rubbish in total (29.31% of Taiwan's annual total) with each square metre of floor area generating an average of 55.8kg of waste. The excavation of basements and foundations also produces waste soil - about 30,090,932m^3 of it annually, using the earthwork estimates cited earlier.

D.3.9 Traffic Impacts at the Construction Stage

The construction stage attracts journeys by commuting workers and by construction vehicles. The main traffic implications of construction work are deterioration in the LOS on nearby roads, obstructed traffic flow due to machinery temporarily occupying roads, and increased parking demands.

Looking first at LOS deterioration, our focus is on vehicles used for construction, transportation and commuting purposes. Construction vehicles do not contribute significantly to traffic volume except for the short period when machinery is being moved. Transportation vehicles (i.e., earthmovers shipping waste soil) make 3,009,093 trips every year - on average, about 10,000 trips per day. The cars carrying commuting staff tend to affect LOS only at morning and afternoon rush hour, and the extent to which they make a significant difference depends on the number of cars involved.

The impact of the construction stage on traffic flow is most marked during the foundation excavation phase. Excavation entails construction machinery and materials being left temporarily on the roadside In addition, as the excavation phase coincides with the lifting and shipping of construction materials cranes usually occupy a large portion of the road space during that phase, reducing the number o available car lanes.

Most city-based construction sites do not have empty land available which can be used as staff car park during the construction phase, so the impact of this stage on parking (and traffic flow) stems fro commuting staff having to park on nearby roads.

D.3.10 Noise and Vibration at the Construction Stage

Noise at the construction stage comes from building lorries (e.g. earthmovers and vehicles carrying plan and machinery (e.g., cranes, power shovels and pumps for concrete). Though the noise of constructio

work is temporary, ceasing on the completion of each particular procedure, some of it can be deafening nevertheless. Piling machines can reach 97-107 dB(A) and pumps for concrete 86-92 dB(A), as we saw in Chapter Eight. The noise of transportation vehicles depends on how many there are on the site; how many journeys they make; how long those journeys take; and the distance they must travel.

The main sources of vibration in the construction stage are from machinery (e.g. compressors and piling machines) or from the roads (caused by the heavy dump trucks moving shifted soil, for example). As Taiwan has no specific regulations governing the nuisance of vibration, noise controls are usually enforced to decrease the impact of vibration. In Chapter Seven, we saw the impact of vibration on neighbouring buildings and local residents. Vibration can have a greater or lesser impact on surrounding buildings and local people's well-being depending on how near the receiver is to the groundborne vibration. Serious vibration damage may include structural fissuring and cracking in nearby buildings. The comfort of local residents, while awake or asleep, may also be compromised.

The bulldozers, compressors and piling machines used for construction work produce the greatest levels of vibration (see Chapter Seven). Vibrating hammers vibrate at a level of 90dB from a distance of five metres. Construction vehicles in motion create periodic vibration whose specific level is related to the flatness of the road and the vehicle's load, velocity and journey length. In general, as driving velocity increases, so too does the speed of vibration; heavy vehicles vibrate more than light ones; and vibration increases with the height of the road surface. By and large, the vibration level of dump trucks felt from a distance of five metres is around 58dB (see Chapter Eight).

D.3.11 Socio-Economic Impacts at the Construction Stage

The socio-economic impacts associated with this stage include alteration of land use, change of social environment, transformation of the economic environment and alteration of social relationships, as Table D-41 shows.

Table D-41: Socio-Economic Impacts at the Construction Stage

Environment Item	Environment Factor	Impact Description
Land use	Type of use	Land changes from original use to construction site. Impact depends on original use and the area of construction.
	Development Characteristics	Development of the area may increase or decrease depending on the region's features and its level of economic activity.
	Use of Adjacent Land	The use of nearby land may be influenced by the construction site.
Social Environment	Population Structure	Migration of construction staff may affect local population structure
	Public Facilities	Migration of construction staff may alter local population, influencing the adequacy of public facilities, i.e., unbalancing the relationship between demand and supply.
	Public Service	Numbers of construction staff may affect the type and quality of public community service, e.g. their scale.
	Public Health & Safety	Public health and safety as well as environmental hygiene may be compromised during the construction phase. Public hazards may arise.
Economic Environment	Jobs	Job opportunities arise, affecting the structure, type and quantity of the working population.
	Economic Activities	Demand for construction materials influences economic activity, the structure of production & economy and the local financial situation
	Land Ownership	Transfer of land ownership
	Price of Land	Price of land fluctuates
	Living Standards	Local income and consumption levels affected by the construction stage
Social Relationships	Social System	Staff movement impacts on local social structure, social organisations and cultural events
	Social Psychology	Attitudes of local people towards the project can be established through interviews or questionnaires
	Safety Hazards	Safety protection facilities; potential safety hazards for residents and for maintaining the project when typhoons or earthquakes occur during the construction period

D.4 ENVIRONMENTAL ISSUES RELATING TO THE OCCUPANCY STAGE

The environmental impact of buildings is more critical at the occupancy stage than at any other phase in the building life-cycle; the sheer length of this stage makes buildings' accumulated impacts more significant. The main environmental issues associated with this stage are: energy consumption, water consumption, effects on global warming and depletion of the ozone layer, acid rain, photochemical oxidant formation and eutrophication, human toxicity, atmospheric pollution, waterborne waste, solid

waste disposal, traffic and noise and vibration.

D.4.1 Energy Consumption at the Occupancy Stage

Electric power is the dominant way energy is consumed during this stage. The extent to which other forms of energy are used depends on the purposes of the buildings. For example, although electricity is the main energy source for houses, some fossil fuel is also burnt, e.g., natural gas or liquefied petroleum gas (LPG).

As we are only concerned with buildings' daily energy consumption, we will not examine the vehicular energy (i.e., petrol or diesel) used to travel to or from them. According to the 1996 statistical yearbook of the Construction & Planning Administration (CPA, 1997), buildings fall into 10 categories: residential structures, offices, shops, hotels, hospitals, factories, warehouses, schools, recreational buildings and cottages. In terms of their total floor area, residential buildings account for 49.58% of all building space: offices 6.25%; shops 21.81%; hotels 0.25% and hospitals 6.74%.[26] Factories and warehouses account for 13.94% of total floor area. Since the energy consumption of these two types more properly belong to the energy needs of industrial manufacturing, the analysis offered here will largely exclude them and will group the other categories of building into two types, "Commercial" and "residential". On this basis, residential buildings account for 52.12% of total floor area in Taiwan; offices 6.23%; businesses 8.04%; hotels 0.25%; hospitals 0.05%; and schools 4.79%, as Table D-42 shows.

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[26] See LPA Construction & Planning Statistical Yearbook of Taiwan, R.O.C., pp.190-193, Taipei, 1997EPA Environmental Information of R.O.C. (pp.21-23, Taipei,1997a); and CEPD Urban & Regional Development Statistics, pp.116-125, Taipei, 1997.

Table D- 42: Types of Building Use in Taiwan (1995)

Type		Area (m^2)	Rate of Total Floor Area (%)
Residence	House	618461317	49.58
	cottage	31740306	2.54
	Total	650201623	52.12
Office		77801847	6.23
Business	Shop	98875790	8.0
	Recreation	453558	0.04
	Total	99329348	8.04
Hotel		3081000	0.25
Hospital		638466	0.05
Factory	Plant	164091078	13.15
	Warehouse	9826232	0.79
	Total	173917310	13.94
School		59779711	4.79
Others		182651496	14.58

Data Source: based on CPA, 1997, pp.190-193, EPA, 1997a, pp.21-23, CEPD, 1997, pp116-125 and MOTC, 1997, p.443.

In 1995, the energy consumption of residential buildings was 8.25 million kilolitres of oil equivalent (11.8% of Taiwan's total energy consumption).[27] Electric power is the dominant energy source (74%), followed by LPG (17.7%) and natural gas (8.3%).[28] If we divide residential energy consumption by the number of households, then the average amount of energy used by each household is 12,790,067 Kcal (i.e., 1.42 kilolitres of oil equivalent per household year). Households use electricity mainly for lighting, air-conditioning and electric appliances while gas fuel is used for cooking and hot water. Energy consumption per unit of floor area can be obtained by dividing total residential energy consumption with total residential floor area, giving us a figure of 114,195 Kcal/m^2.per year.

To estimate the energy consumption of commercial buildings such as offices, businesses, hotels, hospitals and schools we may use Liu's findings (Liu, 1994) and the energy consumption per unit area

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[27] In 1990, the energy consumed by households was 5.93 million kilolitres of oil equivalent (or 11.4% of Taiwan's total). The difference in proportion between 1990 and 1995 indicates that households' consumption share is increasing annually. See MOE, 1996, pp.28-32.

[28] See Yang, 1996, p. 17

can be calculated accordingly[29], as Table D-43 shows, to give a figure of 141,335 Kcal/m^2 per year.

Table D-43: Energy Consumption of Various Types of Building in Taiwan

Type of Building	Type of Consumed Energy	Consumed Energy of a Unit Floor Area (kcal/m^2.yr)	Rate	Fuel Consumption of a Unit Floor Area
Residence	Power	84504	74.0	38.83 KWH/m^2Year
	LPG	20212	17.70	3.37 l/m^2Year
	Natural Gas	9479	8.30	1.05 m^3/m^2Year
	Total	114195	100.00	
Office	Power	141335	100.00	65.22 KWH/m^2Year
commerce	Power	308839	99.74	142.0 KWH/m^2Year
	Natural Gas	805	0.26	0.09 m^3/m^2Year
	Total	309644	100.00	
Hotel	Power	176374	40.90	81.05 KWH/m^2Year
	Fuel for Boiler	111098	25.70	12.6 l/m^2Year
	Fuel	103752	23.90	11.28 l/m^2Year
	Natural Gas	41067	9.50	4.6 m^3/m^2Year
	Total	432291	100.00	
Hospital	Power	185173	62.08	85.10 KWH/m^2Year
	Fuel for Boiler	7248	2.43	0.82 l/m^2Year
	Fuel	77553	26.00	8.43 l/m^2Year
	Diesel	4356	1.46	0.50 l/m^2Year
	Natural Gas	23952	8.03	2.66 m^3/m^2Year
	Total	298282	100	
School	Power	43998	100	20.22 KWH/m^2Year

Electricity is the dominant energy source of commercial buildings (99.74%). In summer, air conditioning consumes 58,188 Kcal/m^2 Per Year (26.74 KWH/m^2Year)[30], (41% of commercial buildings' total energy use). The annual energy consumption of commercial buildings is 1.22 million kilolitres of oil equivalent (see Figure D- 15), which represents 1.74% of Taiwan's total.

[29] See Liu, 1994, pp. 57-59

[30] See Pan, 1999, p. 42.

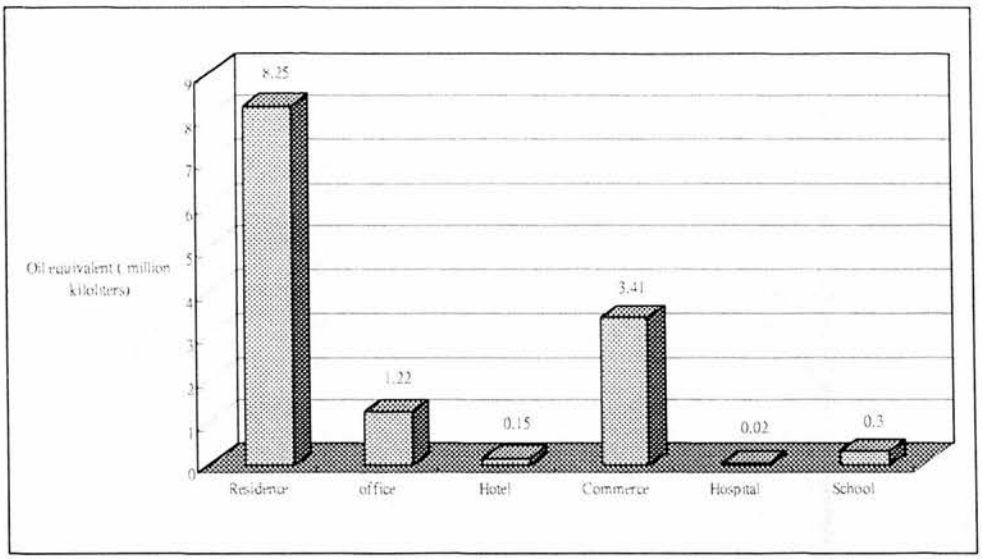

Fig D-16: Energy Consumption of Various Types of Building

On average, the energy consumption of commercial buildings per unit floor area is 309,644 Kcal/m^2 Year (see Table D-43). Their annual energy consumption is 3.41 million kilolitres of oil equivalent (4.87% of Taiwan's total).

As hotels provide a round-the-clock service most of their consumed energy is spent on providing hot water and restaurants, using liquid and gas fuel energy sources. Electricity meets their air conditioning, lighting and equipment needs. Hotels' energy consumption per unit floor area is 432,291 Kcal/m^2 Per year (3.8 times greater than the equivalent measure for residential buildings). Their annual energy consumption is 148,000 kilolitres of oil equivalent (0.19% of Taiwan's total).

Hospitals are like hotels in that they provide 24-hour care, consuming energy in the form of electric power, fuel (26%) and natural gas (8.03%). Their energy consumption per unit of floor area is 298,282 Kcal/m^2 per year. Generally speaking, their annual energy consumption is 21,200 kilolitres of oil equivalent (0.03% of Taiwan's total).

Electricity supplies lighting and air conditioning for school buildings and their energy consumption per unit of floor area is 43,998 Kcal/m^2 Per Year. Their annual consumption is 292,000 kilolitres of oil

equivalent (0.42% of Taiwan's total).

The analysis conducted in this section shows that energy consumption at the occupancy stage accounts for 19.05% of Taiwan's total. Residential buildings use the highest proportion (11.8%) followed by commercial buildings (4.87%) and offices (1.74%). The total energy used at this stage comes to 13.34 million kilolitres of oil equivalent.

Different types of building consume different kinds of energy, although electric power dominates. For instance, electricity accounts for 74% of residential buildings' energy consumption; 100% of offices and schools; 40.8% of hotels, and c. 60% of other types of building. Electricity during the occupancy stage is used for air conditioning, lighting and equipment. Air conditioning accounts for the greatest proportion - 31%~58% in summer and 19% to 43% in winter, as Table D-44 shows. As for lighting, the rate is 26% to 44% in summer and 31% to 58% in winter. What this data suggests is that if we are to reduce buildings' energy consumption we must begin by decreasing their electricity needs, especially for air conditioning and lighting.

Table D-44: Rates and Types of Usage of Electric Power in Buildings with Central Air Conditioning in Taiwan

Type of Building	Season	Air Conditioning	Lighting	Dynamic Power
Office (sample 8)	Summer	0.41	0.35	0.25
	Spring/Fall	0.27	0.48	0.25
	Winter	0.19	0.58	0.24
Department Store (sample 8)	Summer	0.36	0.44	0.20
	Spring/Fall	0.30	0.48	0.22
	Winter	0.29	0.50	0.21
Hotel (sample 19)	Summer	0.50	0.26	0.24
	Spring/Fall	0.39	0.37	0.24
	Winter	0.30	0.31	0.39
Hospital (sample 16)	Summer	0.58	0.31	0.11
	Spring/Fall	0.53	0.25	0.22
	Winter	0.43	0.38	0.20

Data Source: Lin, 1997, p.12

Residential buildings consume the most power at the occupancy stage, using 25.25 billion KWH per year (or 20.9% of Taiwan's total electricity consumption); commercial buildings use 14.11 billion KWH per year (11.7%); offices 5.07 billion KWH per year (4.2%); hotels 0.25 billion KWH per year (0.21%); hospitals 0.5 billion KWH per year (0.05%); and schools 1.21 billion KWH per year (1.0%). The power needs of occupied buildings account for 38.06% of Taiwan's total usage.

D.4.2 Water Consumption at the Occupancy Stage

During this stage, water is mainly used for daily living and for generating power. For the most part, surface water is the source. In 1993, the volume of water used for daily living in Taiwan was 2,771 million m^3, 16.20% of the total annual water volume, with each person using 132.3m^3 on average. It is estimated that by 2001 the water needed annually for daily living will be 3,479 million m^3 or 16.86% of Taiwan's total water volume (EPA 1997, p.105). (See Table D-45)

Table D-45: Volume of Annual Water Needed for Various Uses in Taiwan (Unit: million m^3)

Item			1993		2001		2011		2021	
			Water Vol.	%	Water Vol.	%	Water Vol.	%	Water Vol.	%
Agriculture			12650.58	73.95	15000	72.69	15000	69.02	15000	67.06
Daily Living			2771.00	16.20	3479	16.86	4242	19.52	4803	21.47
Industry			1684.49	9.85	2156	10.45	2490	11.46	2564	11.46
Total			17106.07	100.	20635	100	21732	100	22367	100
Population (per 1,000 people)			20944		22057		23934		24862	
Average Annual Water Vol. per Person			816.75		936		908		900	
Water For Power	Hydro electric power		15477.58		-		-		-	
	Thermo-electric power	Fresh Water	6.20		-		-		-	
		Sea Water	10678.70		-		-		-	

Data Source: EPA, 1997, p.106

Though the water used for generating power is non-consumable as such, it still comes to a great amount. Table D- 46 shows the non-consumable water volume for hydro-electric power generation to be 15,477 million m^3 and thermo-electric 10,684.9 million m^3. As we know from the analysis offered in the previous section, the electricity used in the occupancy stage accounts for 38.06% of Taiwan's total power consumption. As for water sources, 226 million m^3 of the water used for daily life comes from underground; this source accounts for 9.6% of the total used for this purpose and 1.32% of Taiwan's total water consumption. The depletion rate of underground water (i.e., the amount used set against the annual average auxiliary volume) reaches 178.5% (EPA, 1997), showing that underground water sources are being overused.

D.4.3 Effects on Global Warming at the Occupancy Stage

In the occupancy stage of the life-cycle, buildings consume energy and emit greenhouse gases (mainly CO_2, CH_4, N_2O and CFCs). As these four impact on global warming in different ways, each gas should be converted into equivalent CO_2 emissions and then accumulated, giving us a total volume of equivalent CO_2 emission (abbreviated as GWP).

The level of carbon emissions can be obtained by multiplying the thermal value (consumption level) of each kind of energy used with its respective carbon emission factor and the incomplete burning coefficient (99%). CO_2 emissions from energy consumed during this stage can be obtained by converting emitted carbon into CO_2. The volume of CO_2 emissions per unit floor area and total CO_2 emissions associated with various types of building are listed in Table D-46.

Table D-46: CO_2 Emissions from Various Types of Building at the Occupancy Stage

Type	CO_2 Emissions Per Unit Floor Area (kg/m^2 year)	CO_2 Emissions (thousand tonnes/year)	Rate of CO_2 Emission in Taiwan (%)
Residence	30.67	19942	12.05
Office	38.84	3022	1.83
commerce	84.76	8919	5.39
Hotel	126.03	388	0.23
Hospital	85.03	54	0.03
School	12.04	720	0.37
Total		33045	19.9

Of the different types of building, residential buildings emit the most CO_2, (12.05 % of Taiwan's total CO_2 emissions), followed by commercial buildings (5.39%). Overall, the CO_2 emissions from occupied buildings account for 19.9% of Taiwan's total. Hotels emit the highest level of CO_2 per unit floor area (126.03kg/m^2 per year), followed by hospitals (85.03kg/m^2 per year) and commercial buildings (84.76kg/m^2 per year). As hotels and hospitals provide round-the-clock services, they are high energy consumers and consequently emit higher volumes of CO_2. Commercial buildings emit a high volume of CO_2 because they use a great deal of electricity.

To estimate the volume of CH_4 emitted, we multiply the energy consumed with each kind of emission factor (i.e., based on whether the building is commercial or residential (see Table D-47).

Table D-47: CH_4 Emissions from Various Types of Building at the Occupancy Stage

Type	CH_4 Emissions Per Unit Floor Area (kg/m^2, year)	CH_4 Emission (thousand tonnes/year)	Rate of CH_4 Emission in Taiwan (%)
Residence	4.55×10^{-4}	295.84	1.45
Office	5.28×10^{-4}	41.08	0.20
commerce	1.15×10^{-3}	114.22	0.56
Hotel	1.43×10^{-3}	4.41	0.02
Hospital	1.04×10^{-3}	0.66	0.01
School	1.63×10^{-4}	9.74	0.05
Total		465.95	2.29

Note: CH_4 figures for Taiwan are based on what is emitted as a consequence of energy consumed, and do not include CH_4 emissions from other sources.

Per unit of floor area per year, hotels emit the highest volume of CH_4 (1.43×10^{-3} kg/m^2), followed by commercial buildings (1.15×10^{-3} kg/m^2), while schools emit the least (1.63×10^{-4} kg/m^2). In terms of total volumes, residential buildings emit the most (295.84 tonnes/year), accounting for 63.5% of the volume emitted at the occupancy stage. Commercial buildings account for 24.5% by the same measure. In total, occupied buildings emit 2.29% of Taiwan's total.

To estimate N_2O emissions we multiply the volume of NO_x emission with the transformation factor and this volume can be obtained by multiplying energy consumed with the associated emission factor. Table D-48 shows the N_2O emissions of each type of building. Per unit of floor area per year, hotels emit the most (2.05×10^{-3} kg/m^2) followed by commercial buildings and hospitals (1.63×10^{-3} kg/m^2), while schools emit the least (2.33×10^{-4} kg/m^2). Schools tend to be low energy consumers (and consequently low on greenhouse gas emission) because most of them are not installed with air conditioners (except in their administration departments) and classrooms have two side windows, obviating the need for artificial light.

Table D-48: N_2O Emissions from Various Types of Building at the Occupancy Stage

Type	N_2O Emissions Per Unit Floor Area (kg/m^2, year)	N_2O Emissions (Thousand tonnes/year)	Rate of N_2O Emissions in Taiwan (%)
Residence	4.99×10^{-4}	324.45	5.02
Office	7.50×10^{-4}	58.35	0.90
Commerce	1.63×10^{-3}	161.91	2.50
Hotel	2.05×10^{-3}	6.32	0.10
Hospital	1.63×10^{-3}	1.04	0.02
School	2.33×10^{-4}	13.93	0.22
Incineration of General Waste	1.64×10^{-2} kg/tonne	34.14	0.53
Total		600.14	9.29

Residential buildings emit the most N_2O (324.45 tonnes/year), accounting for 54.06% of the total N_2O emitted at this stage; commercial buildings emit 161.91 tonnes/year (26.98%); and offices 58.35 tonnes/year. These three kinds of building account for 90.76% of the N_2O emitted from occupied buildings.

According to EPA statistics on CFC_s consumption in Taiwan (EPA, 1998), CFC_{11} and CFC_{12} come to 96 tonnes and 89 tonnes respectively. $HcFc_{22}$ comes to 4,233 tonnes and $HcFc_{123}$ 3,419 tonnes. Central air conditioners are the application most responsible for generating CFCs.

The main greenhouse gases emitted at the occupancy stage are CO_2, CH_4, N_2O, CFC_{11}, CFC_{12}, $HCFC_{22}$ and $HCFC_{123}$. Thus, the GWP amounts to 33,443 thousand tonnes/year - 1.18 times that found at the manufacturing stage and 160 times the level at the construction stage. It is not hard to see that the occupancy stage, over its long course, has the greatest impact on global warming of any stage in the building life-cycle.

D.4.4 Effects on Ozone Depletion at the Occupancy Stage

The ozone layer, 20-50 kilometres up, absorbs most of the sun's ultraviolet rays and so protects the earth's surface from their harmful effect. Substances like chlorofluorocarbon (CFC) lower the concentration of ozone in the ozone layer because they rise to that layer and then decompose through photochemical reaction, releasing chlorine which mixes with ozone. Evidence of ozone depletion at the south polar region was first presented in 1985 (EPA, 1997); it was found that the total volume of ozone had been decreasing since 1970 and that a hole about the size of North America now appears in the ozone layer over the south polar region every autumn (September-October). More recently, evidence of ozone depletion has been discovered at several other locations, suggesting that this problem is even more serious than was first conceived.

Taiwan started to control its production and consumption of CFCs in July 1989. The import of CFC equipment was banned in 1996 and stocks remaining in the country are subject to approval and control before they can be used. According to EPA statistics of 1998, CFC_{11} and CFC_{12} emissions only came to 96 tonnes and 89 tonnes respectively (see Table D-49). Hydrochlorofluorocarbons (HCFCs) with a low

ODP are also included in the Montreal Protocol as a control material, so the volume of HCFCs has also been limited.

To estimate the threat posed by ODSs like CFC we can take the ozone depletion potential (CFC_{11} = 1) as the basis. The formula for calculating CFC_{11} equivalent (ODP) is as follows:

$$ODP = 1 \times CFC_{11} + 1 \times CFC_{12} + 0.05 \times HCFC_{22} + 0.014 \times HCFC_{123}$$

The application volume of each CFC substance is listed in Table D-49; the rate of emission to the atmosphere is about 10%. According to the formula above, the CFC_{11} equivalent during the occupancy stage comes to 44.5 tonnes and its major source is $HCFC_{22}$.

Table D-49: CFC Application Volume At the Occupancy Stage (1998)

Substance	Application Vol. (tonne)	Major Application
CFC_{11}	96	Central air conditioning , ice-making machines
CFC_{12}	89	Air conditioning in buildings, ice-making machines
$HCFC_{22}$	4233	Air conditioner for home
$HCFC_{123}$	3419	Air conditioning in buildings

Notes:

a. Application volumes of CFC_{11} and CFC_{12} are based on EPA statistics
b. Application volumes of $HCFC_{22}$ are based on air conditioners used in households
c. Application volumes of $HCFC_{123}$ are based on central air conditioning systems in offices, commercial buildings, hospitals, etc.

D.4.5 Effects on Acid Precipitation at the Occupancy Stage

Acid rain results from the mix of acidifying substances with rain. Those emitted by occupied buildings are SO_2 and No_x. SO_2 is generated as a consequence of power consumption while NO_x is emitted from various kinds of consumed energy. N_2O emission volumes can be obtained by multiplying the volume of NO_x emissions with the transformation coefficient, giving us 60.014 tonnes/year as mentioned earlier. SO_2 emission volumes can be estimated by multiplying the types of energy used by various kinds of building with their respective emission factors. Results are shown in Table D- 50.

Table D- 50: SO_2 Emissions from Various Types of Building at the Occupancy Stage

Type	SO_2 Emissions Per Unit Floor Area (kg/m^2, year)	SO_2 Emissions (thousand tonnes/year)	Rate of SO_2 Emission in Taiwan (%)
Residence	0.07	45514	10.21
Office	0.12	9336	2.09
commerce	0.27	26818	6.02
Hotel	0.15	462	0.10
Hospital	0.16	102	0.02
School	0.04	2391	0.54
Incineration of General Waste	0.96 kg/tonne	1991	0.45
Total		86614	19.43

Commercial buildings emit the greatest amount of SO_2 per unit floor area per year (0.27 kg/m^2) followed by hospitals at 0.16 kg/m^2. Nevertheless, in terms of total annual emissions from occupied buildings, residential buildings head the league at 45,514 tonnes (10.21% of Taiwan's total). The major source is from the use of electric power. LPG, which accounts for 17.7% of households' energy consumption, only generates 848 tonnes/year (a mere 1.8% of the SO_2 emissions from residential buildings). Natural gas, which accounts for 8.3% of households' energy consumption, only generates 8 tonnes per year (0.02% of the SO_2 emissions from residential buildings). This data shows that electricity used by residential buildings is the main cause of their SO_2 emissions. Commercial buildings generate the second highest emission of SO_2 at 26,818 tonnes/year (6.02% of Taiwan's total). In total, occupied buildings account for 19.43% of Taiwan's total SO_2 emissions.

The AP (equivalent SO_2) is 128,624 tonnes/year. SO_2 accounts for 67.3% of AP and the occupancy stage produces the most AP within the building life-cycle. As the consumption of electricity is the main source, reducing power demand is the critical path towards alleviating buildings' contribution to acid rain.

D.4.6 Photochemical Oxidant Formation and Eutrophication at the Occupancy Stage

The substances we are most concerned with here are the CH_4 and hydrocarbons (HC) which are

generated from energy consumed, the burning of fossil fuel and exhausts from restaurants. To assess the impact of various substances on photochemical oxidant formation, equivalent ethylene has to be first converted. The transformation coefficient complies with the photochemical oxidant creation potential (POCP).

The HCs emitted from the smoke exhausts of commercial buildings serving food and drink come to 1,176 tonnes (EPA, 1997). Table D- 51 shows that commercial buildings emit the highest volume per unit floor area (1,350.8 tonnes) which accounts for 68.7% of HC emissions at the occupancy stage. The food and drink sector generates 1,176 tonnes per year, while residential buildings emit 519.5 tonnes/year (26.4% of the total HCs emitted from occupied buildings).

Table D-51: Hydrocarbon (HC) Emissions at the Occupancy Stage

Type	HC Emissions Per Unit Floor Area (kg/m^2, year)	HC Emissions thousand tonnes/year	Rate of HC Emissions in Taiwan (%)
Residence	7.99×10^{-4}	519.5	0.085
Office	8.54×10^{-4}	66.4	0.011
Commerce	1.36×10^{-2}	1350.8	0.222
Hotel	3.51×10^{-3}	10.8	0.002
Hospital	2.61×10^{-3}	1.7	0.001
School	2.65×10^{-4}	15.8	0.003
Total		1965.0	0.324

The equivalent ethylene (POCP) at the occupancy stage is 744 tonnes/year; hydrocarbons accounting for 99%. When we compare each stage of the building life-cycle, we see that the manufacturing stage generates the most equivalent ethylene (POCP) at 53,334 tonnes/year, followed by the construction stage at 20,682 tonnes/year. In contrast, the occupancy stage only generates 744 tonnes of equivalent ethylene per year, a mere 1.4% of that found at the manufacturing stage.

The prime contributors to eutrophication are NO_x and COD. The former is emitted by occupied buildings at a volume of 60,014 tonnes, as we estimated earlier. Emissions of the latter will refer here

to COD from the waste water of daily living as the COD emitted from factories more properly belongs to the category of industrial waste water and the COD which stems from agriculture to dairy waste water. In Taiwan, each person generates about 60g of COD per day as they meet their daily needs (Chang 1998, p.42), resulting in annual COD emissions of 466,561 tonnes. However, after treatment in sewage plants and waste water treatment centres, the volume of COD from daily living falls to 407,307 tonnes (744 tonnes per day).[31]

Equivalent PO_4 (NP) needs to be converted before evaluating the impact of occupied buildings on eutrophication. The transformation coefficient is based on the nutrification potential (NP). Accordingly, NP (equivalent PO_4) at this stage is 16,762 tonnes; NO_x and COD account for 54% and 46% of equivalent PO_4 respectively.

D.4.7 Effects on Human Toxicity at the Occupancy Stage

Occupied buildings cause the emission of various substances toxic to human beings such as benzene, cadmium, carbon monoxide (CO), lead (Pb), mercury (Hg), nitrogen oxide (NO_x), sulphur dioxide (SO_2, SO_x), copper, tin and zinc. Benzene, cadmium, tin and zinc stem from industrial manufacturing processes and should be categorised as industrial pollutants; likewise, Hg comes from this industrial source as well as from waste batteries and so should properly be considered as an industrial pollutant. In this section we will consider CO, Pb, NO_x, SO_2 and CFC_{12}. The formula for equivalent human toxicity is as follows:

$$HT(E) = 0.78\ NO_x + 1.2\ SO_2\ (\text{or } SO_x) + 0.012\ CO + 160\ Pb + 0.22\ CFC_{12}$$

Earlier, we found that annual No_x emissions come to 60,014 tonnes and SO_2 86,614 tonnes. We can estimate CO emissions by multiplying the application volume of each kind of energy used by occupied

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[31] See EPA, 1997a, pp.120-121. The reduction rate is 12.7%.

buildings with their emission factors (see Table D- 52).

Table D-52: CO Emissions at the Occupancy Stage

Type	CO Emissions Per Unit Floor Area (kg/m^2 Year)	CO Emissions (thousand tonnes/year)	Rate of CO Emissions in Taiwan (%)
Residence	5.15×10^{-3}	3348.5	0.225
Office	6.48×10^{-3}	504.2	0.034
commerce	1.49×10^{-2}	1480.0	0.099
Hotel	7.26×10^{-2}	223.7	0.015
Hospital	1.62×10^{-2}	10.3	0.001
School	2.12×10^{-3}	126.7	0.009
Incineration of General Waste	4.77×10^{-1} (kg/tonne)	994.0	0.067
Total		6687.4	0.45

Hotels emit the most CO per unit floor area per year (7.26×10^{-2} kg/m^2) while hospitals emit 1.62×10^{-2} kg/m^2 Per year. As to volume, residential buildings emit the most CO (3,348.5 tonnes/year) while commercial buildings generate 1,480 tonnes/year. Generally speaking, CO emissions from this stage come to 6,687.4 tonnes/year (0.45% of Taiwan's total).

The level of Pb emissions can be acquired by multiplying buildings' energy consumption with the emission factor. Pb emissions from various types of building are listed in Table D- 53.

Table D-53: Pb Emissions at the Occupancy Stage

Type	Pb Emissions Per Unit Floor Area (kg/m^2, year)	Pb Emissions (thousand tonnes/year)	Rate of Pb Emissions in Taiwan (%)
Residence	2.01×10^{-6}	1.307	0.410
Office	3.37×10^{-6}	0.262	0.082
commerce	7.34×10^{-6}	0.729	0.229
Hotel	4.19×10^{-6}	0.013	0.004
Hospital	4.40×10^{-6}	0.003	0.001
School	1.04×10^{-6}	0.062	0.019
Incineration of General Waste	6.05×10^{-3} (kg/tonne)	12.630	3.966
Total		15.123	4.711

The Pb emitted from incineration of waste accounts for 83.5% of Pb emissions at this stage. Another source of Pb emissions from occupied buildings is electricity consumed (natural gas, LPG and coal

emit very little Pb). Consequently, commercial buildings, followed by hotels, emit the most Pb per unit floor area as they consume the most power. In total, the volume of Pb emissions from this stage accounts for 4.711% of Taiwan's total.

HT from this stage comes to 153,247 tonnes; SO_2 generates 67.8% of that and NO_x 30.5%. SO_2 and NO_x account for 98.3% of equivalent human toxicity.

D.4.8 Atmospheric Pollution at the Occupancy Stage

The main atmospheric pollutants generated from occupied buildings include sulphur oxide (SO_2), hydrocarbons (HC), lead (Pb), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and particles. Their sources are power consumed, other forms of energy consumed and waste incineration. Particles, in particular, stem from energy consumed (electric and otherwise) and the burning of non-fuel items (waste incineration and smoke exhausts of restaurants). To estimate the volume of TSPs from burning fuel, we multiply the amount of each type of energy used with their emission factors. To estimate the volume of TSPs from incinerating non-fuel items, we can use EPA statistics (EPA, 1997) and then distribute them across different types of building.

Table D- 54 shows that commercial buildings emit the most TSPs per unit floor area (6.72×10^{-2} kg/m^2 Per year), as a result of their power consumption and restaurants' use of smoke exhausts. Commercial buildings also emit the greatest volume of TSPs (6,674 tonnes) which accounts for 1.026% of Taiwan's total. Residential buildings emit 2,802 tonnes (0.431% of Taiwan捺 total).

Table D-54: TSP Emissions at the Occupancy Stage

Type	TSP Emissions Per Unit Floor Area (kg/m^2 Year)	TSP Emissions (,000 tonnes/year)	Rate of TSP Emissions in Taiwan (%)
Residence	4.31×10^{-3}	2802	0.431
Office	6.66×10^{-3}	518	0.079
commerce	6.72×10^{-2}	6674	1.026
Hotel	1.58×10^{-2}	48	0.007
Hospital	1.23×10^{-2}	8	0.001
School	1.94×10^{-3}	116	0.018
Total		10166	1.562

Table D- 55 lists the volumes of each air pollutant emitted by occupied buildings. CO_2 accounts for the highest proportion (21.34%), followed by SO_2 (19.43%).

Table D-55: Emission Volumes of Various Atmospheric Pollutants at the Occupancy Stage

Substance	Emission (tonnes/year)	Rate of Total Emissions in Taiwan (%)
Carbon Dioxide (CO_2)	33045000	19.9
Methane (CH_4)	465.95	2.29
Nitrous Oxide (N_2O)	600.14	9.29
Sulphur Oxides (SO_2, SO_x)	86614	19.43
Nitrogen Oxide (NO_x)	60014	9.29
Carbon Monoxide (CO)	6687.4	0.45
Lead (Pb)	15.123	4.71
Total Suspended Particulate (TSP)	10166	1.561
Hydrocarbons (HC)	1965	0.321

To assess the impact these air pollutants have on air quality, we use the CDV concept. This method transforms and accumulates the main stressors of air quality with their critical dilution volume(CDV) to measure their impact. Using this method, we find that the equivalent CDV of air pollutants from this stage comes to 387,064 tonnes of CDV equivalent SO_2.

D.4.9 Waterborne Pollution at the Occupancy Stage

The residents and/or staff of occupied buildings produce waste water, though our discussion here will be limited to municipal sewage and will exclude consideration of the waste water from farms and factories.

The term municipal sewage covers the waste water of business organisations and households. The

volume from residential buildings can be obtained by multiplying the population with the daily volume of effluent. To estimate the waste water from commercial buildings, we multiply the numbers attracted to those buildings daily with the daily volume of effluent. The volume from hospitals can be estimated by multiplying the total number of beds (including those in clinics, health centres, etc.) with the daily volume of effluent per bed. To calculate the volume from schools, we multiply the total number of students with the daily effluent volume per person. (See Table D- 56).

Table D-56: Waterborne Effluence from Various Types of Building at the Occupancy Stage

Type	Effluent Vol.	Substance	Concentration of effluent (mg/l)	Effluent Vol. (tonnes/year)
Residential (including offices)	1944	BOD	106.8	207619
		COD	162.0	314928
		SS	173.1	336506
		NH_3-N	67	130248
Business (including hotels)	1668	BOD	50	83400
		COD	100	166800
		SS	51	83400
		NH_3-N	10	16680
		Fat/Oils	30	50040
Hospitals	14	BOD	30	420
		COD	100	1400
		SS	30	420
		NH_3-N	10	140
Schools	257	BOD	106.8	27448
		COD	162.0	41634
		SS	173.1	44487
		NH_3-N	67	17219
Total		BOD		318887
		COD		524762
		SS		464813
		NH_3-N		197648

COD, at 524,762 tonnes/year, accounts for the greatest volume, followed by suspended solids (SS) at 464,813 tonnes/year. The CDV at the occupancy stage can be acquired using the effluent volume of various pollutants and their equivalent CDV relative to BOD, giving us 2,626,380 tonnes of equivalent-BOD.

D.4.10 Solid Waste at the Occupancy Stage

The solid waste from occupied buildings covers the general rubbish of households and commercial

businesses. The waste of special categories of building such as hospitals or factories more properly should be considered enterprise waste and will not be considered here.

The management of solid waste is a common problem for buildings. As living standards improve and life-styles change accordingly, the volume of solid waste has increased accordingly. In 1995, Taiwan generated 870,000 tonnes/year of general solid waste. The volume of daily rubbish per person is 1.14kg and is growing annually at a rate of 5%.

Of the rubbish from occupied buildings, paper accounts for 26.37%-33.1%; plastics 17%-20%; glass 3.6%-7.98%; metals 4.41%-8.35%; and rubber 0.28%-1.01%. These five types account for over half the solid waste from occupied buildings and as they are all reusable materials, more effort should be made to recycle them fully to maximise resources and reduce the quantity of rubbish. Solid waste disposal requires landfill sites; to handle the annual 870,000 tonnes of general solid waste, 24 hectares of landfill space is needed every year.

D.4.11 Traffic Impacts at the Occupancy Stage

The extent to which occupied buildings affect traffic depends on their scale; on where they are situated; and on the prevailing traffic situation in their vicinity. Over recent years as urban populations have exploded so too have city traffic problems. Development space in cities is limited and as new sites are found outwith the boundaries of the inner city, integral metropolitan transportation systems have given way to local traffic hot-spots.

The volume of traffic different buildings attract varies. One factor which influences this is the reason for traveling. The purpose of journeys can be grouped into three types which give clues as to the trips' origin and destination: business-related trips (e.g., producing or distributing goods and services);

general purpose trips (e.g., attending political, religious or cultural events); and recreational trips (e.g., socialising and attending entertainments). Other factors which influence the volume of traffic a building attracts is its floor area and function.

According to a survey conducted by the Taichung City Government in 1993 of rush hour trips to Taichung's main business facilities (Taichung City Government 1993, p.138), the following formula can be applied:

$$T = 10.31 \times D + 1.48 \times H + 3.62 \times C + 44.29 \times B + 2.01 \times O + 5.83 \times R$$

D: floor area of department stores (a unit is 100 m^2)

H: floor area of hotels (a unit is 100 m^2)

C: floor area of business buildings (a unit is 100 m^2)

B: floor area of banks (a unit is 100 m^2)

O: floor area of office buildings (a unit is 100 m^2)

R: floor area of restaurant buildings (a unit is 100 m^2)

Using this formula, we find there are 5,173,548 rush hour journeys made in Taiwan.[32] To estimate the proportion of public transport vehicles to private cars, we multiply the model split rate of various buildings with the volume of trips they attract. When assessing the traffic impact of buildings, private cars are usually the main concern. The calculation shows us that there are 2,437,805 passenger car units (PCUs) at rush hours to and from business and office buildings, which suggests that these buildings have a sizable impact on traffic.

Another traffic implication of occupied buildings is parking. As parking spaces in cities are always

[32] The trips made at rush hours were estimated in relation to commercial buildings. For the purposes of

insufficient, cars must park on roadsides reducing the number of available lanes and worsening the flow of traffic. The formula for calculating the parking requirements of buildings is as follows:[33]

$$P = 0.36 \times A + 0.96 \times O + 1.23 \times C + 0.48 \times H + 1.08 \times I + 0.45 \times S + 0.26 \times F$$

A: floor area of residential buildings (a unit is 100 m^2)

O: floor area of offices (a unit is 100 m^2)

C: floor area of business buildings (a unit is 100 m^2)

H: floor area of hotels (a unit is 100 m^2)

I: floor area of hospitals (a unit is 100 m^2)

S: floor area of schools (a unit is 100 m^2)

F: floor area of factory buildings (a unit is 100 m^2)

According to this formula, occupied buildings in Taiwan generate the need for about 5,050,000 parking spaces. Based on the survey data of the Construction & Planning Administration, Taiwan's actual parking spaces only come to about 25% of this figure so parking is a major issue posed by buildings at the occupancy stage.

D.4.12 Noise and Vibration at the Occupancy Stage

As buildings have become both taller and more geographically concentrated in Taiwan in recent years, vibration and noise problems are becoming more serious. The noise of equipment (whether in households, factories or offices) and of the indoor sounds from neighbours can hardly be avoided as residents live close together. Though the components of city noise are complicated and their influence extensive, the issue of noise and vibration at the occupancy stage is usually ignored even though it

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the exercise, hospitals and hotels were counted as one category.

[33] Obtained in compliance with the requirement coefficient of the Institute of Transportation within the Ministry of Transportation & Communication. See Taichung City Government, 1993, p.149

affects a majority of people. The indoor noise of our daily lives is of specified types and occurs in particular places at particular times. In addition to the high-decibel noise from the external environment, indoor noise may disturb the mutual comfort of neighbouring residents.

Aimed at the residents of compound buildings in Taiwan, Chiang (1993, p.93) conducted a survey in 1993 and found that the most troubling indoor noise for residents is street noise (recorded as a disturbance level of 78.0%), followed by the sound of car and motorbike ignitions (76.7%). The most troubling time periods are during the early morning and the late afternoon, as Table D- 56 indicates.

Table D-56: Main Sources and Features of Indoor Noise

Rank	Noise Source	Disturbance Level %	Source	Bothering Time
1	traffic on the street	78.0	outdoor	morn, late afternoon
2	starting of cars & motorbikes	76.7	outdoor	morn, late afternoon
3	kids crying & playing	45.0	outdoor,	afternoon, late afternoon
4	audio & video appliances	42.7	residence	late afternoon
5	talking & fighting	41.3	outdoor,	afternoon ñ late afternoon
6	animals	40.3	outdoor	Night
7	household appliances	37.3	residence	late afternoon, noon
8	business activities	35.3	outdoor	late afternoon
9	wedding & burial ceremonies	32.7	outdoor	late afternoon
10	peddling & collecting recycled waste	32.0	outdoor	Night
11	firecrackers	30.0	outdoor	occasional
12	housework	29.3	residence	late afternoon, noon
13	operation of construction machinery	28.3	outdoor	afternoon
14	entertainment (Majohn)	26.3	neighbours	late night, early morning
15	water supply & drainage of hygiene facilities	25.3	residence,neighbour	late afternoon, night
16	general equipment	25.0	residence, neighbour	late afternoon, night
17	Impact noise of floor	24.7	upstairs residence	late afternoon, night
18	Interior trim	24.3	residence, neighbour	late afternoon, noon
19	phone, beeper	22.7	residence, neighbour	occasional
20	market, night market	20.7	outdoor	late afternoon ñ eve

Data Source: Chiang, 1993, p.92

As for vibration, the major sources are the vibration of construction machinery and vibration on the road. Vibration within buildings (e.g., equipment or factory machines) is limited to some specific buildings and so has only a minor impact.

Vibration from construction sites is caused by the operation of machinery. The power of groundborne vibration depends on distance from the source; if the distance is doubled, then its power decreases 3-6dB. Generally speaking, sleep is disturbed when vibration levels go above 65dB.

Road vibration is caused by moving vehicles generating a periodic vibration, which is related to the smoothness of the road surface, the vehicles' load and velocity and the hearer's distance from the road. Generally speaking, road vibration is more obvious when vehicles are traveling at speed; are carrying heavy loads; if the surface of the road is uneven; and if the hearer is close to the road. Thus, to assess the impact of vibration on residents of occupied buildings, the characteristics of the ambient environment need to be analysed. Table D- 57 lists vibration standards.

Table D-57: Standards of Vibration Specification

Standard	Zone	Standard Vibration Level (dB)
standard of workshop vibration	Zone 1	day 60-65 night 55-60
	Zone 2	day 65-70 night 60-65
standard for traffic vibration	Zone 1	day 65 night 60
	Zone 2	day 70 night 65

Day: between 5-8 & 19-22 Night: between 19-22 & 5-8 hour

Data source: Lai et al, 1991, p.301

D.5. ENVIRONMENTAL ISSUES RELATING TO THE DEMOLITION STAGE

As the occupancy stage endures for decades or even centuries, it is difficult to access reliable information about this final stage of the building life-cycle and so the impact assessment task is full of uncertainties. Consequently, this section will restrict its focus to analyses of energy consumption, air pollution and treatment of waste at the demolition stage. The inventory of environmental themes associated with this stage include energy consumption, global warming, acid rain, photochemical oxidant formation, nutrification, human toxicity, atmospheric pollution, treatment of solid waste and resource recycling.

D.5.1 Energy Consumption at the Demolition Stage

The demolition of buildings with steel structures is quite rare as yet. Most of the buildings in Taiwan which have been demolished have been less than seven storeys high and have been made of reinforced concrete, so this assessment is mainly targeted at them.

Energy consumed at the demolition stage is mainly via diesel- or petrol-powered machinery, e.g., bulldozers, trucks etc. To simplify the estimation task, demolition can be divided into two procedures: the actual demolition (including decomposition and loading of materials) and the transportation of demolition waste. The energy requirements for the demolition procedure are met, by and large, by breakers and bulldozers whose diesel consumption is listed in Table D- 58. 0.8 litre of diesel is needed for every square metre of floor area, about 7,040 Kcal.

Table D-58: Energy Consumption at the Demolition Stage of RC Buildings

Item	Time (Hr)	Diesel Consumption Volume (litre)
Breaker	0.07	0.7
Bulldozer	0.01	0.1
Total		0.8

Notes: This table refers to the volume consumed per each m^2 of floor area of RC buildings. The table is provided by Hsiao Chia-ching of Chung Hsin University

The energy used to transport demolition waste is based on Chang (Chang, 1997). Transportation of a tonne of waste consumes 0.011 litres of petrol and 0.40 litres of diesel. Using the thermal value of energy, the transportation of a tonne of waste takes 3,600 Kcal as Table D- 59 shows.

Table D-59: Energy Used to Transport Demolition Waste

Transportation Tonnage	7889645.7
Total oil consumption	19226873
Consumed Gasoline Volume (litre)	213020.43
Consumed Diesel Volume (litre)	7676625.27
Consumed Gasoline Volume for Every Tonnage (litre/tonne)	0.011
Consumed Diesel Volume for Every Tonnage (litre/tonne)	0.40
Energy Consumption Volume for Every Tonnage (Kcal/tonne)	3600

Data Source: Arranged from Chang, 1997, p. 20

The demolition of a unit of floor area (m^2) produces the volume of waste listed in Table D- 60. For lower floors (those below the 7th storey), the demolition of $1m^2$ of floor area generates 1,601.1kg of waste. Thus, it can be estimated that the energy used by vehicles transporting the demolition waste of $1m^2$ floor area is 5,766 Kcal/m^2 - 0.02 litres of petrol and 0.64 litres of diesel as Table D- 61 indicates.

Table D-60: Solid Waste at the Demolition Stage of RC Buildings

	Lower Floors (<7F)	**Mid-level Floors (7-12F)**	**Mid-level Floors (12-50F)**	**Upper Floors (>50F)**
	volume per m^2 floor area	volume per m^2 floor area	volume per m^2 floor area	volume per m^2 floor area
Volume of Demolition Waste Soil	1.095 m^3/m^2	1.234 m^3/m^2	1.262 m^3/m^2	1.272 m^3/m^2
Weight of Demolition Waste	1601.1kg/ m^2	1823.7 kg/ m^2	1873.5 kg/ m^2	1896.2 kg/ m^2

Data Source: Chang , 1997, p.18

Table D-61: Energy Consumed at the Demolition Stage (per m^2 of Floor Area)

Operation Item	**Energy Consumption (litre)**	**Thermal Value (Kcal)**	**Oil Equivalent (litre)**
Decomposition Procedure	0.8 litres of diesel	7040	0.76
Transportation of Wastes	0.02 litres of petrol; 0.64 litre of diesel	5766	0.64
Total	0.02 litre of petrol; 1.44 litres of diesel	12806	1.4

The amount of energy consumed at the demolition stage in Taiwan is listed in Table D- 62. In 1996, this total was 2.4 times more than the figure in 1995 (see Figure D-17), which shows that demolition

work is a growth area. Demolition not only consumes a great deal of energy but also wastes large amounts of natural resources, like tiles and roof tiles.

Table D-62: Total Energy Consumption at the Demolition Stage

Year	No. of House	Floor Area (m^2)	Thermal Value (Kcal)	Oil Equivalent(litre)
1992	8625	862500	1.1 E10	1207500
1993	5625	562500	7.2 E09	787500
1994	6300	630000	8.1 E09	882000
1995	6417	641700	8.2 E09	898380
1996	15437	1543700	2.0 E10	2161180

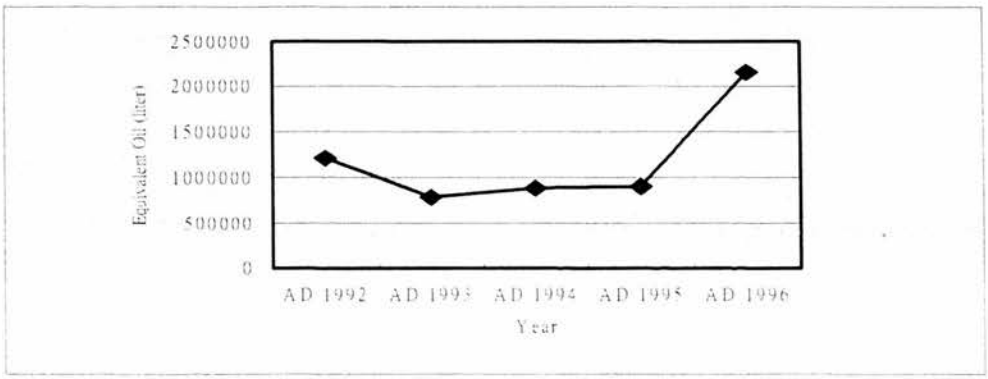

FIG. D-17: Energy Consumption at the Demolition Stage by Year

D.5.2 Effects on Global Warming at the Demolition Stage

Greenhouse gases are emitted at the demolition stage from the use of construction machinery and from the transportation of demolition waste. The volume of CO_2 emissions is estimated by multiplying the energy used for the task (its thermal value unit) with the carbon emission factor and incomplete burning coefficient. The corresponding CO_2, CH_4 and NO_x can be obtained by multiplying the energy used with their emission factors. The volume of N_2O emissions can be acquired by multiplying NO_x with the transformation coefficient. One square metre of floor area produces 3.9kg of CO_2 (Chang, 1997); 0.003kg of CH_4; and 0.002kg of N_2O, as Table D- 63 shows.

Table D- 63: Greenhouse Gas Emissions at the Demolition Stage (Unit: 1m^2 floor area)

Greenhouse Gas	CO_2 (kg/m^2)	CH_4 (kg/m^2)	N_2O(kg/m^2)	GWP(kg/m^2)
Emissions	3.9	0.003	0.002	4.3

Notes: The emission coefficient of CH_4 is based on the transportation activity. The estimation of N_2O emissions from demolition work is based on the emission factor of power shovels, and the volume of emissions from a truck is based on the assumption of a 20 tonne load traveling 10km.

Assessing the effect on global warming from each greenhouse gas emitted is based on the long-term (500 years) global warming potential (GWP), transformed to equivalent CO_2 (GWP). The formula is as follows:

$$GWP = 1 \times CO_2 + 9 \times CH_4 + 190 \times N_2O$$

Demolishing one square metre of floor area produces 4.3kg of CO_2 equivalent. As a result, 90% of GWP emissions come from CO_2; C_{H4} and N_2O between them only account for 10%. In total, the task of demolishing buildings in Taiwan in 1996 generated 6,638 tonnes/year of GWP - 0.02% of the level found at the occupancy stage.

D.5.3 Effects on Acid Precipitation at the Demolition Stage

Acidifying substances produced during the demolition stage mainly refer to NO_x and SO_x, whose major source is the liquid energy used by construction machinery and trucks. To assess the impact of demolition on acid rain we estimate the volume of acidifying substances emitted. The volume of NO_x emissions can be transformed from the N_2O figures mentioned above; SO_x emissions are the same as N_2O. Table D- 64 shows the emission volumes from construction machinery and trucks.

Table D-64: Emissions of Acidifying Substances at the Demolition Stage (Unit: 1m² of floor area)

Procedure	NO_x (kg/m²)	SO_x(kg/m²)	AP(kg/m²)
Demolition	0.14	0.017	0.115
Waste Transportation	0.02	0.002	0.016
Total	0.16	0.019	0.131

To compare the effects of each stage of the building life-cycle on acid rain we convert the acidification potentials (APs) and add them up. The AP's value is relative to SO_x. For example, the AP of NO_x is 0.7 and ammonia (NH_3) 1.9. Thus, the equivalent SO_x can be acquired as follows:

$$AP = 1 \times SO_x + 0.7 \times NO_x + 1.9 \times NH_3$$

Therefore, the volume of AP emitted as a result of demolishing 1m² of floor area is 0.131kg/m². The AP produced from demolition work in 1996 was 202 tonnes/year - 0.16% of the volume found in the occupancy stage, showing that demolition causes the least emissions of any stage of the building life-cycle.

D.5.4 Photochemical Oxidant Formation at the Demolition Stage

The demolition of buildings contributes to photochemical oxidant formation through the CH_4 and hydrocarbons (HCs),which are emitted by construction machinery and trucks. The level of HC emissions can be obtained by multiplying the length of time construction machinery and trucks are in use with their respective emission factors (see Table D- 65).

Table D-65: Emissions of Photochemical Oxidant Formation Substances at the Demolition Stage

Procedure	CH_4 (kg/m²)	HC (kg/m²)	POCP(kg/m²)
Demolition	0.002	0.01	0.004
Waste Transportation	0.001	0.003	0.001
Total	0.003	0.013	0.005

To compare the emission volume at every phase, the photochemical oxidant creation potential (POCP) is used as the transformation basis. The level of equivalent ethylene can be acquired by transforming the volumes of CH_4 and HCs emitted relative to ethylene, giving us a figure of 0.005kg/m^2, i.e., demolishing 1m^2 of floor area generates 0.005kg of ethylene equivalent. In 1996, the task of demolishing buildings generated 7.72 tonnes of equivalent ethylene (POCP), 88% of it from HCs. Comparing the effect of different stages of the building life-cycle on photochemical oxidant formation we see that the demolition stage only has 1% of the effect that the occupancy stage has.

D.5.5 Effects on Eutrophication at the Demolition Stage

Eutrophiccation occurs when nutrients are concentrated in aquatic ecological systems. As the waste water from agriculture, industry and daily domestic needs ends up in the aquatic environment, the current pace of nutrient collection is much faster than the pace of re-cycling and photosynthesis. At the beginning of the growing season when temperatures rise, nutrients at the surface of water help algae and other aquatic plants to propagate and this process continues until one of the nutrients (nitrogen or phosphorus) becomes in short supply. The phenomenon of rapid and extensive algal growth is followed by the equally rapid and extensive death of algae which then float to the surface. Algal decomposition consumes a tremendous amount of the oxygen in the water killing most of the creatures the water supports, especially fish. After the concentration of oxygen in the water normalises, the water can purify itself. However, a second algal bloom can occur in the autumn if the conditions are right causing the whole cycle to recur (Jones et al. 1990). In Taiwan, nutrification is noticeably bad in the Fengshan dam, the A-gong Ten dam and the Cheng Chin Lake dam (EPA, 1997).

NO_x is the main substance related to nutrification which is produced at the demolition stage. Generally, it is transformed into the relative weight of phosphate (PO_4). As we know, the demolition of 1m^2 of

floor area produces 0.16 kg/m^2 of NO_x, which equals 0.021 kg/m^2 of phosphate (see Table D- 66). In 1996, building demolition generated 33 tonnes of equivalent phosphate (NP) - only about 0.2% of the NP generated at the occupancy stage. Of all the stages of the building life-cycle, the demolition stage emits the lowest volume of NP.

Table D-66: Emissions of Nutrifying Substances at the Demolition Stage (Unit: 1m^2 of floor area)

Procedure	NO_x (kg/m^2)	NP (kg/m^2)
Demolition	0.14	0.019
Waste Transportation	0.02	0.002
Total	0.16	0.021

D.5.6 Effects on Human Toxicity at the Demolition Stage

The substances produced at the demolition stage that are toxic to people are NO_x, SO_x and CO and they stem from the use of construction machinery and trucks. Emission volumes can be obtained by multiplying the length of time the machinery is in use, or the mileage clocked up by the demolition trucks, with the emission factors. Table D- 67 shows the volumes emitted per unit area (1m^2 of floor area).

Table D-67: Emissions of Substances Toxic to Humans at the Demolition Stage (Unit: 1m^2 of Floor Area)

Procedure	No_x (kg/m^2)	So_x (kg/m^2)	CO (kg/m^2)	Human Toxicity Equivalent (kg/m^2)
Demolition	0.14	0.017	0.05	0.13
Waste Transportation	0.02	0.002	0.01	0.01
Total	0.16	0.019	0.06	0.14

To compare the volume of emissions of HT substances at each stage of the building life-cycle, the HT

potential is transformed into the coefficient relative to 1kg of the human body. Per unit area (m^2), the demolition stage generates 0.14kg of HT; NO_x accounts for 89% of that figure. Demolition procedures account for more than 90% of the demolition stage's HT emissions. The volume of HT emissions in 1996 was 216 tonnes. Comparing HT emissions from different stages, we see that the occupancy phase generates the most (153,247 tonnes/year), followed by the manufacturing phase (102,305 tonnes/year). The demolition stage only generates 0.14% of that found at the occupancy phase, and has the lowest volume of HT emissions of any of the stages.

D.5.7 Effects on Atmospheric Pollution at the Demolition Stage

Atmospheric pollutants produced at the demolition phase include sulphur oxide (SO_x), hydrocarbons (HC), methane (CH_4), carbon monoxide (CO) and particles. The estimation of total suspended particles (TSPs) is done in two parts: the first relating to demolition procedures on-site and the second to emissions from trucks carrying demolition waste. Demolition procedures include the tasks of decomposing materials, loading them onto trucks, moving items around by truck within the site and bulldozing. As Table D- 68 shows, the emission factor of PM_{10} is 0.0614 kg/m^2 and that of TSP is 0.0959 kg/m^2 (EPA, 1993).

Table D-68: Emission factors of PM_{10} and TSP at the Demolition Stage

Operation Item	PM_{10} (kg/m^2)	TSP (kg/m^2)
Decomposition of Materials	0.00025	0.00039
Loading of Materials	0.0046	0.0072
Truck Pass	0.052	0.0811
Operation of Bulldozers	0.0045	0.0072
Total	0.0614	0.0959

Data Source: EPA, 1993, pp. 3-37

As roads adjacent to demolition sites are always full of dust, passing vehicles stir it up as they go. The EPA formula for measuring this is as follows (EPA 1993, p.3.35):

$E = VP \times T \times EF \times N \times (1\text{-}CE)$

E: emission volume

VP: vehicle passing (PCU/day), 120 units as the basis

T: duration the nearby roads are affected (day), 20 days for one site

EF: emission factor, based on 39 g/vehicle pass

N: number of construction sites

CE: control efficiency, 80% as the basis

Using this formula, we find that the volume of dust stirred up by passing traffic is 0.18 kg/m^2.

Trucks that remove demolition waste produce TSPs both from their exhausts and from the dust they stir up as they travel. The formula for calculating the volume they produce is as follows:

$E = (Q_1 + Q_2) \times V$

Q_1: TSPs from vehicle exhausts, based on 3 g/km

Q_2: dust on the surface of vehicles & dust stirred by traveling = (3×10^{-6}) S. L. W.

S: slurry on the surface of vehicles (5%)

L: dust on the surface of roads (150 lb/mile)

W: weight of vehicle (20 tonnes)

Q_2 = 12.8 g/km

Using this formula, we find that the volume of TSPs emitted per unit floor area (m^2) at the demolition stage is 0.2883 kg/m^2, as Table D- 69 shows.

Table D-69: TSP Emissions at the Demolition Stage

Operation Item	Emission Factor (kg/m^2)
Decomposition of Materials	0.0959
Moving Trucks Stir Dust from the Site	0.18
Truck Exhausts	0.0024
Moving Trucks Stir Fugitive Dust	0.01
Total	0.2883

The emission volumes of each air pollutant per unit floor area is listed in Table D- 70. From this table, we see that TSPs have the greatest emission factor. A comparison of the total volumes of various air pollutants at the demolition stage is shown in Table D- 71. From this table, we see that CO2 is the most voluminous.

Table D-70: Emissions of Various Air Pollutants at the Demolition Stage (Unit: $1m^2$ of Floor Area)

Procedure	SO_x (kg/m^2)	NO_x (kg/m^2)	CO (kg/m^2)	TSP (kg/m^2)
Demolition	0.017	0.14	0.05	0.2759
Waste Transportation	0.002	0.02	0.01	0.0124
Total	0.019	0.16	0.06	0.2883

Table D-71: Total Emission Volumes of Various Air Pollutants at the Demolition Stage

Substance	Unit Emission Volume (kg/m^2)	Emission Vol. (tonne/year)	Proportion of Total Emission Vol. in Taiwan (%)
CO_2	3.9	6020	3.9
CH_4	0.003	5	0.02
N_2O	0.002	3	0.05
SO_x	0.019	30	0.007
NO_x	0.16	247	0.04
CO	0.06	93	0.006
TSP	0.288	445	0.07

To estimate the impact of each air pollutant on air quality, we use the CDV concept. Each pollutant is transformed into SOx CDV [CDVA].

$$CDVA\ (SOx) = 1 \times SO_x + 0.61 \times NO_x + 36.5 \times CO + 1.4 \times TSP$$

The CDVA (SOx) per unit area at the demolition stage is 2.71 kg/m^2 of equivalent Sox, which also means that the CDV is 7.42 million m^3. In 1996, the atmospheric pollution CDV was 4,198 tonnes

CDVA (E), 1.08% of that generated at the occupancy phase.

D.5.8 Solid Waste at the Demolition Stage

A tremendous quantity of solid waste is generated at the demolition stage which has a severe adverse impact on the environment if it is not properly taken care of. The issues posed by demolition waste include pollution, the costs of disposal and the difficulty of finding suitable sites to deposit and treat it.

The volume of demolition waste can be obtained by multiplying the volume of building materials per unit floor area with the expanding pore space factor following demolition. Different kinds of building produce different volumes of demolition waste: low-rise residential buildings generate the most ($1.095m^3$), followed by schools, as Table D- 72 shows.

Table D-72: Volume of Demolition Waste per m^2 of Floor Area of Various Kinds of Building

Application	Volume	Lower Floors(<7F)	Mid-level Floors (7-12F)	Mid-level Floors (12F-50m)	Upper Floors (>50m)
Residential	Volume (m^3/m^2)	1.095	1.234	1.262	1.272
	Weight (kg/m^2)	1601.1	1823.7	1873.5	1896.2
Office	Volume (m^3/m^2)	1.054	1.139	1.201	1.207
	Weight (kg/m^2)	1613.3	1748.0	1847.2	1855.0
School	Volume (m^3/m^2)	1.094	1.218	N/A	N/A
	Weight (kg/m^2)	1637.1	1834.6	N/A	N/A

Notes: N/A means not available

Data source: Arranged from Chang, 1997, pp. 18-19

Disposing of $1m^3$ of demolition waste costs £12 (see Table D- 73) and takes up $0.06m^2$ of landfill space. It costs £13.10 to dispose of $1m^2$ of floor area of a low-rise residential building. In 1996, the volume of demolition waste was 1.69 million m^3 which cost £15.55m to dispose of and which used up 10.1 hectares of landfill space.

Table D-73: Disposal Costs of Demolition Waste (unit volume)

Item		Unit cost
Cost	Construction Cost of Landfills (including lands)(pound/m^3)	8.4
	Operation Cost of Burial (pound/m^3)	1.8
	Cost of Closing Landfills (pound/m^3)	1.8
	Total	12
Required area for landfill (m^2/m^3)		0.06

Note: This table was devised from the cost of landfill of 27 hectares in Taichung City

D.5.9 Resource Recycling at the Demolition Stage

Much of the waste from demolition can be recycled, e.g., metal, glass and timber. If these materials continue to be treated as waste, not only do they pose an environmental hazard but they make no contribution to the recycled or "Green" building programme. Given the practical constraints imposed by economic and technological considerations, the demolition waste which is currently most likely to be recycled is waste steel bars, steel products and metals. There are already specialist companies in Taiwan with the processing capability and production equipment to contribute to the establishment of a recycling market.

Generally speaking, the recycling of metals such as steel and aluminium is more economically viable than the recycling of concrete, tiles or gravel. Nevertheless, based on the pursuit of environmental protection measures, we need to conduct R&D into technologies that can support the emergence of a competitive recycling market and so limit the wastage of natural resources.

Most Taiwanese buildings' structures are made from steel-framed reinforced concrete (SRC), reinforced concrete (RC) and steel-scaffolded concrete (SSC). In 1996, these three structural types accounted for 96.7% of total building floor area (CPD, 1997). For this reason, this section will deal mainly with the recycling of waste metal and steel as they are the main materials used in these types of

structure.

There are two direct benefits to the environment from the recycling of waste metal and steel, apart from the obvious benefit of savings on disposal costs. First, recycling limits the depletion of natural resources caused by the excavation of new mines. Second, recycling enables new products to be manufactured which, since the process is not starting from scratch, will consume less energy and so emit less greenhouse gases.

To estimate the energy saved by recycling waste steel and metal (i.e., the recycling economy effect) we calculate the difference in energy needed to refine metal in a high temperature electric resistance furnace (iron ore material) and in an electric arc furnace (waste steel). However, to gauge the real recycling economy effect we also need to calculate and deduct the amount of energy needed to transport the waste steel and metals to the treatment furnace. Table D- 74 indicates that recycling one tonne of waste metal and steel can save 63.7 litres of oil equivalent, which means that 1.472 Kcal per kg can be saved with a related decrease in CO2 emissions of 0.41kg. The extent to which the volumes of other atmospheric pollutants can be reduced are listed in Table D- 75.

Table D-74: Energy Savings from Recycling Waste Metal and Steel

Procedure Item	Consumed Energy (equivalent oil l/tonne)	Thermal Value (Kcal/kg)
A. Steel Refining Using Ironsand (new)	314.49	283(
B. Steel Refining (electric arc furnace)	149.98	135(
C. Transportation of Waste Steel & Metal	0.81	7.2(
Saved Energy (A-B-C)	163.7	147

Notes: The calculation of energy needed to refine steel is based on Yang, 1996, p.41. Th transportation costs of waste steel and metal are based on Chang, 1997, p. 19.

Table D-75: Reduced Emission Volumes of Air Pollutants from Recycling Waste Metal/Steel

Gas	Reduced Emission Volume (kg/kg)
CO_2	0.41
CH_4	1.56×10^{-3}
N_2O	1.59×10^{-3}
NO_x	1.59×10^{-1}
TSP	6.3×10^{-5}
SO_2	1.8×10^{-4}
CO	0.9×10^{-5}
HC	0.54×10^{-6}

When we compare the volume of CO_2 emissions from the recycling of waste steel and metal with the volume emitted from manufacturing reinforced steel materials at the manufacturing stage, we find there is a reduction of 70% which could make an enormous contribution to reducing the building life-cycle's effect on global warming and natural resource depletion. Clearly, recycling demolition materials can lessen the burden that buildings impose on the environment.

D.6 A COMPARISON OF THE ENVIRONMENTAL IMPACTS ASSOCIATED WITH EACH STAGE OF THE BUILDING LIFE-CYCLE

Of the environmental impacts of the building life-cycle, some can be quantified (e.g., pollutants emitted) and some cannot (e.g., aesthetic effects).

On the issue of natural resource depletion, the building sector consumes 18.3 million tonnes of gravel and stone each year, 1.79% of the usable gravel and stone in Taiwan's rivers.[34] At that rate, the aggregate of concrete reserved in rivers will be used up in 55 years time. The construction process uses 8.4 million tonnes of reinforced steel every year and 22.7 million tonnes of cement, 90% of which comes from limestone excavated from the central mountains of Taiwan. In addition, 41,430 tonnes of aluminium doors and windows and 1.50 million window-style air conditioners are installed annually

[34] In 1990, 12.2 billion m^3 of gravel in Taiwan's rivers were reserved. See EPA, 1997, p. 276.

during construction. As we can see, the building sector is a major consumer of natural resources.

Power is consumed in vast quantities by the building sector, from the initial manufacture of building materials to the final disposal of demolition waste. Table D- 76 shows that the building sector consumes 217,204 billion Kcal of energy each year (about 24,133 million litres of oil equivalent) which represents 34.4% of Taiwan's total energy consumption (as compared with 47% in the UK, 36.8% in Japan and 51.7% in the US).

Table D-76: Comparison of Environmental Impacts of Emitted Pollutants at Each Life-Cycle Stage

Environmental Impact Inventory	Stressor	Unit	Manufacture phase	Transportation phase	Construction Phase	Occupancy Phase	Demolition Phase	Total	Proportion of National Emission Volume (%)
Energy Consumption	Fossil fuel electricity natural gas	Million Kcal (%)	94689000 (43.4)	1821150 (0.9)	603282 (0.3)	120070800 (55.3)	20000 (0.1)	217204232 (100)	34.4
Global Warming	CO_2, CH_4, N_2O, CFC_{11} CFC_{12}, $HCFC_{22}$, $HCFC_{123}$	Relative To 1 tonne CO_2 (%)	28270000 (45.1)	675641 (1.1)	205981 (0.3)	33443000 (53.4)	6638 (0.1)	62601260 (100)	36.9
Acid Rain	NO_x SO_x	Relative To 1 tonne SO_2 (%)	91129 (37.1)	24206 (9.9)	954 (0.4)	128624 (52.5)	202 (0.1)	245115 (100)	27.3
Ozone Depletion	CFC_{11} CFC_{12} $HCFC_{22}$ $HCFC_{123}$	Relative To 1 tonne CFC_{11} (%)	* (0.0)	15 (25.2)	* (0.0)	44.5 (74.8)	* (0.0)	59.5 (100)	21.74
Photochemical Oxidant Formation	CH_4 HC	Relative To 1 tonne ethylene (%)	53334 (69.8)	1918 (2.4)	20682 (26.7)	744 (0.9)	8 (0.1)	76686 (100)	32.4
Nutrification	NO_x COD	Relative	16184 (43.9)	3806 (10.3)	75 (0.2)	16762 (45.5)	33 (0.1)	36860 (100)	7.8

Environmental Impact Inventory	Stressor	Unit	Manufacture phase	Transportation phase	Construction Phase	Occupancy Phase	Demolition Phase	Total	Proportion of National Emission Volume (%)
	PO_4	To 1 tonne PO_4 (%)							
Human Toxicity	SO_x NO_x CO CFC_{12} Pb	Relative To 1 tonne human body (%)	102384 (36.0)	27599 (9.7)	1148 (0.4)	153247 (53.8)	216 (0.1)	284594 (100)	25.6
Atmospheric Pollution	SO_x NO_x CO Pb TSP PM_{10}	Relative To CDV of NO_x (%)	313042 (20.6)	643348 (42.4)	170039 (11.2)	387064 (25.5)	4198 (0.3)	1517691 (100)	2.7
Waterborne Pollution	BOD COD SS	CDV of BOD (%)	28290(1.1)	*	16111 (0.6)	2626380 (98.3)	*	2670781 (100)	40.13

Environmental Impact Inventory	Stressor	Unit	Manufacture phase	Transportation phase	Construction Phase	Occupancy Phase	Demolition Phase	Total	Proportion of National Emission Volume (%)
Energy Consumption	Fossil fuel electricity natural gas	Million Kcal (%)	94689000 (43.4)	1821150 (0.9)	603282 (0.3)	120070800 (55.3)	20000 (0.1)	217204232 (100)	34.4
Global Warming	CO_2, CH_4, N_2O, CFC_{11} CFC_{12}, $HCFC_{22}$, $HCFC_{123}$	Relative To 1 tonne CO_2 (%)	28270000 (45.1)	675641 (1.1)	205981 (0.3)	33443000 (53.4)	6638 (0.1)	62601260 (100)	36.9
Acid Rain	NO_x SO_x	Relative To 1 tonne SO_2 (%)	91129 (37.1)	24206 (9.9)	954 (0.4)	128624 (52.5)	202 (0.1)	245115 (100)	27.3

The occupancy stage accounts for 19.0% of Taiwan's total energy consumption and 55.3% of the total consumed by the building sector (see Figure D-8). The manufacture of building materials accounts for 43.4% of the energy consumed by the building sector while the remaining phases only account for 1.3% of this total

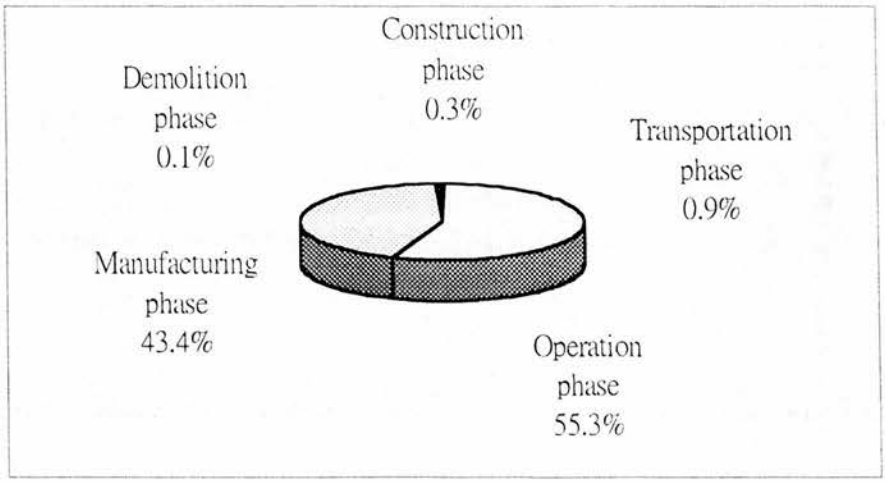

FIG. D-18: Energy Consumption at Each Stage of the Building Life-Cycle

The emission of greenhouse gases from the burning of fossil fuel is the key reason why this century has seen clear and dangerous signs of global warming. As the building sector consumes energy from cradle to grave, a large amount of fossil fuel is used in the process. The building sector in Taiwan emits 62.62 million tonnes of equivalent CO_2 (GWP) every year, which accounts for 36.9% of Taiwan's greenhouse gas emissions (equivalent CO_2) - a percentage which is higher than Japan's 34% but lower than the UK's 48.6% and the States' 50.1%. The occupancy stage accounts for 20% of Taiwan's total equivalent CO_2 emissions and, of all the life-cycle stages, is the major source of greenhouse gas emissions (see Figure D-19).

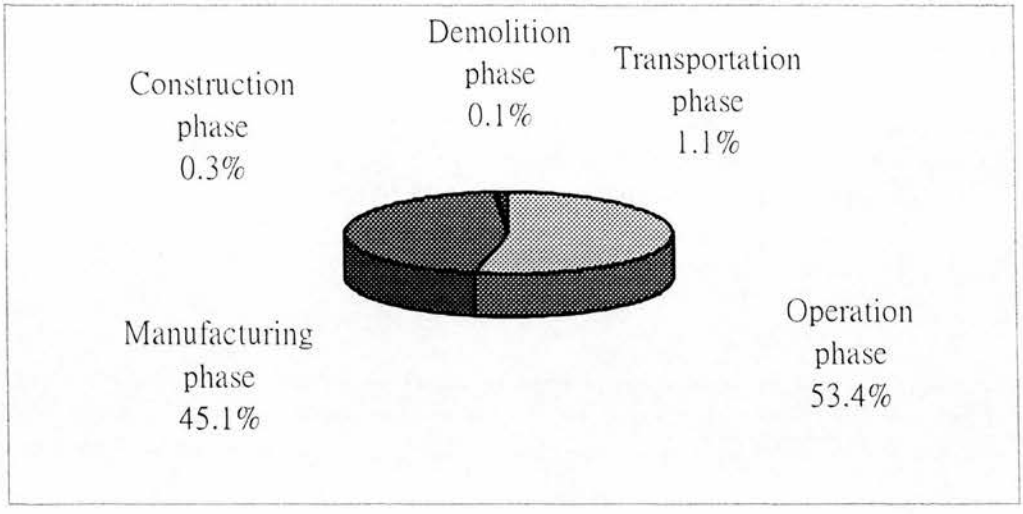

FIG. D-19: Effect on Global Warming by Each Life-Cycle Stage

Commercial buildings have the highest annual average growth rate of emitted CO_2, growing by 8.91% between 1970 and 1990 and by 15.18% between 1990 and 1995, as Table D- 77 shows. Residential buildings' emissions of CO_2 have an annual growth rate of 9.14%, the second highest amongst building types (MOE, 1997, p.129). To reduce the contribution the building sector makes to global warming, its daily energy consumption needs to be addressed. Gases like CFC_5 are also greenhouse gases but as CFC_{11} and CFC_{12} have had an importation and production ban placed on them since 1996, their impact is not significant.

Table D-77: Annual Average Growth Rate of CO_2 Emissions in Taiwan (1970-1995) Unit: %

	1970 - 1990	1990 – 1995
Supply of Energy	7.17	8.0
Change of Energy	8.01	8.67
Energy Industry	7.70	8.35
Transportation	12.21	7.97
Industry	6.84	5.93
Agriculture	5.93	0.90
Residence	8.68	9.14
Business	8.91	15.18
Other	5.26	5.20

Data Source: MOE, 1997, P.129, Table 4.2.25.

The acidifying substances, SO_2 and NO_x, which contribute to the formation of acid rain come from burning fossil fuels at high temperatures. Annual emissions of equivalent SO_2 from the building sector come to 245,000 tonnes, accounting for 27.3% of Taiwan's AP emission volume. Of this figure, the occupancy stage accounts for 52.5%; the manufacturing stage 37.1%; and the transportation stage 9.9%, as Fig. D-20 shows.

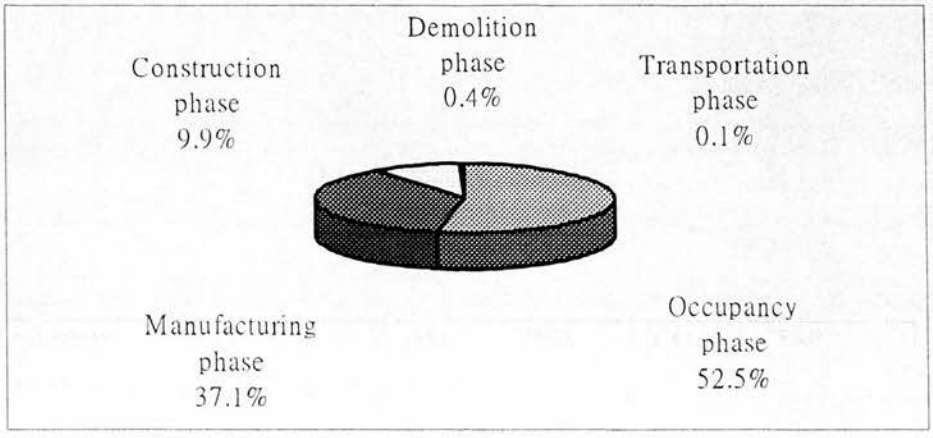

FIG. D-20: Impact on Acid Rain of Each Life-Cycle Stage

The depletion of the ozone layer is a global problem which is being addressed by a stage-by-stage reduction in ODS emissions. Following the spirit of the Montreal Protocol on Substances that Deplete the Ozone Layer, Taiwan has prohibited the production and importation of CFC_s since Jan. 1, 1996, though stockpiled items which emit this chemical can still be used. HCFC emissions will be subject to control from 2004. The annual ODS emissions from the building sector account for 21.74% of Taiwan's total. The occupancy stage accounts for the highest proportion of this: 16.2% of Taiwan's total and 74.8% of the total emitted from the building sector. The remaining 25.2% is generated at the transportation stage, as Figure D-21 shows.

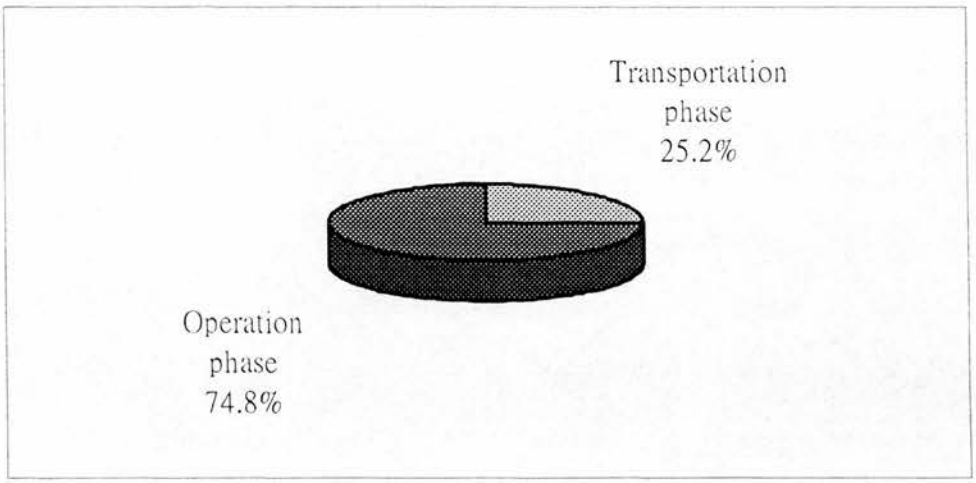

FIG. D-21: Impact on Ozone Depletion of Each Life-Cycle Stage

CH_4 and HCs become poisonous secondary air pollutants through photochemical reaction in the air. The emission volume of equivalent ethylene (POCP) from the building sector is 76,686 tonnes, 32.4% of Taiwan's total POCP emissions. The manufacturing stage accounts for 69.8% of this figure and the construction stage 26.8%, as Figure D-22 shows.

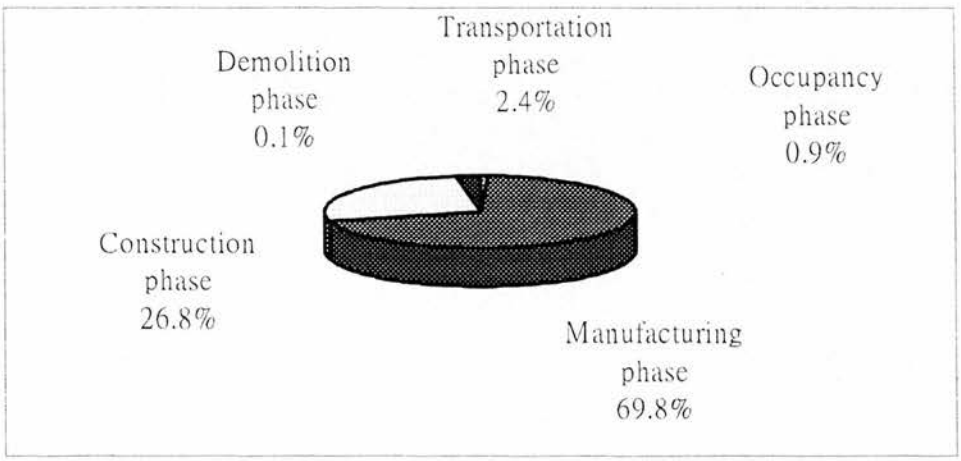

FIG. D-21: Proportion of Photochemical Oxidant Formation at Each Life-Cycle Stage

Nutrification in reservoirs is a consequence of phosphate and nitrogen pollution. The building sector generates nutrification potential (NP) substances like NO_x, COD and PO_4. Its annual emission volume is 36,860 tonnes of equivalent phosphate (NP), which accounts for 7.8% of Taiwan's total. The occupancy stage accounts for the greatest proportion of this (46.5%) followed by the manufacturing stage, as Figure D-23 shows.

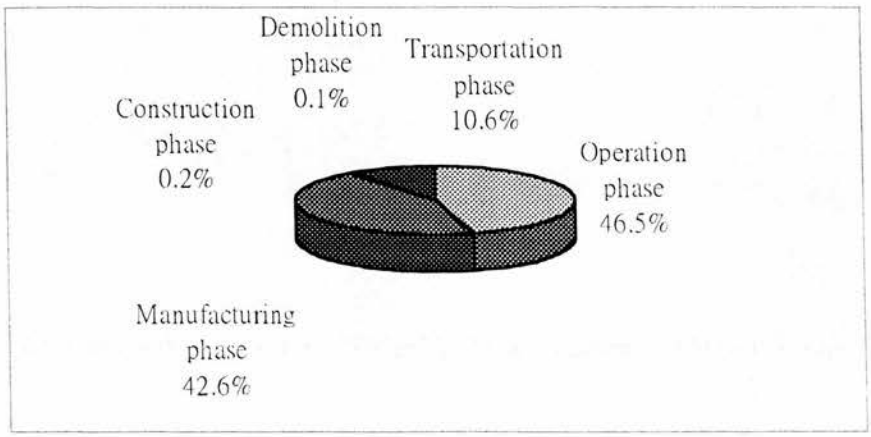

FIG. D-23: Impact on Eutrophication at Each Life-Cycle Stage

As for atmospheric pollution, Taiwan has seven index pollutants which it uses to assess air quality (TSP, PM_{10}, SO_2 (SO_x), NO_2 (NO_x), CO, O_3 and Pb), and an integral assessment of them is conducted using the concept of critical dilution volume (CDV). The building sector only accounts for 2.7% of the CDV in Taiwan because Taiwan's CO emissions are high (1,489,543 tonnes/year) and largely caused by cars and scooters (accounting for 75.88% of Taiwan's total). However, the building sector's emissions of individual air pollutants account for between 20% to 40% of Taiwan's total, as Figure D-24 shows. CO_2 accounts for the largest proportion (36.9%) and CO the smallest (2.0%), as Table D-78 shows. The impact on atmospheric pollution of each stage of the life-cycle is shown in Figure D-25.

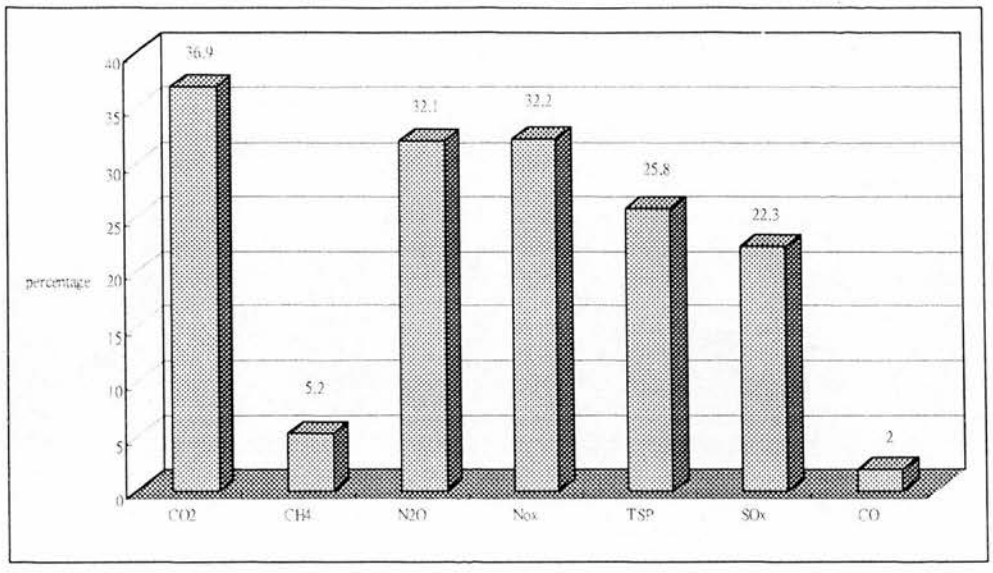

FIG. D-24: Proportion of Each Air Pollutant to Taiwan's Total Volume of Emissions

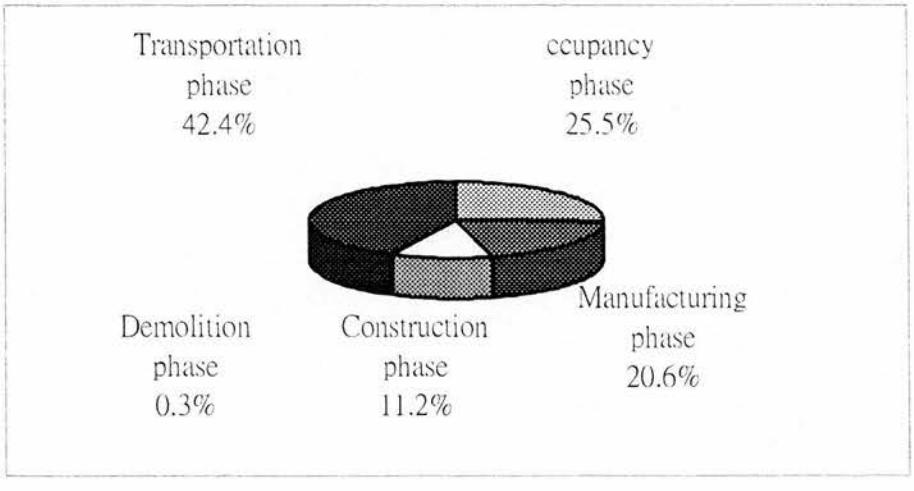

FIG. D-25: Impact on Atmospheric Pollution at Each Life-Cycle Stage

Table D-78: Emissions of Major Pollutants at Each Life-Cycle Stage

Substance	Manufacture	Transport	Construction	Operation	Demolition	Total	% of national emissions
CO_2 tonnes(%)	27950000 (45.3)	558266 (0.9)	204778 (0.4)	33045000 (53.3)	6020 (0.1)	61764064 (100)	36.9
CH_4 tonnes(%)	109 (10.0)	511 (46.5)	7 (0.6)	466 (42.4)	5 (0.5)	1098 (100)	5.2
N_2O tonnes(%)	1180 (56.7)	293 (14.1)	6 (0.3)	600 (28.8)	3 (0.1)	2082 (100)	32.1
NO_x tonnes(%)	118038 (56.7)	29276 (14.1)	576 (0.3)	60014 (28.8)	247 (0.1)	208151 (100)	32.2
TSP tonnes(%)	96878 (57.6)	21428 (12.8)	39000 (23.2)	10166 (6.1)	445 (0.3)	167917 (100)	25.8
SO_x tonnes(%)	8503 (8.5)	3713 (3.7)	551 (0.6)	86614 (87.1)	30 (0.1)	99411 (100)	22.3
CO tonnes(%)	2650 (9.3)	16136 (56.2)	3138 (10.9)	6687 (23.3)	93 (0.3)	28704 (100)	2.0
BOD tonnes(%)	6866 (2.1)	*	29784 (8.4)	318887 (89.7)	*	355537 (100)	52.5

Notes: ( ) refers to the proportion of emissions from each phase in relation to the building sector's total emissions. * refers to a relatively low volume of emissions from a particular phase, estimation excluded.

Tables D-79 and D-80 show the volume of emissions from the major building materials in the manufacturing and transportation stages. The volume of energy consumed by each type of building together with the pollutants emitted by each type can be estimated by examining the kinds and quantities of building materials used by each type, as Table D- 81 shows.

Table D- 79: Energy Consumed and Pollutants Emitted at the Manufacturing Stage

Construction Material	Energy Consumed (Kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	TSP (kg)	SO_2 (kg)	CO (kg)	Pb (kg)	HC(kg)
Cement Mortar (m^3)	555034	194	0.001	0.008	0.8	1.96	0.08	0.02	3.0E-06	8.9E-04
Pre-mixed Concrete(m^3)									2.3E-06	6.9E-04
Moulding board (m^2)	1071	0.3	9.3E-07	1.1E-05	0.001	0.01	4.9E-05	3.6E-05	1.6E-08	5.0E-06
Reinforced Steel (T)	2107424	579	2.2E-03	2.3E-02	2.28	0.76	0.15	0.08	2.6E-05	7.6E-03
Timber (m^3)	45418	11.39	3.9E-05	4.5E-04	0.05	0.63	0.002	0.002	7.0E-07	2.1E-04
Metal Door Window (m^3)	36752	9.8	3.1E-05	3.4E-04	0.03	0.007	0.002	0.001	1.9E-07	3.5E-05
Metal Curtain Wall (m^2)	118800	29.3	1.0E-04	0.001	0.12	0.002	0.005	0.004	1.9E-07	1.0E-05
Glass (m^2)	16081	4.8	1.2E-05	1.3E-04	0.01	0.001	0.002	0.0009	8.5E-08	2.5E-05
Paint (m^2)	942	0.21	8.6E-07	1.1E-05	0.001	1.3E-05	1.9E-05	2.2E-05	2.5E-08	5.8E-06
1/2 B brick (m^2)	45780	14.7	4.9E-05	0.0005	0.05	0.21	0.005	0.002	2.1E-07	6.1E-05
1 B brick (m^2)	91560	29.4	9.8E-05	0.001	0.1	0.42	0.01	0.004	4.2E-07	1.2E-04
Tile (m^2)	30454	6.9	1.9E-05	1.5E-04	0.02	0.09	6.8E-05	0.002	1.6E-07	4.7E-05
Marble (m^2)	46431	16.1	8.1E-05	6.4E-05	0.007	0.02	0.006	0.002	3.3E-07	7.7E-05
Plywood (m^2)	3118	0.7	3.0E-06	3.5E-05	3.5E-03	0.006	3.1E-05	5.9E-05	6.8E-08	2.0E-05

Notes:

a) This estimate of various construction materials assumes $1m^3$ of cement mortar, 0.5 tonnes of cement and $1m^3$ of gravel, premix concrete requires 0.34 tonnes of cement and $1.37m^3$ of gravel. $1m^2$ of wood mould takes $0.07m^3$ of timber and is repeated three times. $1m^2$ of metal (aluminium) door/window uses 4.35kg of aluminium frames and 6.5kg of glass. $1m^2$ of curtain wall requires 25kg of aluminium. $1m^2$ of glass needs 6.5kg. To paint $1m^2$, 0.32kg of paint is needed. $1m^2$ of floor tiles take 18kg of tiles 1/2 B brick including 70 pieces of bricks 1B brick including 140 pieces of bricks. $1m^2$ of marble requires $0.1m^3$ of stone, 0.08 of cement mortar and 0.4kg of metal. $1m^2$ of plywood takes $0.009m^3$ of timber.

b) The unit emission volume can be obtained by multiplying the amount of material required with its emission factor.

Table D- 80: Energy Used and Pollutants Emitted at the Transportation Stage

Major Construction Material	Energy consumed (Kcal)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	NO_x (kg)	TSP (kg)	SO_x (kg)	CO (kg)	Pb (kg)	HC (kg)
Cement Mortar (m^3)	11031	3.39	0.003	0.001	0.13	0.059	0.017	0.074	3.2E-06	0.02
Pre-mixed Concrete (m^3)	15000	4.61	0.004	0.002	0.247	0.33	0.034	0.131	5.9E-06	0.04
Moulding board (m^2)	649	0.20	1.8E-04	1.1E-04	0.010	0.004	0.001	0.006	2.5E-07	0.002
Reinforced Steel (T)	8304	0.003	2.9E-06	1.3E-06	1.3E-04	9.6E-05	1.7E-05	7.3E-05	3.2E-09	2.3E-05
Timber (m^3)	6229	1.92	0.0018	0.001	0.1	0.05	0.012	0.055	2.4E-06	0.017
Metal Door/Window (m^3)	210	0.07	5.9E-05	3.4E-05	3.4E-03	5.0E-04	4.3E-04	0.002	8.3E-08	5.9E-04
Metal Curtain Wall (m^2)	506	0.16	1.4E-04	8.1E-05	8.1E-03	0.003	1.0E-03	4.5E-03	2.0E-07	1.4E-03
Glass (m^2)	123	0.04	3.5E-05	2.0E-05	2.0E-03	8.0E-04	2.5E-04	1.1E-03	4.8E-08	3.4E-05
Paint (m^2)	11	0.003	2.9E-06	1.6E-06	1.6E-04	4.9E-05	2.1E-05	9.1E-05	4.0E-09	2.8E-05
1/2 B brick (m^2)	921	0.28	2.6E-04	1.5E-04	0.015	0.013	1.9E-03	8.2E-03	3.6E-07	0.003
1 B brick (m^2)	1842	0.56	5.2E-04	3.0E-04	0.03	0.026	3.8E-03	0.02	7.2E-07	0.006
Floor Tile (m^2)	269	0.08	7.6E-05	4.3E-05	4.3E-03	0.002	5.5E-04	2.4E-03	1.1E-07	7.5E-04
Marble (m^2)	780	0.24	2.2E-04	1.3E-04	0.01	0.017	1.6E-03	0.007	3.1E-07	2.2E-03
Plywood (m^2)	186	0.000 06	5.1E-08	3.0E-08	3.0E-06	4.4E-07	3.8E-07	1.7E-06	6.8E-11	5.2E-07

Notes: The weight of gravel is 1700 kg ^{m3}. 1m3 of pre-mixed concrete is 1500kg. $1m^2$ of moulding board is 17kg. $1m^3$ of timber is 400kg. $1m^2$ of metal (aluminium) door/window requires 4.35kg of aluminium frames and 6.5kg of glass. $1m^2$ of curtain wall weighs 25kg. $1m^2$ of glass weighs 6.5kg. $1m^2$ of painting demands 0.32kg. $1m^2$ of floor tiles need 18kg of tiles. each brick weighs 2kg. $1m^2$ of marble requires 200kg and the weight of $1m^2$ of plywood is 6kg.

Table D-81: Energy Consumed and Pollutants Emitted at the Manufacturing and Transportation Stages

Item	Below 4 floors (RC)		5 - 12 floors (RC)		Above 13 floors (SRC)		Above 20 floors (SS)	
	manufacture	Transport	manufacture	Transport	manuf.	Transport	manufacture	Transport
Energy Consumed (Kcal/m^2)	474114	12852	649351	15090	700435	15062	605090	9258
CO_2 (kg/m^2)	146.0	3.8	196.8	4.3	209.7	4.2	175.1	2.4
CO_4 (kg/m^2)	6.4E-04	3.3E-03	8.7E-04	3.8E-03	9.1E-04	3.7E-03	7.2E-04	2.1E-03
N_2O (kg/m^2)	6.9E-03	1.9E-03	8.1E-3	2.3E-03	8.6E-3	2.2E-03	7.0E-3	1.3E-03
NO_x (kg/m^2)	6.9E-01	1.9E-01	8.1E-01	2.3E-01	8.6E-01	2.2E-01	7.0E-01	1.3E-01
TSP (kg/m^2)	1.4	2.1E-01	1.8	2.5E-01	1.7	2.4E-01	1.1	1.4E-01
SO_x (kg/m^2)	4.5E-02	2.5E-02	6.0E-02	2.9E-02	6.3E-02	2.9E-02	4.9E-02	1.6E-02
CO (kg/m^2)	1.7E-02	1.1E-01	2.6E-02	1.2E-01	2.8E-02	1.2E-01	2.4E-02	6.9E-02
Pb (kg/m^2)	3.8E-06	4.7E-06	5.7E-06	5.4E-06	6.4E-06	5.3E-06	6.0E-06	3.1E-06
HC (kg/m^2)	1.1E-03	3.3E-02	1.7E-03	3.8E-02	2.0E-03	3.8E-02	1.8E-03	2.2E-02

Buildings of over 13 floors with an SRC structure consume the most energy at the manufacturing stage (each square metre of floor area uses 700.435 Kcal), followed by mid-rise buildings (5 to 12 floors) with an RC structure, while the lowest energy consumers are buildings of less than four floors, as Figure D-26 illustrates.

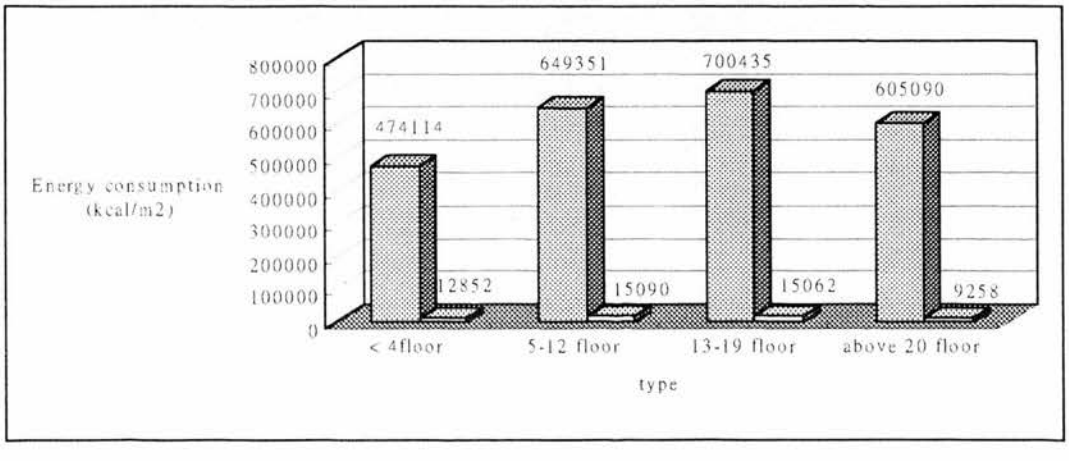

FIG. D-26: Energy Consumed by Various Types of Building at the Manufacturing and

Transportation Stages

Buildings with an SS structure consume less energy than those with an RC structure because the latter demands a large amount of reinforced steel, concrete and gravel whereas the former only requires plenty of reinforced steel and steel frames.

For the two phases of manufacture and transportation of construction materials, the former consumes more energy than the latter. Generally speaking, the energy consumed at the transportation phase only accounts for 2.5% of that needed for the manufacturing stage. Buildings with an SS structure also consume less energy at the transportation phase, only 1.6% of the energy they require at the manufacturing stage.

As the for building life-cycle's impact on waterborne pollution, the annual emissions from the building sector account for 40.13% of the Taiwan's total volume of BOD, COD and SS emissions. The occupancy stage accounts for most of this, as most of these pollutants result from people捉 normal daily water needs.

In addition to the environmental themes discussed above, the building sector also impacts on loca ecologies, landscapes and culture. For instance, acquiring raw materials for building affects th ecological landscape; transporting materials affects traffic; and occupied buildings affect the loca socio-economic environment.

APPENDIX E: THE HISTRICAL DEVELOPMENT OF THE SYSTEM IN TAIWAN

E.1 INTRODUCTION

Over the past 50 years, Taiwan has gained a world-wide reputation as an economic miracle, earned as a result of the Taiwanese government's commitment to economic development as well as the Taiwanese people's industry (Lee et al. 1987, p.109). Its national income has increased impressively year on year, reaching $13,000 per capita in 1998. Though the economy has been thriving and Taiwan is undoubtedly now a wealthy country, development has not been achieved without cost. Economic growth has been blighting Taiwan's environment. Pollution, noise, traffic etc. have increasingly damaged the nation's quality of life - to such an extent, in fact, that the government have been obliged to address Taiwan's environmental problems as a matter of urgency. By now, the general public is in favour of economic policies which treat environmental protection as an duty equal to wealth creation.

This change in public opinion has been fomenting since the 1980s. As organisations and industrial sectors continued to expand, they did so almost solely in terms of the feasibility of their techniques and the soundness of their financial planning. As a result, many development programmes had severe environmental knock-on effects: instances of pollution, damage to property and public health risks increasingly triggered angry responses from the public (Chung, 1993, p.8). As the number of protests increased, so too did the membership of existing and newly-founded environmental protection movements (Liu 1995, p.1).

Since its inception, the Environmental Impact Assessment (EIA) System has occupied an important position in Taiwan environmental policy planning. In 1975, the Economic Planning Council (EPC)

borrowed the US's EIA system and published it in the *Free China's Industry*[1]. The following year, the Chinese Engineers' Association discussed the EIA in its seminar on Modern Industrial Techniques. The environmental pollution team within the Executive Yuan, holding its first scientific meeting in 1978, suggested the government promote the EIA system as soon as possible. A pilot project - the EIA Demonstration Project at Coastal Industrial Areas in Northern Taiwan - was conducted in 1980. By 1985, the Health Administration had drawn up a programme to strengthen the EIA's remit and announced a follow-up programme along the same lines in 1991. Thus, by the time the EIA Act became law on 31st December 1994, Taiwan had accumulated many years of practical experience implementing the system, and the EIA's pervading influence on Taiwan's environmental policies has proved crucial.

High-rise developments have flourished in Taiwan because of the burgeoning demand for commercial and residential properties, the soaring price of land and technological developments in construction techniques and equipment. Estate agencies vie for floor space on limited land sites in order to yield the highest investment benefits. However, the first flurry of high-rise development was characterised by a lack of environmental planning and the result was inadequate provision of public amenities in the buildings vicinity, chaotic urban development, and a consequent deterioration in the quality of life in and around the high-rises. Furthermore, the two EIA programmes which were in place in Taiwan during the 1980s excluded high-rise developments from their remit. However, recognising the environmental consequences of the high-rises springing up in their midst, the city governments of Taipei, Taichung and Kaohsiung gradually began to formulate their own guidelines for conducting an EIA on high-rises located within the city boundaries. Eventually, with the enactment of the EIA Act in 1994, it was formalised that all high-rise proposals must submit to the EIA process.

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[1] The EPC, a predecessor of the Council for Economic Planning and Development, was a department within the central government's committee system.

In order to understand the setting-up and implementation of the EIA system, we identify four periods in its evolution: the germination of the concept; the preparatory groundwork on codifying its terms; the establishment of the system; and the EIA in action. Throughout, we look at the the social and economic environment within which the emergent EIA sytem was embedded: the gradual development of environmental policies and environmental management systems and the transformation of administrative organisation across the phases of its evolution.

The first phase - the concept germination stage - is pre-1980. It was during this phase, as mentioned above, that the EPC introduced the US version of the EIA system into Taiwanese government and industrial circles, and the first pilot study of the system was conducted at the prompting of the specialist environmental group within the Executive Yuan.

The second phase - laying the legal groundwork - lasted from 1980 to 1990. During this period, the government set up an EIA research team who initiated the task of establishing the EIA's parameters and who selected several projects for testing them out. As valuable experience was gained, the Executive Yuan was ready by 1985 to announce a programme for strengthening the EIA system, using 14 major projects as test cases. As a result of this endeavour, the Environmental Protection Administration (EPA) was established in 1987; by 1988 the first draft of the proposed EIA Act was deliberated on; and by 1989 the EPA had submitted a draft of the Act to the Executive Yuan for approval.

The third phase (1990 to 1995) was the period when a formal EIA system was established. In 1990, the Executive Yuan examined the draft EIA Act and passed it on to the Legislative Yuan who, in turn, submitted it to the Committee of the Interior, the Economy and the Judiciary in the 86th session. Meantime, the EPA continued to strengthen the EPA system by initiating a follow-up programme. Throughout this period, migration into the cities continued apace and the demand for urban dwellings and

workplaces continued to boom. High-rises increasingly represented a way of balancing high urban population densities with expensive land prices. In an effort to forestall some of the worst environmental damage caused by high-rises, some of the bigger cities began to insist on them submitting to an EIA examination. Thus, during this phase, both central and local governments were actively seeking ways to legalise the EIA system. By the end of 1994, the EIA Act came into law and the legal groundwork was almost complete. Indeed, this Act was selected by Taiwan's environmental protection groups as one of its top ten news items (Liu 1995, p.62).

Once the Act became law, the Executive Yuan announced at the end of '95 how its terms should be implemented so that the EIA system could operate smoothly. Its coverage was also extended from the original three development types to 16 categories. The central EPA and local environmental agencies al set up EIA committees to conduct reviews, borrowing some of the procedural practices used in Europe and the US. In 1997, review guidelines were issued by the SEA, and the "3 Ps" (Policy, Plan and Programme) were incorporated into the EIA system's targets. In December 1997, a conference on globa climate change was held in Kyoto, Japan which reached several agreements to reduce CO_2 emissions. I 1998, Taiwan responded by calling a National Energy Meeting which resolved that assessing the CC emissions of all major development proposals would be included in the EIA's scope (Central Daily News 1998, p.3).

E. 2 THE FIRST PHASE (PRE-1980): THE GERMINATION OF THE EIA CONCEPT

A concern with environmental protection only began to emerge in the '70s; prior to this there were fe laws (or policies, since the two tend to go hand-in-hand) regulating levels of pollution or advocatir management of the environment (Cou 1993, p.22). Until 1980, economic development policies we paramount over all others; the government spared no effort in improving economic growth, enhancir export trade and raising national living standards.

Environmental policies were neglected both by the government and by the general public, though - drawing on the US's establishment of an EIA system in 1969 - by 1975, Taiwan EPC had started to float the idea by publishing an outline of the EIA concept in Free China's Industry[2]. As mentioned earlier, the Chinese Engineers Association first discussed the concept in 1976 at a seminar on Modern Industrial Techniques and, by 1978, a committee of the Executive Yuan had decided to promote the EIA idea. However, at this early stage, the EIA was viewed as a set of scientific techniques rather than as a holistic approach to environmental protection. In order to understand how it began to evolve into the more rounded framework that is evident today, we need to examine the shifts which occurred in Taiwan's political, economic and social environment during this first phase.

E.2.1 National Economic Policy Development

Taiwan is a 36,000km2 island in the Pacific Ocean off the Southeast coast of mainland China. It is mountainous - over half its area is hills and mountains over 500m high (See FIG. E-1).

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[2] "An Introduction to the US's EIS System", **Free China's Industry**: 44: 6, pp. 19-25 December, 1975. This was the first article to appear on Taiwan's nascent EIA system.

FIG. E-1: Map of Taiwan

A Japanese colony from 1895 to 1945, Taiwan's economy was thoroughly entwined with Japan's and was subject to the colonial policy of "industrial Japan, Agricultural (Material) Taiwan" such that each economy relied heavily on the other. For instance, Taiwan's Peng Lai rice and cane sugar was exported to Japan while other Japanese products were imported. When Taiwan was recovered in 1945, its economy was separated from Japan and became part of China's. However, by 1949, Mainland China was controlled by the Communist Party so Taiwan's economic basis suddenly turned from a colonial one to an independent island economy. Losing its original backing, the economy quickly entered a period of turmoi (Lee et al. 1987, p.9).

In order to stabilise affairs so as to encourage industrial development, Taiwan accepted economic aid fron the US between 1951 and mid-1965, averaging c. $100m over those 15 years with an average amount pe capita of c. $10 annually. In the 1950's, Taiwan's annual exports only came to $120m so US aid wa particularly helpful in balancing imports and exports (Lee et al. 1987, p.24). Much of the aid monie (37.3%) were invested in infrastructural development which accelerated Taiwan's economic development.

Between 1949 and 1980, the number of Taiwanese agricultural and industrial products grew rapidly an

the structure of the economy altered. In 1952, agricultural products accounted for 35.9% of Taiwan total production while industrial products only accounted for 18%. By 1980, the balance had shifted: industrial products accounted for 45.3% and agriculture products had fallen to 9.3%(as figure E-2).[3]

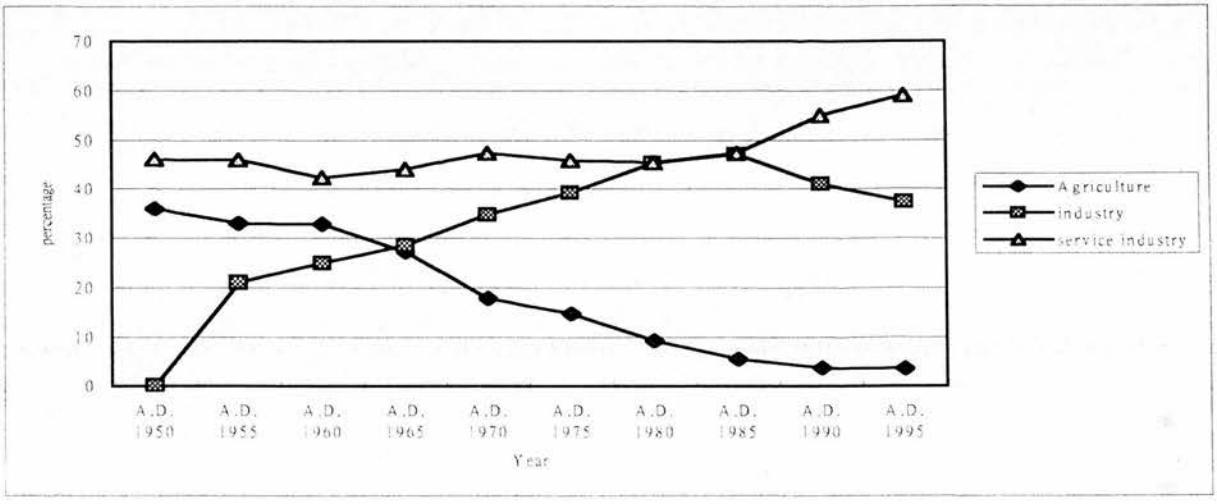

FIG. E-2: Changes to Taiwan's Industrial Structure (1950-1995)

As the balance shifted, the number of agricultural workers dropped rapidly. In 1952, 56.1% of those employed worked in agriculture; by 1980, only 19.5% did so. As these workers moved into other rapidly-growing industries, unemployment was never a significant problem.

Rapid industrial growth also brought with it a demand for land to be put to commercial use. In particular, manufacturing industry needed more space. As the economy's leading sector (in 1952, it accounted for 60.2% of Taiwan's industrial base rising to 75.2% by 1980) with a huge manpower requirement, most

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[3] In 1963, industrial products (at 28.2%) overtook agriculture (26.7%) for the first time. This was the turning point in Taiwan's economic pattern. See Lee et al. Economic Development in Taiwan (Taipei, 1985), p.39.

labour-intensive factories were located in city suburbs. To encourage factories to purchase machinery and manufacturing sites, the government promoted an investment package to develop 61 industrial parks, covering 9,536 hectares (CEPD 1996, p.68). However, as there was no regional planning prior to 1983, the distribution of population and of industrial activities was extremely uneven. Urban development concentrated at the north and south of Taiwan.

Under Kuomintang (KMT) rule, the emphasis was on economic development and social stability. From 1952 to 1980, average annual economic growth reached 8.9% (see FIG. E-3). Growth in the '60s was extremely fast, averaging 9.53%. The '70s also averaged 9.70% growth despite the slowdown of 1974 and 1975 (i.e., the time of the two global energy crises) when the rate only reached 1.12% and E.24% respectively. By the end of that decade, annual economic growth was topping 10%.

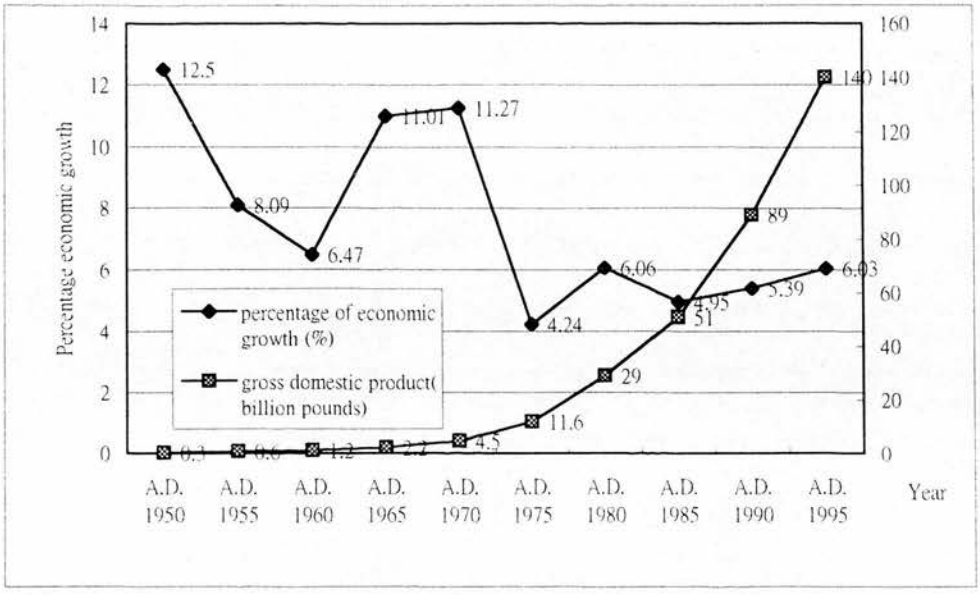

FIG. E-3: Taiwan's Economic Growth (1950-1995)

When the central government retreated to Taiwan in 1949, its overwhelming imperative was to raise living standards and strengthen Taiwan's ability to counterattack Mainland China so no effort was spared to spur the economy forward. Until 1980, economic development meant everything: the ex-president Chiang, Kai-Shek stated in *China's Fate* that 'the economy is not only the main point of development but the premise for all development' (Lee et al. 1985, p.109). From 1953 onward, a series of four-year economic development programmes were set in motion to advance Taiwan's infrastructure in terms of its railways, motorways, airports, harbours, transportation facilities, telecommunications and postal service networks.

During his term as Premier of the Executive Yuan, Chiang Ching-Kuo announced 10 important construction projects. All had obvious environmental implications: six of them addressed traffic facilities[4], three, heavy chemical industries, and the tenth was the construction of a nuclear power plant.

[4] The 10 projects included Chun-shan motorway, the electrification of the west line and north line railways, Taichung and Su-Ao harbours, C.K.S. international airport, and a steel mill, shipyard and

The last to be completed was the north line railway in 1979. All the others were finished before 1978 despite the fact that they were constructed during the mid-'70s when the global economy was in recession as a result of the energy crises and private investment funds were consequently in quite thin supply.

While the 10 projects were under construction, the government judged that Taiwan's economic development was better than expected and so, in 1977, announced a second wave of 12 major projects, worth more than £8 billion. With the exception of three agricultural programmes, all were set to have significant impacts on the environment.[5] The government hoped that these additional 12 projects would stimulate economic development and turn Taiwan into a modern nation.

As we have seen, the main goal throughout this great effort was national economic development. And, indeed, the stategy worked: the development of the industrial areas, the simplification of procedures tc establish factories, and the major infrastructural construction projects stimulated growth to over 8%. As Taiwan transformed itself from an agricultural to an industrial economy, its foreign trade between 195: and 1980 grew by 131% and the value of its foreign exports by 170%. This rapid growth in trade furthe stimulated national economic growth.

The early strategy for Taiwan's industrial development was to use imports as an alternative to indigenou industry until the 1960's when export trade expanded swiftly, production scales were raised and th number of sources and parts hugely increased. By the 1970's, the government had decided to develop th heavy chemical industries. Consequently, the construction of petrochemical factories and steel mills wer amongst the first and second waves of major developments announced by the government. Though th

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petrochemical factory.

[5] These projects included expanding a steel mill; building the second and third nuclear power stations; constructing a circum-coastal railway network; building three cross-island motorways; starting a new town project; and the second and third stages of building Taichung harbour.

heavy chemical industries consume a great deal of energy and produce significant levels of pollution, they were still favored by government and public alike because, at that time, economic development was the over-riding goal.

In July 1972, the Biological Science Research Centre and the Residential and Urban Research Centre of Tung Hai University held a seminar on "the Environmental Problem", marking Taiwan's first academic discussion of environmental issues. As a result, Tung Hai University established an Environmental Science Research Centre which held summer courses on Environmental Science, in particular aiming to tackle the problem of pollution. In October 1973, the lawyer Huang Shih-Ying addressed parliament on damage being done to the natural environment. This was the first time that Taiwan's congress heard concerns being raised about the lack of any environmental protection measures (Chang 1991, p.114).

E.2.2 The Gradual Acknowledgement of Environmental Problems

As a consequence of the pursuit of rapid economic growth, environmental problems gradually began to become apparent. In the 1950's, a particular clause of the land law was invoked to reform land use and protect farmland. Clause 30 stipulated that the ownership of private land could only be conferred if the owner guaranteed that the land would be cultivated, i.e., farmers were the only people who had the right to obtain farmland. Yet, as industrial development and the export trade boomed, thousands of mainly small- and medium-sized factories opened in Taiwan; by 1980, there were 60,277 of them. Acquiring land for industrial use was extremely difficult because of Clause 30, so many investors built factories without having permits. These illegal factories were scattered on the outskirts of big cities and along main roads. For example, Taichung (Taiwan's third largest city) had 4,320 of them in 1980.[6] (Actually, their belt-like scattering subsequently shaped how new road constructions and infrastructural developments were

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[6] Taichung City Government, Report of Industrial Park Planning for the Fourth Area Taipei, 1992, pp.1-5.

decided on.) Both agriculture and the environment were affected by the growth of this kind of factory: on the one hand, fertile land was being illegally occupied and, on the other, the uncontrolled spread of factories without operation permits degraded living conditions and blighted the natural environment.

In 1960, the Investment Encouragement Regulation came into effect. Its Rule 29 established that those intending to establish or expand an industrial firm could rent or buy private farmland for that purpose. While this regulation solved the problem of how new factories were to legitimately acquire industrial sites, the earlier scattered and unplanned history of land use on the outskirts of the cities left a legacy of residential, commercial and industrial sites sitting side by side. Factories were typically surrounded by the homes of the labourers who worked in them and adjacent businesses sprang up to provide their daily necessities.

In this unplanned way, Taiwanese cities grew. By 1980, 72.2% of the population lived in urban areas; the scatter areas of the factories spread out as far as 4,009 hectares. Urbanisation, together with the characteristic mixed use of land, gradually led to a situation where public facilities were clearly insufficient and the living environment inferior. Meanwhile, the lack of regional planning[7], meant that both population and industry concentrated at the northern and southern ends of Taiwan and the problems of over-crowding, traffic congestion, poor public amenities and an unhealthy environment were most marked in these areas. Above all, over-crowded city life spelled social isolation and the disintegration of traditional family ethics.

During the 1950's, Taiwan natural increase in population was running at 3.5%, due to the traditional view that having more children brings more luck. In 1950, Taiwan's population density was 210 people per m

[7] Regional planning in Taiwan emerged in 1983 and 1984; Taiwan's regions are divided into North, Central, South and East.

By 1960, that had risen by 43% to 300 people per m2 and by 1970 to 408 - an increase of 95% over the 1950 figure. As Table 1 shows, the population doubled in 20 years.

Table E-1 Taiwan's Population Index (1950-1980)

ear	Total pop. (person)	Pop. density on total area (persons/km^2)	Annual growth rate %	Natural increase rate(%)
950	7,554,399	210		
960	10,792,202	300	4.3%	3.51
970	14,675,964	408	3.6%	2.83
980	17,805,067	494	2.1%	97.00
990	20,352,966	565	1.4%	1.14

Data Source: EPA, 1997a, p.21

Since 1960 the government have been promoting birth control to help lower the birth rate. This fell from 3.51% in 1950 to 2.82% in 1960 to 1.97% in 1970. Although the birth rate has dropped significantly, the total population still increases each year owing to the low death and emigration rates. Taiwan's population has increased from 7.5 million in 1950 to 17.8 million in 1980, i.e., over a 30 year span, it had grown by 10 million, or one million extra per three years. By 1980, the population density was 494 people per m2 - 2.4 times that found in the UK. In addition, the amount of usable land per Taiwanese citizen is only 40% of that available per British citizen. When we deduct Taiwan's mountainous terrain, we see that the Taiwanese do not have abundant land resources.

Thus, high urban population density coupled with unplanned use of land left city-dwellers living in an increasingly deteriorating urban environment. Meantime, land prices were soaring so illegal building increased rapidly to meet the demand for residential space. As there were no planning laws in Taiwan relating to building in rural areas prior to 1973, buildings simply sprang up along the main roads - homes,

shops and factories all mixed together. In 1980, there were 4,350 illegal buildings in Taichung alone.[8]

In 1960, due to the over-crowded cities and limited land space, the average domestic floor area per capita was only 7.6m2. However, by 1975 this had increased to 13.5m2 and by 1980 to 16.8m2. Although living space did improve, many homes are still located in illegal buildings and some even occupy land designated for public use. For example, Taichung City Stadium (the country's second stadium) is home to 752 households.[9] Illegal buildings on public land have reduced the usability of parkland in Taichung from 0.7m2 per capita in 1940 to 0.2m2 in 1980 (Hsiao, 1991, p.102). On this evidence, we can easily picture the increased urban population, illegal residences, insufficient parkland and confined domestic space of the time. Although national income was rising rapidly every year, it was at the price o environmental quality.

Pollution was becoming a serious hazard what with the concentrated population, the thousands of factorie and the millions of cars. The levels of TSP in the air (measured as ug/m^3) massively exceeded air qualit standards; in 1970 the level was as high as 250.3 ug/m^3 and in 1980 216.1 ug/m^3[10]. Compared to the U and Japan, Taiwan's situation was indeed bad. In 1980, dust fall reached 11.5 tons/km^2/month and th haze coefficient (COHS/1,000 ft.) was 1.5 (Lee et al. 1985, p.104).

These indices demonstate inferior air quality, especially in the vicinity of city-based factories. I Kaohsiung, for example, with its many petroleum, pharmaceutical and cement factories, the TSP level i 1980 reached 332 ug/m^3; dust fall 19.8 tons/km^2/month; and the haze coefficient was 1.4. The gener

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[8] Taichung City Government, "Dismantling Illegal Construction in Taichung" (Taipei, 1991), pp.1-6.

[9] This stadium is the Taiwan Provincial Stadium located in Taichung and is sited on land that used to l water-source parkland in earlier times. Its east side is occupied by people living in illegal buildings.

[10] The national standard for TSPs is 140 ug/m^3. Japan's standard is 100 ug/m^3 and the USA's 75 ug/m^3.

health of ordinary city-dwellers could not remain unaffected for, by 1980, there was an average of 1.7 factories per square metre. Taichung, for example, averaged 24 factories per m2 and Kaohsiung 22. To this picture we may add the congestion, noise and pollution of traffic: in 1980, there were 5,413,407 vehicles in Taiwan - an average of 151 vehicles per square kilometre.[11]

Water quality was another issue of growing concern. Both sewage facilities and pollution prevention equipment in factories were insufficient. Pre-1980, municipal sewage and factory effluent was not properly handled before draining into rivers, resulting in serious pollution of Taiwan's waterways. In 1980, it was estimated that 38.9% of Taiwan's total river length was contaminated, 15.6% seriously and 23.3% lightly or moderately. The contamination of some rivers adjacent to urban centres (e.g., Pei-Kang River) exceeded 90%.

As we discussed earlier, environmental protection did not seriously figure in Taiwanese economic planning at the time. Heavy industry was promoted which accelerated pollution levels even as it brought wealth; huge investments were made in transport and communications infrastructure but little in waste water treatment plants. Indeed, the popularisation rate of sewage in Taiwan at the time was only 3%; most domestic effluent drained directly into the rivers. Inevitably, instances of hazardous environmental damage occurred: in 1965, sulphur dioxide escaped from the Tungnan chemical factory in Kaohsiung poisoning many teachers and students; in 1970, the chemical haze pollution in Hsinchu and the broken oil tank in Kaohsiung polluted fisheries and seawater.

E.2.3 The Gradual Emergence of an Environmental Policy

We have already seen how the 7th term of the Economic Development Plan assisted industry in buying up

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[11]Of this total figure, cars accounted for 821,860 (an average of 23 cars per square metre) and scooters 4,591,547.

farmland for factory use through a mix of tax incentives and equipment investment aid packages. However, the idea of regional land planning had not yet emerged and a series of scattered industrial zones was the result, all fighting for space cheek-by-jowl with farms and homesteads. In raising the economy by the boot-straps, factories were established in the shortest time possible so as to encourage investors to commit to more and more production. In this context, environmental planning and ecological protection were seen as stumbling blocks, if they were indeed acknowledged at all by government, investors or the public alike; factories meant work and wealth and were welcomed by all.

Throughout the 1950's, Taiwan's unfavourable balance of international revenue and expenditure was not attractive to financial investors and changes in US aid policy did not help matters either. To attract capita for industrial development, the government introduced tax reductions on manufacturing equipmen although pollution prevention equipment was not one of the items that was tax deductible. By 1980 however, the Investment Encouragement Regulation was amended to encourage enterprises to purchas anti-pollution equipment by reducing tax payable on it for, by then, pollution was starting to become political issue.

To maintain the safety of drinking water, the government introduced the Drinking Water Contr Regulation in 1972 - the first of Taiwan's laws on environmental quality. Later, laws pertaining to a pollution, water pollution and the treatment and disposal of waste were also introduced. However, aft such a long period of neglect, Taiwan's natural environment was already seriously compromised. I Section 2.1, we noted the extraordinarily high levels of TSPs and dust fall in the atmosphere in 1980 an the extent to which Taiwan's rivers were contaminated. What was beginning to be at issue now was n the destruction of the environment per se, but the threat that that presented to public health.

The pollution generated from industrial output had by now exceeded the environment's ability to puri

itself. Instances of pollution-related disease, damage and death occurred routinely. In 1978, hydrogen cyanide escaped from the Chinese Petroleum Corporation's propylene factory in Kaohsiung, killing one person and injuring over 200 others. The Taipei Water Pollution Prevention Institute collected samples from Houchin River and found its cyanide content to be alarmingly high (the sample with the most cyanide was 250 times higher than standard). At that time, many livestock farms were based downstream of Houchin River and the contamination was serious enough to threaten food safety. In 1980, a chlorine leak from the Jenwu factory of the Formosa Plastics Corporation hurt over 400 people in Kaohsiung.[12] These accidents were all caused by the inadequacy of anti-pollution facilities, the improper disposal of waste, and the fact that factories sat on the very doorstep of people's homes.

By now it was becoming apparent that public health and well-being was under threat from the several cases of industrial pollution which were starting to surface. By April 1979, the Taiwanese Environmental Protection Programme was instigated. This programme aimed to prevent pollution and to promote environmental hygiene using the slogan 'Everyone is responsible for protecting the environment'.

E.2.4 Environmental Legislation Aimed at Hygiene and Health Care

The urgency of economic development pre-1980 was such that the government adopted a 'one pole development' strategy: everything, from democracy to regional planning to environmental management were made subservient to the imperative of economic growth.[13]. Decades later, the environment was wreaking its revenge. For example, as hillside forests were destroyed, soil was being eroded: in one serious case of consequent flooding in August 1959, severe losses were sustained. Recognising the importance of forest preservation, the government announced a law on national parks in 1972, specifying that areas of especial natural beauty or utility should remain free of arbitrary development, though it was

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[12] EPA, Environmental Information on Taiwan, Taipei, 1995, p. 414-443.

[13] Hung, A Study of Taiwan's Environmental Law, (Taipei: Ye Ta Ltd, 1994) p. 39.

1980 before the first national park was declared.

The quality of drinking water was sometimes at issue and the pollution of underground water threatened public health.[14] According to the Taiwan Water Corporation, 77% of its water came from ground water sources (EPA 1995, p.122); with the rate of river pollution running at 38.9%, public health was at risk. As we saw, the Executive Yuan announced drinking water control regulations at the end of 1972, but these only addressed the safety of drinking water rather than the whole issue of waterborne pollution for the notion of environmental protection had been yet been conceived.

By 1978, solid waste was reaching 6,605 tons per day. At least some of the waste was not being disposed of properly, polluting water courses even further. While some steps were taken to prevent pollution - for instance, the Water Pollution Prevention law (1974), the Cleaning and Disposal of Waste law (1974) and the Air Pollution Prevention law (1975) - the aim of environmental regulations was to safeguard public health against the inadequacies of industrial pollution prevention facilities. Table E-2 lists the environmental regulations issued by the government pre-1980, and their enactment suggests the slow but growing realisation of the seriousness of the environmental problem Taiwan now faced.

Table E-2: Environmental Laws Passed in Taiwan Pre-1980

Title	Date of proclamation	Purpose of legislation
National Park Law	June 13,1972	Prevent deforestation to protect soil and w
Regulations on Drinking Water Control	November 10, 1972	Prevent water pollution to protect public h
Law on Water Pollution Prevention	July 11, 1974	Prevent pollutants being emitted direc rivers.
Law on Cleaning and Disposal of Waste Material	June 26, 1974	Dispose of waste to prevent secondar pollution.
Law on Air Pollution Prevention	May 23, 1975	Prevent pollution to maintain public healt

[14] In 1980, c. 71% of the population used tap water but the remaining 30% still used underground water c

Despite the passing of these laws, their enforcement was not particularly effective and the terms of two of them (on water emissions and air quality standards) were challenged and debated until 1991. Furthermore, the law on air pollution only applied to certain areas deemed by the government to require attention. As a result, only a few cities were made subject to its terms. Huang (1994, p.33) describes these laws as 'unwholesome legislation and bad enforcement'.

Environmental hygiene and health protection were the key-notes for environmental policies during this period. By 1980, it was clear that this stance was inadequate. The booming industrial economy was pumping out ever more pollutants and instances of environmental disasters and accidents were common news.

E.2.5 Administrative Changes in Environmental Protection Authorities

Throughout this period, Taiwan was under martial law: the government had absolute power over the drafting of policies and this task was undertaken by bureaucrats who also held the prevailing view that economic growth was everything. Table E-3 shows that, in addition to the Ministry of Economic Affairs, there were more than 10 committees in charge of economic affairs. In contrast, environmental divisions were housed only within the Department of Health; integrated environmental organisations were very rare.

Table E-3: Comparison of Economic Development Organisations and Environmental Protection Organisations in Central Government Pre-1980

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other water sources.

Economic development	• the Ministry of Economic Affairs, the Ministry of Finance • Council for Taiwan Production Business Management (incorporated in ESB in 1953) • Council for U.S.A. Aid Application, the Executive Yuan (incorporated in CIECD in • Council for Industrial Economic Cooperate and Development (CIECD, founded in 1 • Economic Stabilization Board (ESB, founded in 1953 and dismissed in 1958) • Financial & Economic Commission, the Executive Yuan (founded in 195 incorporated in ESB in 1958) • Research Team for Industrial Development and Investment (founded in 1959) • Economic Planning Council (EPC, transformed from CIECD in 1973) • Five Person Financial & Economic Team (transformed together with EPC into C 1977) • Council of Economic Planning and Development • Foreign Trade Development Association (founded in 1970) • World Trade Center Promotion Team (founded in 1980)
Environmental protection	• Department of Health, the Ministry of Interior • Department of Health, the Executive Yuan (transformed from the Department of the Ministry of Interior, in 1971) • The Seventh Team in Industrial development Bureau, the Ministry of Economic (waste gas prevention) • Water Resource Planning Committee, the Ministry of Economic Affairs (water p prevention)

Organisational changes to bodies charged with administering environmental regulations occurred in two phases pre-1980. Pre-1971, at central government level, the Health Department was established within the Ministry of the Interior to handle the prevention of infectious diseases, environmental hygiene and health care facilities. At the local government level, the Taiwan Environmental Sanitation Institute was established in 1955 to handle the safety of drinking water and effluent, and rubbish disposal and treatment. In some cities and counties, subsidiary sections of the Health Bureau handled sanitation issues. The focus of all these disparate organisations was the management of environmental sanitation (see Table E-4).

Table E-4: Organisational Changes to Environmental Protection Institutes Pre-1980

Time	Before 1971	1971 to 1980
Central government	Department of Health, the Ministry of Interior	Administration of Health, the Executive Yuan
Local government	Health Department, Taiwan Province Taiwan Environmental Sanitation Institute (1955) Environmental Sanitation Department, Taipei City Subsidiaries of the Bureau of Health in each city/county	Taiwan Health Department Taiwan Environmental Sanitation Institute Water Pollution Prevention Institute, Taiwan Environment Management Department, Kaohsiung City Subsidiaries of the Bureau of Health in each city/county

The second stage lasted from 1971 to 1980. In central government, the Health Administration in the Executive Yuan was set up in March 1971. Within it, the Environmental Health Department took charge of environmental sanitation, waste disposal and pollution prevention. Some affairs remained within the Health Department in the Ministry of the Interior (before 1971) and others were the responsibility of different departments. For example, noise pollution was handled by the Department of Police Administration; water pollution by the Water Resource Planning Committee of the Ministry of Economic Affairs; and air pollution by the Industrial Development Bureau of the Ministry of Economic Affairs. There was no one integrated institute to handle all environmental problems.

In view of this, the Research and Development Commission of the Executive Yaun suggested in 1977 that Taiwan should emulate the environmental administration systems operating in advanced nations and establish a dedicated Environmental Protection Department within central government (e.g., an Environmental Protection Administration or Environmental Protection Bureau). In 1980, when the Executive Yuan announced the Taiwanese Environmental Protection Programme, one of its aims was to establish environmental protection authorities. By now, the government had recognised that environmental protection was best handled by a single department rather than being apportioned over various departments. Equally important, environmental protection was now seen to encompass more than environmental hygiene; it also meant the prevention of pollution and ecological preservation. Thus, the

Environmental Protection Bureau within the Department of Health was established in January 1982 and a national environmental policy was finally en route.

E.2.6 The Introduction of the EIA

By 1969, the US had passed a National Environmental Policy Act (NEPA) which initiated its EIA system whose terms gradually changed from post-hoc remedial action on pollution to a concern with early prevention. As mentioned earlier, the EIA concept was first aired in Taiwan in December 1975 by the EPC (the predecessor of the CEPD). By that time, the US's EIA system had been operating for more than five years and experience in its use was starting to accumulate. However, even then Taiwanese engineers were interested in it primarily as a set of engineering techniques rather than as a method for managing the environment. Nevertheless, by 1978, as Taiwan gradually became more familiar with the concept and evidence of its results began to filter in from other nations using it, the Environmental Pollution Team in the Executive Yuan suggested that Taiwan should start implementing the system as soon as possible. A pilot scheme was announced in 1979 and this was an important milestone for by then the EIA had been a subject of discussion amongst Taiwanese scientists for several years and the US had been implementing it for nearly a decade.

After this, the Executive Yuan required the Taiwan Power Corporation to submit an EIA report on each nuclear power plant in the country. However, as the EIA was still seen primarily as an engineering tool these EIA reports did not have to be examined or commented on by the Environmental Protection Department, unlike the operation of the system in the US. In the States, the EIA report was submitted to their EPA in the first instance and only later sent to CEQ or the President in disputed cases.

So although Taiwan had come to a common agreement on the EIA concept, the actual implementation of the system did not yet express the core function of the EIA. By 1980, the Executive Yuan had decided

start implementing the system and the process of its evolution moved to another stage, i.e., the preparation of EIA legislation. Table E-5 outlines the time-table of events relating to the introduction of the system in Taiwan.

Table E-5: The Development of the EIA System in Taiwan Pre-1980

ime	vent
March, 1971	Environmental Sanitation Department was established under the Department of Health to manage environmental sanitation.
December, 1965	EPC translated American EIA system and published it in *Free China Industry*, Vol. 44, issue 6. This was the first time the EIA concept was aired in Taiwan.
May, 1977	The Research and Development Commission of the Executive Yuan suggested the stablishment of an environmental protection bureau to take charge of environmental rotection affairs
1978	The environmental pollution team of the Executive Yuan suggested the EIA system be mplemented as soon as possible
May 17, 1979	The 1631 meeting of the Executive Yuan passed the scientific development project to stablish an EIA system and drew up implementation guidelines.
uly 1979	The first EIA was conducted by the China Engineering Consultants on the new Mid-Island Motorway proposal
March 4, 1980	When examining the 4th nuclear plant of the Taiwan Power Corporation, the Executive Yuan asked Tai-Power to present an impact assessment of each plant
April 1980	The Executive Yuan announced the Taiwan Environmental Protection Programme, indicating the establishment of an environmental protection authority.
April 11, 1980	The Minister without Portfolio of the Executive Yuan, K. M. Lee, chaired the Execution plan and negotiation meeting to promote the establishment of the EIA system' to find common opinion between departments
July 1980	Taiwan Province proclaimed the 'Promotion points of EIA by Taiwan province,' regulating the execution of an EIA when planning major construction projects
July 31, 1980	The 1692 meeting of the Executive Yuan passed partial major construction plans or constructions, which should conduct EIA process.

In conclusion, the 5-year period leading up to 1980 represents the gestation of the EIA concept in Taiwan. When the EIA system under NEPA was implemented in the US in 1970, each department neglected it or was reluctant to implement it. Only after the CEQ declared a series of instructions and after judicial review by the courts, did each department start to take the system seriously. Asian nations like Hong Kong, Japan and Singapore established an EIA system in 1972. By the time Taiwan introduced it in 1980,

10 other nations were already implementing it.[15] Although every nation adopted its own procedural details, the bones of the EIA system were now of global interest.

E.3 THE SECOND PHASE (1980-1990): THE PREPARATION OF EIA LEGISLATION

The period from 1980 to 1990 was the preparatory stage towards legalising the EIA system. An EIA demonstration project - Industrial Zones on The Northern Coast of Taiwan - was chosen in 1980 to demonstrate the feasibility of the system. The Environmental Protection Bureau of the Public Health Administration was established in 1982 and was made responsible for environmental protection issues. A draft version of the EIA Act was rejected by the Executive Yuan in July 1983 because of circumstance and a dearth of relevant experts, and an administrative order - the Programme to Strengthen the EIA - was chosen instead as the basis for progressing the EIA system in the country. An EIA was now to be conducted on 14 important development proposals and, by the end of that process, Taiwan had accumulated expertise in using the system and the public were gaining a better understanding of it as well.

During this period, the Environmental Protection Bureau of the Public Health Administration of the Executive Yuan was upgraded to the Environmental Protection Administration (EPA) of the Executive Yuan, making it the first institute of its kind directly accountable to the Executive Yuan. Between 1987 and 1988, various local governments set up their own EPBs. The EPA began the task of issuing technical manuals and guidelines on how to implement the EIA on different kinds of development project. The EPA was also nurturing its own expertise base by reviewing EIA reports on important projects.

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[15]Gilpin has noted when the EIA system became effective in different countries: USA (1969), Hong Kong, Japan and Singapore (1972), Canada(1973), Australia (1974), Germany (1975), France (1976), the Philippines (1977) and China (1979). See Environmental Impact Assessment London: Cambridge University Press, 1995, p.3.

Because there was still no law governing the EIA system, the process was conducted on important developments in terms of their being EIA demonstration projects and so the EIA process lacked teeth. For example, approval for given to the 5th and 6th light oil refinery projects before their EIA reviews were even conducted. Though experience was gained in its use through the auspices of the Stengthening Programme, the EIA was seen quite narrowly at the time as a system for inspecting anticipated pollution levels. In 1989, the EPA drafted a new version of the EIA Act which drew on its own direct experience and on the evidence of the EIA system's operation in other countries. This draft was accepted by the Executive Yuan and submitted to parliament for review in 1990, ending the second phase.

The most important change during this period was political in nature. Having been subject to martial law where political parties and periodicals were banned, Taiwan's political structure changed from 1987 onward. The change was gradual and amidst the slow upheaval, several local environmental protection groups sprang up. The general public's slogan became 'let's have a beautiful environment'

E.3.1 An Era of Social and Economic Change

Economic growth continued to be a prime objective during this phase too. However, Taiwan's economic development policies were adjusted to cope with international competition, to extend private investment and to rejuvenate the economy. As opposed to the stress placed on manufacturing industry which had characterised the previous few decades, Taiwan now looked to develop strategic high-tech industries such as computers, visual communications and automation products.

A science-based industrial area was established in Hsin Chu in 1981 for this purpose, for Taiwan was now keen to transform itself from a labour-intensive industrial nation to a "brains-intensive" one. Upgrading regulations aimed at promoting new kinds of high-tech industry were announced in 1982 in a context where Taiwan's service-based industries were going from strength to strength as a result of

industrialisation, urbanisation and a general rise in the standard of living. Looking at FIG. E-2 above, we can see that agriculture as a proportion of Taiwan's total productivity continued to fall in this decade; by 1990, it represented only 3.5% of GDP. After peaking in 1986 at 47% of GDP, the industrial sector alsc started to fall, accounting for 41.1% by 1990. Meanwhile, the service industries were on the up: 47.2% oh GDP in 1980, rising to 50% in 1989 and 55.1% in 1990.

As the industrial structure evolved, the trend towards urbanisation increased even further. By 1990, 76% o the population were city-dwellers who occupied only 12.1% of Taiwan's total land area at a density o 3,549 people per square kilometres. The increasing density of the urban populations led to a tremendou spurt of development on suburban hillside sites. Between 1980 and 1990, 416 hillside developmer projects went ahead over an area of 5,544.03 hectares[16], and all had impacts on the urban environment.

This decade saw a huge level of change in the political arena. In 1986, martial law was lifted by the la President, Ching-Kuo, and the establishment of political parties, movements and media was now permitte With the declaration of the national security laws in 1986, Taiwan had reverted to constitutional contrc Opponents of the Kuomingtang (KMT) pushed to form a new political party - the DPP (Democrat Progress Party) - which was established in September 1986and which[17], by the end of that same year, hi won 22% of the vote for the Legislative Yuan. Thus, competitive party politics asserted itself in Taiwan

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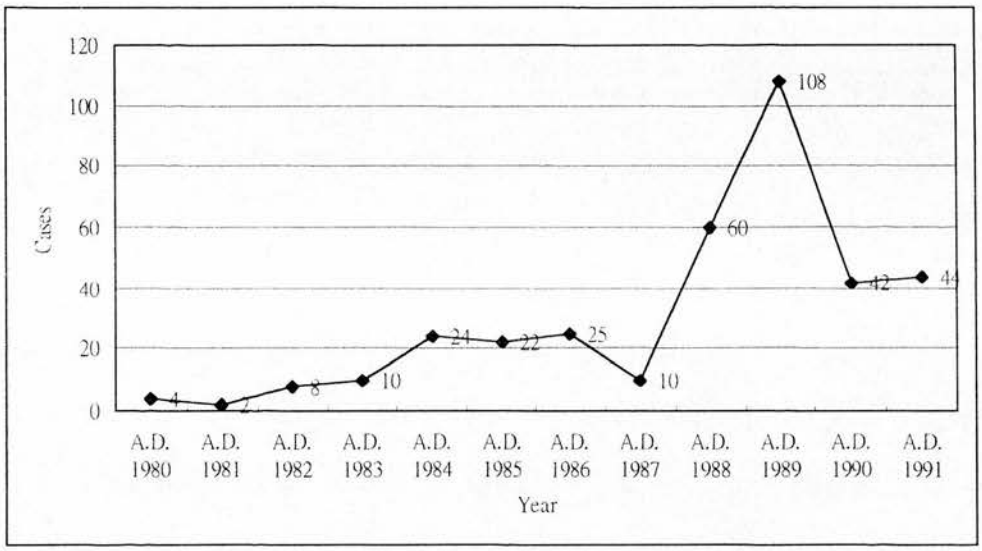
[16] The Construction Management of Hillside Developments was announced in 1983. Of the decade's 41 projects, residential buildings accounted for 1,604.5 hectares; schools 129 hectares; golf courses 2,941.1 hectares; and other constructions 662.0 hectares.

[17] Till the lifting of martial law, opposition parties were officially banned. However, the DPP had bee forging alliances with anti-KMT factions since the late 1970's and had emerged as an important politic force prior to its legal establishment. Indeed, in 1986, when it declared itself as a party it was dor without formal permission.

[18]Taiwan has two Yuans: the Legislative Yuan and the National Assembly, the former being mo important in the political arena. The Legislative Yuan legislates for and supervises the Executive Yua i.e., central administrative government. The Legislative Yuan was not completely reelected till 1992.

The opposition party frequently participated in environmental protection movements which increased the frequency of anti-pollution demonstrations.

As the political and economic structure changed and the standard of living rose, the environmental issue began to really find its voice. Whereas there had been only five environmental protection demonstrations pre-1980, the '80s saw 311 occur (see FIG. E-4). The lifting of martial law was what opened the floodgates. From 1980 to 1987, there were 101 but this rose dramatically by a further 210 in the next three years (1988-1990). This decade was the period when the environmental protection movement went from



"bubbling to boiling" (Hsiao 1994, p.554).

FIG. E-4: Environmental Protection Demonstrations in Taiwan (1980-1991)

The number of environmental protection movements steadily grew during this period; 30% of them were concerned with the treatment of rubbish and 70% with pollution from industrial manufacturing. As a result, the environmental awareness issue in Taiwan was characterised by a concern with pollution and

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1987, a supplementary election for the Legislative Yuan was held.

public nuisance which resulted from the pell-mell rush towards economic growth. More than 90% of Taiwan's environmental protection movements were of the kind that protested after the event. Very few aimed at prevention, though it has to be said that the largest controversial developments (e.g.,the 4th nuclear power plant and the 5th and 6th light oil refineries) faced strong opposition even as they were being installed.

In sum, this was a decade of dramatic social change; popular movements flourished, street demonstration boomed. Amidst this change, the environmental protection issue emerged as a pivotal mainstream socia movement. It was an issue that was in tune with the re-direction of the economy towards high-tech, low pollution, energy-saving IT and communications industries. It also co-incided with Taiwan's growin wealth and the confidence that that bestows upon a nation. The economic growth rate was over 6.0% mos of the time and GDP increased from $2,669 per capita in 1980 to $8,111 in 1990 (see FIG. E-3 above). A GDP accreted, an "excellent living environment" was called for.

E.3.2 Growth in Environmental Awareness

Before 1980, the concept of environmental protection was restricted to maintaining public hygiene and health. Tung Hai university's 1972 seminar on the environment, mentioned earlier, was an unprecedented example of academic discussion on the topic. Yet by May 1978, the volume of dust fall at Soong Shan Elementary School in Taipei reached 22.44 tons per square kilometre and as many as 70% of its staff and pupils were suffering from respiratory problems. This discovery focused the general public on th seriousness of Taiwan's pollution problem.

Throughout the '80s, general awareness of the environmental crisis rose rapidly, aided by the formation o several environmental protection groups and spurred by several alarming discoveries. For example, i April 1980, an investigation revealed that the average pH value of rainfall in Taiwan was 4.2 (a sign o

acidity). It was confirmed that Taiwan was the fourth country to be threatened by acid rain.[19] This finding shocked both the government and the general public alike, and grass-roots anti-pollution protests began to flourish.

In 1985, a resident of Taichung County established " Love My Village: Public Nuisance Defence Groups" which was a pioneering undertaking for private organisations to co-operate in halting public hazards. The locals of Hsin Fong village in Hsin Chu County demonstrated outside Baker Chemicals Co. against its poisonous water and air emissions, forcing the factory to stop production and move to another place. In 1986, about 600 people from Kaohsiung and Ping Tung Counties assembled at the Da Fa Waste Hardware Disposal Centre, Kaohsiung, to protest against the 'Dioxin Event' , which occurred from burning waste cables and wires. In 1987, the US Du Pont Co. was due to set up a titanium dioxide factory in the town of Lu Kang, Zhang Hwa County, but was forced to cancel because of local opposition.

These kinds of demonstration coupled with the formation of environmental protection groups and the growing interest of the mass media served to catalyse public awareness of environmental issues. The suspended construction of the 4th nuclear power plant and the cancellation of the Du Pont project were highly visible examples of how environmental protection was now clearly on the agenda in planning how economic progress could be achieved. From the '80s on, the topic was to become politically hot.

The extent of growing awareness can be shown in terms of statistics on satisfaction levels with pollution

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[19] This investigation was conducted by the Taiwan University's Graduate School for Plant Diseases and Insect Pests. This report indicated that Taiwan was the fourth country to be threatened by acid rain. See Cheng, *Research on Environmental Protection Policy in Taiwan and the US* Taipei, 1991p.45. However, according to Jacobs, *The Politics of the Real World* London: Earthscan, 1996 p.16, 22% of European forests have been damaged by acid rain in the last decade, giving us grounds to doubt that Taiwan was the fourth nation to face the threat of acid rain.

control measures: in Feb. 1980, 55.4% were satisfied; in April 1981, 43.5%; in Dec. 1983, 34.3%; and in Dec. 1986, only 26.1%.[20] What this reveals is that as people's awareness grew, their satisfaction with the management of pollution diminished. In addition, as Table E-6 shows, 70% of people polled in 1983 regarded the environmental problem as being very serious and almost half were pessimistic for the near future (i.e., five years hence). By 1986, 88% considered the crisis to be serious and 70.3% thought that matters would deteriorate over the next five years. Faced with this level of public dissatisfaction, the government set up a central environmental protection organisation in 1987 to coordinate the management of the problem.

Table E-6: Awareness of the Environmental Crisis in Taiwan (1983-1991)

Year	Very Serious/ Serious(%)	Not Serious/ Not Serious At All(%)	Don Know(%)	More Serious In Five Years(%)
1983	70.1	19.9	10.0	50.8
1986	88.0	7.6	4.5	70.3
1990	77.0	16.0	6.0	
1991	81.1	11.6	7.3	47.5

Data Source: Hsiao, 1993, p. 94

Though most of the population were by now concerned about environmental problems, there were many different viewpoints as to what were the most serious issues. Table E-7 shows that noise, air and wate pollution, over-population and the treatment of waste featured large in the public mind and the ranking o these top five topics did not change greatly between 1983 and 1986. That is to say, issues relating to th environmental quality of "home" were felt more sensitively by people than were the more seemingl remote problems of ecological preservation and resource depletion.

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[20]This data is taken from "Modernisation Research in Taiwan" conducted by the Research and Development Council of the Executive Yuan. See Chu, *Environmental Law Research* Taipei, 1995 p.55.

Table E-7: Cognition of Various Environmental Problems: Unit(%)

Item	1983		1986	
	Serious V.S. Not Very Serious	Rating	Serious V.S. Not Very Serious	Rating
1. Noise	85.6	2	72.6	3
2. Air Pollution	87.4	1	77.1	2
3. Water Pollution	78.9	4	65.2	5
4. Over-Population	82.1	3	78.5	1
5. Waste Treatment	67.7	6	65.5	4
6. Natural Disasters	20.0	11	39.3	9
7. Nuclear Waste	35.6	9	17.1	11
8. Soil erosion	51.1	8	41.1	8
9. Depletion of Natural Resource	54.9	7	46.5	7
10 Chemical Abuse	73.9	5	47.8	6
11 Insufficient Energy	33.7	10	34.8	10

Data Source: Hsiao, 1993, p. 95

As FIG. E-4 shows, the apex in the growth of environmental protection demonstrations came at the end of the '80s. By 1989, anti-pollution protests in particular had become a mainstream social movement (these protests accounted for 70% of the activity of environmental groups). The major targets were the petroleum and chemical industries and most of the anxiety and anger expressed concerned the forms of chronic pollution which could not easily be improved. Table E-8 lists the various kinds of environmental group in Taiwan.

Table E-8: Environmental Protection Groups in Taiwan

Environmental NGOs	Academic Groups	Anti-public Hazards & Pollution Group
1. Taipei Wild Birds Society	Environmental Protection Society	Public Nuisance & Control Soci
2. Housewife League of New Environmen	Environment Hygiene Society	County
3. New Environment Foundation	Public Hygiene Society	1. Public Nuisance & Control City
4. Nature Quarter Periodical	Hygienic Education Society	2. Public Nuisance Control So
5. The Dong Foundation	ROC School Hygiene Society	County
6. ROC Consumer Foundation	Ecological Preservation Society	Environmental Protection Societ
7. Foundation of Environment Quality	Taichung New Environment Promotion	3. Environmental Protection &
8. Taiwan Environmental Protection Leag	Engineering Environmental Protection	Prevention & Control Society
9. GreenPeace Workshop	Taipei Environmental Protection Societ	
	Green Environment Society	

Confronted with this kind of social pressure, the government not only established the EPA in August 1987 but on September 24th of that year, the former Prime Minister Yu, Kuo Hwa publicised the

Essential Points of Current Environmental Policies in Taiwan, in which the task of environmental protection was named as one of the most important policy areas for government.

E.3.3 Environment Policy: Control of Pollution as the Main Goal

The scope of environmental protection issues are extensive and their nature is complex. This decade saw a transition in understanding from a concern with hygiene to a much more tranchantly expressed concern with pollution control. As anti-pollution protests escalated, the government directed its environmental protection policies towards controlling pollution and managing public hazards.

The reason why pollution control constituted the practical connotation of environmental protection policy in Taiwan during this decade was that pollution could be - and was - directly and obviously perceived and it bore a close relationship to economic development. As Table E-7 shows, noise, air and water pollution etc. were the environmental issues the general public most wanted addressed, and their dissatisfaction with pollution control measures and their vocal and frequent protests against proposals such as the Du Pont project supplied the social context within which policy responses were conceived.

The Executive Yuan convened an economic conference in 1975. The consensus view on the second main issue was the statement that "because of rapid industrialisation and growth of the metropolitan population, air pollution, water pollution and waste treatment will become our most serious problems in the future. In order to maintain the environment, public hazards prevention and control need an integra plan which should be put into practice as soon as possible" (EPA 1989, p.4). Even then, the governmen had already sensed the importance of pollution control as a policy theme. In 1979, the Executive Yuan passed the Environmental Protection Programme in Taiwan; its purpose was to solidify the kind c organisation that could tackle the pollution issue. Based on this project, the Environmental Protectio Bureau of the Hygiene Administration of the Executive Yuan was established in January 1982. It wa

responsible for water and air pollution prevention/control, environmental hygiene, traffic noise control, environmental impact assessment and control of poisons.

Meanwhile, the Environmental Protection Group was set up in 1986 with the Deputy Minister as its convener. Its goal was to draw up integrated environmental policies and to coordinate the work of different departments. It was this group which drafted the Essential Points of Current Environment Policies in Taiwan in 1987. In August 1987, the government established the Environmental Protection Administration (EPA) under the Executive Yuan to develop national policies for the prevention and control of pollution, increasing its manpower to 284 from the original 124 (EPA, 1990, p.3). Ecological preservation was quite understandably ignored at the time by all except some scholars and experts. For example, the EPA's 'Blue Sky Plan' was for the prevention and control of air pollution; the 'Crystal - Clear River Project' for river pollution. However, a body of expert opinion was beginning to advocate the drawing up of a preliminary environmental protection law which would integrate ecological preservation with pollution control so as to offer more far-sighted guidance on the process of environmental policy-making.

Nevertheless, the general thrust of this decade was to concentrate policy efforts on responding to the public's demand for better controls over pollution, rather than become embroiled in the organisational nightmare of ecological preservation management. This situation can be fully understood by looking at the organisational diffusion of environmental protection items listed in Table E-9.

Table E-9: Departmental Responsibility for Environmental Protection Issues

Central Government	Responsibilities
Environmental Protection Group,	coordination of environmental protection policies
National Science Committee	technological research on environmental protection
Legal Codes Committee	legalisation of environmental protection
Government Information Office	Publication of environmental policies
Agriculture Committee	natural environment & ecological preservation
Atomic Energy Council	nuclear power
Construction and Planning Administration, Ministry of the Interior	urban planning; park management; sewage management
Water Resources Bureau, Min. Economic Affairs	water resources
Cultural Committee	preservation of cultures
Ministry of Transportation and Communications	noise control of roads & airports
Ministry of National Defence	pollution treatment of national defence facilities
Industrial Bureau, Min. Economic Affairs	pollution management of industrial zones
Ministry of Finance	tax-exempt review of pollution prevention/ control equipment
Ministry of Education	environmental education
Ministry of Law, Min. Economic Affairs	litigation of public hazards

As for ecological preservation, energy planning, water resource and land management etc., another set of organisations were responsible for them which was inefficient (Huang 1994, p.33). However, by the end of this period, ecological preservation was beginning to be emphasised by environmental NGOs. In March 1989, 45 groups initiated a Save The Forest campaign; their criticism was that the task of forestry preservation was not being handled well and that the ecological environment was being neither maintained nor valued.[21]

The costs of administering environmental protection continued to multiply after the inception of the EPE in 1982. The annual growth rate reached a peak in 1989 at 154.5% growth in expenditure. Comparing 1990's expenditure with 1983's, the growth rate was 630%, meaning that monies spent on the task increased six-fold within seven years (see Table E-10). After being overlooked for such a long time, the issue of environmental pollution was finally being attended to.

[21] China Times News, 13 March 1989, p.3, Taipei, Taiwan.

Table E-10: Growth of Expenditure on Environmental Protection

Year	Environmental Expenses (million)	Growth Rate
1983	2,563	
1984	2,516	- 1.8%
1985	3,681	43.5%
1986	4,452	20.9%
1987	4,982	11.9%
1988	12,666	154 %
1989	16,397	29.5%
1990	16,066	- 2.0%

Data Source: EPA, 1996, p.29

E.3.4 Environmental Legislation: The Legislative Process Lags Behind Social Change

In theory, democratic legislation is a product of expertise and public opinion which optimises collective decision-making and is arrived at rationally. However, in the real world, the legislative procedure and the content of laws do not necessarily reflect simple truth and public opinion; law-making is a process shaped by relatively static political, economic, social and cultural structures rubbing against dynamic developments. This contradiction between theory and reality most nearly accounts for how environmental legislation is passed in Taiwan.

First, there is the question of expertise. Expertise needs to be accreted gradually; it cannot be implanted directly. As the EPA was not even established until 1987, Taiwan's existing base of environmental protection expertise was relatively slender and was distributed across several relatively atomised organisations. Though the EPB had been in place for a number of years prior to the setting-up of the EPA, it only had 124 staff of whom 17.16% were non-professionals.[22] So, prior to 1987, there were only about 100 experts available to handle the tremendous demands of environmental protection work. Thus, the pace of the legislative process was slow, and the contents of possibly relevant existing laws simply

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[22] Before changing to the EPA, the EPB's administrative staff level was about 17.16% of its total. After 1987, this level fell to 15.77%. Administrative staff refer to those working in the Accounts and Personnel Departments. See EPA, *ROC Environmental Protection Almanac* (Taipei, 1987) p.14, 1990.

did not meet the circumstances of the times.

Second, legislation is also a product of public opinion, with congress acting as its collective voice. Therefore, legislative procedures in democratic countries need to be reviewed and examined by congress before they are passed and put into practice. Yet, in Taiwan, a general election for the Legislative Yuan was not held until 1992.[23] In this context, we find that the chronic disassociation between the people and the Legislative Yuan of the previous decades meant that public opinion was often betrayed or ignored, and very little was to be expected of environmental legislation at this point in Taiwan's political history.

As we know, the EPB was set up in 1982, to be replaced by the EPA in 1987. At the EPB stage of the evolution of the administration of environmental protection affairs, no specific plans for legislation were laid down though the efficiency and integrity of legislation was badly needed. The EPA era heralded aggressive attempts to draft appropriate legislation but, for the reasons mentioned at the opening of this section, their effectiveness was limited. As an interim measure, the Executive Yuan announced its Essential Points of Current Environmental Policies which included the following aims:

- to push forward legislation concerning the prevention and control of damage to the environment and conservation of natural, social and cultural environments;
- to establish environmental quality standards for each phase according to social demands and scientific evaluation;
- to delegate legislation to local governments so that more stringent standards of environmental quality and pollution control can be enforced;
- to establish an administrative system for managing mediation, arbitration and remedial courses of action; and

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[23] Before 1992, it was called the Legislative Yuan of the first term. Most of the legislators were re-elected but only some regularly faced the re-election process, called a supplementary election.

- to improve legal references to civil compensation, administrative regulations and criminal sanctions according to the characteristics of individual public hazards.

What these aims reveal is that the Executive Yuan wished the EPA to comprehensively review the administrative structure for preventing, controlling and redressing environmental damage with a view to establishing organised and systematic environmental laws. The EPA duly mounted a large-scale environmental legislation plan which aimed to finalise the establishment and/or amendment of legal codes within three years (1987 to 1990).

There were 59 kinds of legal regulation relevant to the environment. The status quo was clearly inadequate since 43 new laws would need to be passed and 16 existing laws would need to be amended. Unsurprisingly, the EPA did not manage to meet its own deadline; it only managed to achieve 22% of its legislative plans by the end of 1990. Table E-11 shows that 13 new or amended legal codes were in place by that time. Apart from the legislation governing the organisation of the system's administration, most of these 13 referred to the control of pollution. Preventative or remedial legislation was nowhere in sight as yet.

Table E-11: Environmental Legislation Achievement Rates

Expected Completed Time	Legislation Volume (case)	Actual Completion (case)	Achievement rate(%)
Dec. 31, 1988	24	4	17
Dec. 31, 1988	24	5	20
Dec. 31, 1988	11	4	36
Total	59	13	22

Note: The large-scale environmental plan was started in 1987

Of the legislation passed, the most notable were the laws on Wild Animal Preservation and the

Prohibition on Smoking in Public Places. As the concept of ecological preservation was still underdeveloped in this decade, these two pieces of legislation held a particular significance. The smoking law, in particular, not only reflected the efforts of Taiwanese anti-smoking lobby groups but also a global legislative trend. In general, however, the legislation lagged behind the felt need for change. For example, though we know from our earlier discussion that river pollution was serious (21 of Taiwan's major rivers were suffering some level of contamination), three legislative items relating to this issue remained undone. Or again, six legal codes relevant to ensuring the safety of drinking water continued to be stalled. Obviously, by the end of this stage, environmental legislation still had a long way to go.

In addition to the legislation on pollution which was still waiting in the pipeline, new legislation on natural and ecological preservation needed to be addressed. The powers to enact such legislation were widely scattered across the Ministries of the Interior, Defence, Economic Affairs, Education, Transport and Communications, Agriculture, Atomic Energy and Health and some of these departments were not well equipped to cope with the new demands being made on them.

E.3.5 The EPA's Role as Environmental Goalkeeper

As we saw, the EPA first emerged in 1987 from the ashes of the old EPB. With its new title and expanded remit, it consisted of eight divisions which were responsible for national environmental protection policy-making. Unlike the older EPB which had been located as a second-level division within the Health Ministry, the EPA was constituted as first-level department reporting directly to the Executive Yuan. The establishment of the EPA was a milestone in the promotion of environmental protection measures.

As Table E-12 shows, the regional EPBs of Taipei and Kaohsiung quickly followed on from the

establishment of the central EPB in 1982 and thereafter the second divisions of the Health Department in every city and county were transformed into local EPBs. See Figs. 6-5 and 6-6 (Chapter 6) for an outline of the structure of government in Taiwan and for the organisational structure of the Executive Yuan relating to environmental protection administration.

Table E-12: The Development of the Environmental Protection Administration

Date	Event
Jan. 29, 1982	Established EPB of the Health Administration
July 1, 1982	Taipei & Kaohsiung EPBs established
Aug. 9, 1983	Provincial Government combined Water Pollution Prevention Control Institute and Environmental Hygiene Experiment Institute to become EPB of Hygiene Department.
Sept. 26, 1984	The 2nd division of the Hygiene Bureau became a local environmental protection division in every city & county
July 10, 1986	The Executive Yuan established the Environmental Protection Group with deputy prime minister as its convenor.
Apr. 7, 1987	Prime Minister Yu of the Executive Yuan announced the establishment of the EPA while reporting to the Legislative Yuan.
Aug. 22, 1987	Former EPB of the Health Administration was promoted to EPA of the Executive Yuan
Jan. 15, 1988	Provincial EPB was promoted to the Environmental Protection Department.
Dec. 31, 1988	12 local EPBs were established

Table E-13 shows how environmental protection staffing levels continued to rise. However, they still remained relatively low compared with other countries' manpower. As Table E-14 shows, there were only 0.7 to 0.8 of these staff per 10,000 people in Taiwan, as compared to 2.0 to 2.14 in the US and 1.16 to 1.25 in Japan. Table E-15 shows that Taiwan's expenditure on environmental protection was also lower than other countries' relative to GNP.

Table E-13: Environmental Protection Staffing Levels in Taiwan (1985 to 1990)

Manpower	1985	1986	1987	1988	1989	1990
Central	110	110	116	284	284	414
Local	853	867	881	1115	1346	2004
Total	963	977	997	1399	1630	2419

Note: Local governments began to establish environmental protection units in 1985

Table E-14: Environmental Protection Personnel Per 10,000 Pop. (Government Staff)

Nation	Central Agency (duration)	Central & Local Agency (duration)
Taiwan	0.06 - 0.04 (1985 - 1989)	0.7 - 0.8 (1985 - 1989)
U.S.A.	0.46 - 0.60 (1980 - 1986)	2.0 - 2.14 (1981 - 1986)
Japan	0.07 - 0.08 (1980 - 1986)	1.16 - 1.25 (1980 - 1986)

Data Source: Yao Shi Chen, 1989, p. 93

Table E-15: Environmental Protection Expenditure as a Proportion of GNP (%)

Year	Taiwan	USA	Japan	W. Germany
1988	1.10	1.69	1.76	1.58
1989	1.12	1.67	1.73	1.58
1990	1.09	1.70	1.70	1.56

Data Source: EPA,1996, p. 118

Over the five year transition from the EPB to the EPA, a great deal of social and political change occurred: martial law was lifted, newspapers were no longer banned and oppositional party politics became explicit. The anti-pollution social movement also went from strength to strength: environmental NGOs were established and became influential lobbyists for change and, by 1990, EPBs were set up in half of Taiwan's local government administrations. Six mayoral and county magistrate seats were won by the party in the 1989 election. Some candidates touted their political credentials on the environmental issue, e.g., Yu Chin, the Taipei County Magistrate, who had opposed the installation of the 4th nuclear power plant in Taipei, refusing to issue the project a certificate despite central energy policies. The Yi-lan County Magistrate also openly objected to the installation of high-pollution manufacturing ventures such as light oil refineries and cement factories. These examples serve to show the extent to which both the government and the general public were warming to the topic of environmental damage.

Though it is clear that administrative action on environmental problems was well underway in the '80s the actual effectiveness of the local EPBs depended a great deal on the political stance of the mayors and magistrates. Typically, this stance was in tune with the times and emphasised the control of pollution

rather than ecological preservation (which was, in any event, beyond the direct scope of the EPBs). That said, the continued destruction of Taiwan's natural ecologies coupled with voices heard from the international environmental community meant that the issue of ecological preservation was one that was aired more and more frequently as the decade drew to a close.

E.3.6 The Preparation of EIA Legislation

The series of EIA pilot studies which were conducted in the '80s served to build a base of professional experience in the system's use. As discussed earlier, the Health Administration had drafted an early version of the EIA Act in 1983 which was rejected but which had the effect of focusing minds on the Programme to Strengthen the EIA. When the EPA was set up in 1987, it vigorously renewed the task of preparing a draft version of the Act which was duly presented to the Executive Yuan for review in 1989 and to the Legislative Yuan for approval in 1990. By that time, 123 development projects had submitted to EIA trials.

The spirit of the EIA system was an advance on the policies based on post-hoc clean-up of environmental damage: it was anticipatory and interventionist, aiming to prevent or minimise damage being caused in the first place. The system was therefore well placed to make up for the deficiencies of previous environmental policies. However, this was not entirely an unmixed blessing during the '80s when the EIA system was undergoing a series of pilots with a view to establishing how best it could be modified to suit Taiwan's purposes. For example, its use on the decade's major construction projects was feared to have the effect of slowing their completion schedules. Thus, it was in this context of complicating factors that the EIA was piloted, that draft legislation was prepared and that a series of demonstration projects were selected for EIA trials.

As the implementation of EIA trials clearly had implications for important public and private sector

developments, and for the public's rights, the pilot studies in themselves served as an additional impetus for providing the system with a legal basis. The EPB (as it then was) invited relevant institutions, experts and scholars to form an Interim Research Group on EIA Legislation, and it was this group which drafted up a version of the Act six months later. The bones of this draft were:

- that the EIA should be conducted at the project's planning phase;
- that its assessment procedures should be divided into three phases - the Environmental Statement, an initial EIA Report and, if necessary, a further Environmental Impact Report (EIR) - to be applied at screening and phase examination;
- that environmental agencies should see all EIA reports and that they should be reviewed by a competent authority;
- that environmental agencies should only have the power to comment on EIA reviews within the terms of their specialist professional competencies so as to inform the policy-making process, but that they should not have the authority to approve or withdraw permission for a proposed development; and
- that monitoring should be carried out in compliance with the prescriptions of the EIR (Cheng 1993, p.11).

This draft was a milestone in the development of Taiwan's EIA system. However, it was rejected at the time as the Council for Economic Planning and Development (CEPD) regarded Taiwan's existing base o experience, professional staff and technical skill to be insufficient to the task and it feared that the EIA system as proposed in that version would impact too greatly on Taiwan's economic well-being.[24] As we have already seen, the Health Administration in 1985 then instigated an interim measure - the Programme to Strengthen the EIA - and selected 14 representative development proposals to test the EIA's procedures These projects, which included a power generation station based on a reservoir sewer and an industria

[24]Draft versions of the EIA draft were rejected several times by the Executive Yuan which decided to postpone legislation until more professional training was provided and more experience from other countries' usage of the system could be called upon as a reference. See Liu, *Study of the EIA System in Taiwan* (Taipei, 1995) p. 47, 1995.

the EIA process, there would be critical consequences for the economy. Hence, the trials were more flexible in their application of the EIA process than would otherwise have been the case; their primary purpose was not to conduct a full and binding EIA but to gain experience in the system's use. In addition to these 14 projects, the EPA and CEPD required other test cases; by 1988, 52 development projects had undergone some version of the EIA review process. Of the 123 EIA test cases implemented by 1990, 37 were on places of entertainment, 22 on environmental protection projects (mostly landfill dumps and incinerators), and 20 on industrial parks and factories.

With this growing body of experience at its back, the EPA renewed the task of drafting the EIA Act. It was submitted to the Executive Yuan for review in March 1989, passed in July 1990, and then submitted to parliament for review. As Table E-16 outlines, this closed the phase of preparation of EIA legislation.

Table E-16: Steps towards the Establishment of the EIA System (1980-1990)

Date	Event
1980.4.11	Lee, Minister without Portfolio hosted' Coordination Meeting of EIA system Implementation Program & decided conduct pilot stucy
1980.7	EIA Implementation Principles announced by provincial Government prescribed major constructions should conduct EIA
1981.1	Economic Committee selected Reservior & New Central Cross-island Highway as demonstration
1982.1.29	EPB of Health Administration established
1983.6.2	Amendment to the National Park Law, which required development proposed within national park should conduct EIA
1983.7	The Health Administration finished the draft of 'EIA Law' & the Executive Yuan.
1983.10.13	The 1854th meeting of the Executive Yuan indicated to postpone EIA legislation
1985.10.17	The Executive Yuan announce the Strengthening Programme and indicate that any delay or postponement of the EIA process to be avoided
1986.1.10	Amended Article 30 of 'Preservation and Application principle which prescribed EIA should be conducted during planning stage development of hills. This law was the first to require an EIA
1987.8.22	The Executive Yuan set up EPA.
1987.10.2	Executive Yuan publish Chp. 3 of Essential points of ronmental Protection Policies and declare the reinforcement of EIA
1988.7.1	The 'Mass Rapid Transit Law' was promulgated prescribed that the MRT plan should be attached with an EIR.
1990.6.21	Kaohsiung city Government decide high-rises building with above 100 metres should conduct EISs.

The draft EIA Act had four chapters and 27 articles which featured the following:

- define EIA procedures, including assessment, review and monitoring;

- define EIA procedures, including assessment, review and monitoring;
- arrange public participation (e.g., public meetings) during specific EIA procedures (e.g., scoping);
- set-up review procedures over two phases: an initial EIS and, if necessary, draft and final EIRs (i.e., the latter phase is sub-divided into two further parts);
- define the procedures and content of the scoping process;
- define penalties in cases of default.

E.4 THE THIRD PHASE (1990-1995): THE FORMAL ESTABLISHMENT OF THE EIA SYSTEM

After the draft EIA Act was formally submitted to the Legislative Yuan for discussion in July 1990, the stage of formal legislation began (1990-1995). At the end of 1991, three committees of the Legislative Yuan (the Interior, Economic Affairs and Judiciary Committees) jointly reviewed and amended the draft They altered the review body of the EIA system from the Competent Authority to the EPA itself and made some adjustments to the level and type of public participation. After the amendment process, the role o the EIA review in merely informing the policy-making process was upgraded to having a decisive statu in the approval or withholding of approval for a project. The version of the Act which was finall announced as law in late '94 was based substantially on the amendments made by this group c committees.

During this stage, the economy continued to grow at an average rate of 6.4%, per capita income rose t $10,000, and the nation's standard of living rose From the volume of anti-pollution cases which we under appeal in this period, we can see that the environmental movement also thrived: in 1990, there we 58,778 cases rising to 117,788 in 1995.

Change also occurred in this period in the policial arena, for in 1992 a full general election was held for parliament (the Legislative Yuan).[25] The outcome was that the KMT's seats were greatly reduced and the DPP (with 51 seats) gained about one-third of the chamber. Thus, genuine oppositional parliamentary politics were now in play. In 1994, elections for provincial and city governorships were held and, in 1995, a (partial) election for the third term of the Legislative Yuan was held. Policy-making during this period was characterised by attempts to be sensitive to public opinion, to nurture a hospitable investment climate, and to foster national wealth and stability.

The major policy objective of this period was to improve the economy. However, the difference between this aim and the head-long drive towards growth of previous decades was that "better" was no longer simplistically equated with "core". The environment was firmly on the agenda by now, wanton pollution was unacceptable, and the growing global concern with environmental protection had filtered into the Taiwanese policy-making process.

The Taiwanese branches of global environmental protection groups had been lobbying for some time for more to be done to protect wildlife and were now also proposing that trade sanctions be applied against Taiwan. The activities of the global environmental groups contributed to Taiwan's growing sense that it had an international reputation to manage, and that moral credit could be gained by swimming with the tide of the international environmental movement. For example, in March 1990, Taiwan sent a delegation (the first of its kind) to the Montreal Protocol Conference in Geneva, Switzerland (EPA, 1997, p.348).

Administrative changes to the management of the environment were also afoot during this period but did not come to fruition till the end of the phase. By 1990, all local governments had established regional EPBs charged with responsibility for protecting the environment with the EPA as the central anchor.

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[25] See footnotes 18 and 23.

However, as the very concept of "Environmental protection" was still fragmented - pollution control v. ecological conservation - this split was reflected in the organisational structures set up to manage environmental issues. The EPBs and the EPA were responsible for the prevention and control of pollution but responsibility for aspects of ecological preservation were dispersed across several other units. Unsurprisingly, policy-making on pollution was more in evidence than policy-making on conservation since the former type of issue was supported by an integrated organisational apparatus and the latter was not. For this reason, 13 environmental protection groups and 121 legislators jointly suggested to the Executive Yuan in December 1994 that a dedicated environmental protection ministry was needed which could take responsibility for all issues relating to environmental protection.

This stage was a highly productive one in terms of legislation passed on environmental issues: 106 laws were stipulated or amended and seven others were revoked. On average, a new law was passed every three weeks, a substantial achievement indeed. However, in order for the laws to become truly effective, a strong administrative apparatus was needed and, during this period, this was somewhat lacking. The expert base needed to administer changes to the environmental management regime was not yet sufficiently mature: those professionals who were working in the field needed more experience to hone their expertise and, in any event, more of them were needed. So while several legal codes were beginning to come on-stream, their effective implementation was not yet guaranteed during this phase.

The establishment of the EIA system was the big event for environmental management in this period a was a constitutional change made. In May 1992, the constitution was amended to include a clause on th environment (the first such clause in Taiwan's constitutional history) which endorsed the protection of th environment and its ecosystems. The symbolic significance of this amendment was enormous, as was th constitutional weight it gave to the environmental protection laws which are currently in place in Taiwan.

E.4.1 Dramatic Socio-Economic Change

From 1990 to 1995, Taiwan underwent enormous societal, political and economic change. In the political arena, Li Teng-hui became the 8th President of Taiwan in May 1990. In his inaugural speech, he declared the end of the Mobilisation Against Communist Rebellion, repealed the Temporary Provisions which had been put in place to quell it, and named General Hao Po-tsun as Premier of the Executive Yuan.[26] There was popular up-roar at the appointment. Once in post, Hao Po-tsun adopted an unyielding working style (Liu 1995, p.103), responding in a high-handed manner to all kinds of popular demonstration. He aimed to stabilise the country for, with the environment going from bad to worse, he considered this measure was necessary if Taiwan was to create an attractive climate for investment.

As mentioned earlier, in December 1992 a full general election for the Legislative Yuan was held, which returned a resounding 51 seats to the opposition party, the DPP. Its greatly enhanced oppositional power in parliament played an important role in moving environmental legislation forward since at least some of these new DPP members had credentials as anti-pollution campaigners (e.g., Huang Tien-sheng, who played a central role in opposing the establishment of the 5th light oil decomposition factory in Kaohsiung). In the mayoral and local government magistrate elections of November 1993, the KMT had another setback in Changhua County, losing the seat to the DPP. In 1994, at the elections for Provincial Governor and City Mayor in Taipei and Kaohsiung, the DPP won the Taipei City Mayor seat and the KMT the seats of Taiwan Provincial Governor and Kaohsiung City Mayor. In 1995, the (partial) 3rd term election for the Legislative Yuan was held.

Thus, during this short period, there was almost one big election each year, making Taiwan's political landscape unstable and interrupting the smooth flow of some important policies. Frequent elections also made Taiwan's Legislative Yuan focus almost exclusively on political, financial and economic affairs: of

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[26] Hao, Po-tsun was a powerful military figure. A most senior general in the military ranks, he had been Chief of General Staff in the Defence Ministry as well as holding the post of Minister of that Department.

environmental protection, and of the eight of similar ranking proposed by the DPP, only one did.[27] Clearly, amidst this turbulent political upheaval, environmental issues were not the government's (or the people's) top priority.

As we have already seen, both in the lead-up to this phase and during it, anti-pollution demonstrations (especially against factories) were frequent. One consequence of this activity was that several industrial enterprises chose to locate their factories outwith Taiwan and this, in turn, led to a fear that the country was losing its appeal for investors.[28] To reassert Taiwan as a good investment environment, economic growth was again a major policy objective. Table E-17 shows that from 1990 to 1995, the annual economic growth rate was nearly always maintained at more than 6.0%. Meanwhile, the structure of the economy was becoming both more liberal and more international.

Table E-17: Social and Economic Norms in Taiwan (1990-1995)

Year	Growth Rate of Economy (%)	Average G.N.P.		Price Index of Customers (1991=100%)	Registration of Factories (Factory No.)
		US$	pounds		
1990	5.39	8,111	5,069	96.51	92,978
1991	7.55	8,982	5,614	100.00	95,327
1992	6.76	10,470	6,544	104.47	94,673
1993	6.32	10,852	6,783	107.54	96,630
1994	6.54	11,587	7,248	111.94	95,581
1995	6.03	12,396	7,748	116.06	97,012
1996	5.71	12872	8,045	119.62	96850

Year	Density of Factories (Factory No./km^2)	Volume of Motor vehicles(thousand)	Density of Motor vehicles(vehicle No./km^2)	Average trash Volume per Person(kg)
1990	2.58	10,050	279	0.96

[27] Because there were hundreds of bills, emanating from one party or another, waiting to be reviewed and approved by the Legislative Yuan, each party was asked to rank the bills they most wanted dealt with in order of priority so that the most urgent topics could be placed on the parliament's agenda. See Yeh, *Environmental Rights and Legislation* Taipei, 1993, p.110.

[28] The stream of enterprises who eventually chose to locate their factories off-shore was dubbed the "Emigration of Industry." In general, the two main reasons given were a shortage of labour and the resistance of the environmental protection movement.

	No./km²)		No./km²)	Person(kg)
1990	2.58	10,050	279	0.96
1991	2.65	10,610	295	1.00
1992	2.63	11,270	313	1.09
1993	2.68	11,860	329	1.10
1994	2.66	12,380	344	1.12
1995	2.69	13,200	367	1.14
1996	2.69	14,270	396	1.20

Data Source: EPA. 1997b. Table 2-3-1

During this period, the structure of industry also changed: the ratio of manufacturing business to GDP fell from 32% to 28.5%, while tertiary service industries rose from 56% to 60.2%. Within the manufacturing sector, the capital- and technology-intensive industries were still growing though labour-intensive light industries seemed to decline significantly. Although the economy was still growing steadily, other factors such as the appreciation of the Taiwanese dollar, soaring wages, shortage of land for industrial use and labour shortages[29], meant that there was a bottleneck in upgrading industrial techniques. One of the consequences of this bottleneck was that public investment in Taiwan's economy fell and the "immigration of industry" discussed earlier grew to more than a trickle. In response, the government announced a Six-Year Programme of National Construction in January 1991.

This programme had an enormous impact on Taiwan's landscape, water sources and raw material resources. It included the development of 28,600 hectares of farmland, 800 hectares of land for a large shopping centre and an industrial and commercial centre, the building of nine reservoirs and the completion of seven fossil-fuelled power plants.

In December 1990, the Ministry of Economic Affairs announced its Regulations to Promote the

[29]Because of these labour shortages, the government adopted a policy of buying in some foreign labour. In 1995, a total quota of 270,000 foreign workers was approved of whom more than 200,000 came from Thailand and the Philippines. See Yeh, 1997, p.35.

Upgrading of Industry in a bid to encourage rationalised production techniques and to make manufacturing processes more efficient. Under these regulations, the purchase of anti-pollution and energy-saving facilities was encouraged by means of tax breaks offered against these items. The success of this incentive can be measured by the fact that, in 1995, investment in automation and anti-pollutant facilities reached £6 billion and the growth rate was up to 51.6% (EPA 1997a, p.346). In addition, Taiwan's place in the international product market also grew. As Table E-18 shows, over 10 kinds of product made in Taiwan (e.g., monitors, PCs, bicycles, etc.) ranked amongst the global economy's top three.

Table E-18: The Global Ranking of Major Taiwanese Manufacturing Products (1995)

Ranking of No. 1 in the World	Amount (Million Pounds)	Global Market Share (%)
Monitors	2,000	51.00
Polyester Fibre	830	29.45
Bicycles	660	8.62
Computer Plates	560	62.00
Screws	520	31.52
ABS Resin	440	15.00
Sewing Machines	360	25.30
Mini Scanners	60	76.00
Printing Circuit Plates	880	5.50
Personal Computers	1760	9.40

Note: The exchange rate used is £1 to US$ 1.6

Data Source: quoted from EPA, 1997a, p.347, Table 16-1-1

Although the regulations issued in 1990 had improved the use made of anti-pollution equipment, sever major development proposals were still allowed some preferential treatment in terms of their requiremen for land and water sources and their need to use certain wharves. In general, the effect was to pla further pressure on natural resources that were already overstretched (Liu 1995, p.103).

The 6-year National Construction Plan was largely focused on meeting the objective of econon development. Its four major targets were to raise national income, strengthen Taiwan's potency in t

global economy, redress the historical skew in Taiwan's regional development and increase the nation's quality of life. Though it aimed to cover societal, cultural and environmental considerations, its main thrust remained the development of the economy.

In addition to the spurs of the Upgrading of Industry Programme and the National Construction Programme, Taiwan's economy was now increasingly shaped by international economic and societal forces. After the General Agreement on Tariffs and Trade (GATT) was reorganised as the World Trade Organisation (WTO) in 1995, issues such as intellectual property rights, environmental protection and labour conditions became increasingly important topics (EPA, 1997a, p.348), bringing new challenges for Taiwanese industry.

In particular, environmental protection was clearly a global hot potato by now. Several important treaties on environmental protection and biological conservation, which included trade clauses, were now in play, e.g., the Framework Convention on Climate Change to Control the Greenhouse Effect, the Montreal Protocol on Ozone Layer Depletion, the Basel Convention on Cross-Border Transportation and Management of Hazardous Waste, the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) and the Convention on Biological Diversity (CBD) These treaties frequently used trade sanctions as an enforcement method which at least had the effect of forcing participants in the global economy to take the issues seriously. Taiwan, as an export-oriented trade economy, had already begun to adjust its internal policies on the environment so as to remain a credible player in the global market place. Taiwan's stance in principle - if not quite always in practice - was as an economy committed to economic development though not at the expense of the environment.

Socially, this period was also a time of turmoil in Taiwan. The old order had just collapsed and it was not yet clear what would take its place. Street demonstrations were on the increase and it appeared as if social

order was under threat. Hao Po-tsun, the strong-arm General who had been appointed to the post of Premier of the Executive Yuan, claimed his legitimacy to govern in terms of his concern with re-asserting social order (Liu 1995,p.103). His tactics were overbearing: demonstrative social activity declined during his tenure as did the number of anti-pollution protests (from 42 in 1990 to 11 in 1995) (EPA 1997a, p.724).

In sum, this was a time of enormous political, economic and social change. Though the temptation was t shelf the environmental issue in favour of dealing with the more immediately pressing problems Taiwa faced, the government during this period could not quite turn its back on the environmental question. T remain a credible global competitor, it was forced to acknowledge at least some of the terms of th international environmental protection conventions or face trade sanctions which would impact o Taiwan's status as an important trading nation in the international economy. The two major programm set in place during this period aimed to strengthen Taiwan's global competitiveness yet at the same time t improve the quality and quantity of anti-pollution facilities in factories. While the latter aim met wit some success, such was the scale of some of the major national construction projects of the time (e.g., tl 6th and 7th light oil decomposition factories and the Cement Special Zone) that inevitably tl environment was damaged further.

E.4.2 The Shift from Local to Global Environmentalism

While local pollution problems continued to assert themselves, issues to do with pollution at the nation level were what most occupied the government agencies, e.g., the management of nuclear waste and t protection of wildlife. Yet to this mix was added Taiwan's growing involvement with glob environmentalism (an international movement augmented by the ending of the Cold War) as we saw in t last section (Yeh 1997, p.49). In particular, the Montreal Protocol and CITES mattered to Taiwan for the conventions threatened trade sanctions against those infracting their terms. In the WTO, a Trade a Environment Committee was set up to coordinate the management of problems which resulted fr

specific conflicts of interest between trade and environmental protection. All of these layers of environmental problem meant that the work of environmental protection became hugely more complex: environmental policy-making not only had to respond to local and national problems but also had to follow the precepts set by international conventions and standards.

Looking first at the local pollution situation, in 1990 there were 58,778 appeals raised against pollution rising in 1995 to 117,788 - one every four minutes on average. Table E-19 shows that appeals against waste, noise and air quality were the most frequently cited problem.

Table E-19: Appeals Raised against Public Pollution(1990 ~ 1995)

Year	Total	Air Pollution	Water Pollution	Noise	Waste	Odour	Public Health	Others
1990	58,778	17,781	4,659	13,559	18,267	2,865		1,647
1991	67,438	12,966	3,145	15,726	31,332	3,814		465
1992	77,547	16,916	3,980	20,328	29,805	5,603		915
1993	84,273	18,676	4,801	19,165	32,319	8,186		1,126
1994	86,517	12,957	4,695	20265	34,855	10,049		3,696
1995	117,788	12,275	4,889	21,149	52,462	11,950	9,147	5,916

Data Source: EPA, 1996, p.96, Table 25

The volume of rubbish had mounted from 6,840,000 tons in 1990 to 8,700,000 in 1995. Landfill sites were hard to come by amicably for no-one wanted one on their own doorstep, causing "rubbish wars" in several Taiwanese cities. Although the concepts of reducing and recycling waste were promoted, the results were limited: the volume of rubbish per person increased from 0.96kg in 1990 to 1.14kg in 1995. Noise was another hazard that was difficult to control because of Taiwan's complex mix of homes, factories and businesses being located in close proximity to each other. Factory noise was the source most likely to be appealed against (accounting for 33.62% of cases) followed by noise from places of entertainment (27.78%). Air pollution (mainly suspended particles - PM10 - emitted by industry) was the issue which generated the third more frequent reason for raising an appeal. For each year before 1990, the rate of poor air quality PSI was around 15%, decreasing each year thereafter to 5.73% in 1995. A majority of the appeals (c. 45%) were ranged against industrial and commercial enterprises - factories most of all.

However, it must be remembered that measures to control pollution were by now underway, and the situation by the close of 1995 was an improvement on 1990. Protests against pollution fell from 42 cases in 1990 to 11 cases in 1995.

National environmental problems were also receiving attention during this stage. According to the terrain and distance from the coast, Taiwan is divided into five areas, the Mountain, Hilly, Coastal, Plains and Surrounding Island Areas (see FIG. E-7). Each area has its own environmental problems.

FIG. E-7: Taiwan's Geographical Divisions

Data Source: EPA. 1997a, p.25 Fig. 2-3-1

The Mountain Area indicates the areas 1,000 metres above sea level; they account for almost a half Taiwan's total land area, are dispersed across the island, and Taiwan's aboriginal peoples li predominantly in these places. Due to the steep terrain of these areas, development has an enormo impact on the flow of water to midstream and downstream river areas. For example, the establishment the new cross-island motorway caused soil erosion, landslides, slippery land and damage to the landsca

(EPA 1997a, p.26).

The Hilly Area indicates places whose elevation is between 100 and 1,000 metres, about 27% of Taiwan total land area. Over half of this kind of terrain in already used as agricultural land and that half tends to be located near cities. This terrain is also frequently used to site residential communities, industry enterprises and golf courses. Development on hilly ground tends to harm water and soil: golf courses, in particular, have destroyed ecologies which then cause flooding and other ecological problems in midstream and downstream water catchment areas. For example, the source of Hsintien River - Taipei's major water source - is now causing problems for the city, not helped by the fact that the river is being further damaged by pig farming effluent and by the spraying of chemical pesticides on tea plantations and orchards.

The development of the Coastal Area began early: this terrain houses the country's fossil-fuelled power stations, nuclear power plants, airports, harbours, industrial parks and many of its places of entertainment. Long-term pollution has damaged the coastal ecology enormously. City and factory effluent as well as the hot waste water emitted by electricity generation stations produce serious pollution which kills fish and shellfish in short order. The carrying capacity of the coastal environment is already hugely stretched to the anger of Taiwan's fishing industry. In 1989, 19 cases were raised by this industry against land-based enterprises, of which 17 referred to industrial waste water.

The Plains Area occupies less than one-third of Taiwan's total land area, but it has been more affected by industrialisation and urbanisation than any other kind of terrain. It has both urban and rural areas within it though the extent of the urban areas is growing partly because of the increasing numbers of city-dwellers and partly because rural land has been rezoned as industrial parkland. The volume of industrial parks has gradually increased: in 1990, they covered a total area of 12,216 hectares but by 1995 this had risen to

16,365 hectares. Over this five year period alone, rural land redesignated for industrial use increased by one-third. These factories scattered across the countryside not only destroy the water conservation systems of the original farmland but also damage agricultural production. For example, in 1995, the rice plants in Taichung did not bear fruit and this sterility was almost certainly related to the pollution of crops.

The Surrounding Island Area is quite sparsely populated because of its low level of industrialisation but this very situation has also guaranteed that environmental damage to this terrain is lower than elsewhere in Taiwan. After parts of the islands were opened to the tourist trade (e.g., Orchid Island) some additional environmental problems ensued but, fortunately, Orchid Island's environmental problems are less dramatic than Taiwan's (EPA 1997a, p.29).

At the next level up from national environmental problems, international environmental concerns revolv around the issue of sustainable development (Yeh 1997, p.140). In 1992, the United Nations establishe Agenda 21 - the principle of sustainable development - at the Earth Summit held in Rio de Janeir Agenda 21 attempted to sketch out how global development should be approached in the 21st century. B May 1992, the Executive Yuan had set up a Global Change Task Force, which was followed in August b the establishment of a Global Environmental Change Research Centre in National Taiwan University. I 1994, the Global Change Task Force was expanded and renamed as the Policy Guidance Task Force fc Global Change. At the same time, six discrete work teams were formed to deal with Taiwanese topic relevant to the Montreal Protocol, the Basel Convention, Climate Change, CITES and CBD, Agenda 2 and Trading and Environmental Protection. In December 1995, another team began work on ISO 1400 the environmental management system which aims to audit the environment (EPA 1997b, p.335).

At the end of 1993, when agreement on the Uruguay Negotiation was reached, each member state thoug it necessary to discuss trade and environmental protection in order to unite both issues as an indivisib

topic under a multilateral trading system. At this stage, there were about 180 international environmental protection agreements, of which about 20 had trade sanction clauses (EPA 1997b, p.335), e.g., CITES, the Montreal Protocol, the Basel Convention and CBD. All these agreements have had a great impact on Taiwan for although it has never signed any regional or international environmental treaty it has been subject to their provisions.[30] in 1994 CITES condemned Taiwan for its failure to curb the smuggling of rhino and tiger parts and imposed the Pelly sanction against the country.

Between 1990 and 1995 the public gradually came to consider economic growth and environmental protection as being almost equally important. Table E-20 shows that, in 1993, 39% of those polled thought that environmental protection should be rated more highly than economic growth while 31% thought the opposite. We can see that the Taiwanese remained more committed to economic growth than their American or European counterparts. For example, in 1990, only 19% of Americans thought that economic growth should be rated highest, whereas 71% thought the opposite. The American trend was also apparent in the EU countries though with a high percentage thinking that economic growth and environmental protection were equally important. For example, in 1992, 66% of British people thought that economic growth and environmental protection were equally important; 25% that environmental protection should be prioritised; and 5% that economic growth was more important.

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[30] Because of Taiwan's ambiguous diplomatic status and lack "national" standing, it has never had international environmental treaty membership. However, it is subject to international environmental laws which it has not participated in drafting, nor has signed. See Yeh, *Environmental Rationality and Institutional Choice*(Taipei, 1997), p.50.

Table E-20: Cross-National Opinion Poll on the Importance of Environmental Protection v. Economic Growth

Country	Year	Number of Interviews (person)	Results of Investigation (%)			
			Priority to Environmental Protection	Both Are Possible	Priority to Economic Growth	Don Know
USA	1990	1,223	71	n.a.	19	10
Japan	1990	3,753	36	43	8	13
Finland	1989	1,985	63	26	6	5
Norway	1992	1,506	48	49	1	2
Belgium	1992	1,000	23	67	5	5
Denmark	1992	1,000	34	61	2	4
France	1992	1,000	13	79	5	4
Germany	1992	2,000	29	66	3	2
Greece	1992	1,000	21	71	6	3
Ireland	1992	1,000	15	59	12	14
Italy	1992	1,000	18	71	4	6
Luxembourg	1992	500	28	59	6	7
Netherlands	1992	1,000	31	65	2	2
Portugal	1992	1,000	18	62	9	11
Spain	1992	1,000	19	69	6	6
UK	1992	1,300	25	66	5	5
EEC	1992	14,800	22	69	4	5
Taiwan	1992	1,664	39	18	31	12

n.a. = not asked

Data Source: EPA, 1996, p.406, Table 8-12

In sum, the scope of environmental concerns was expanded during this stage from the local to the national and international. While protests about local pollution problems fell, national issues such as deforestation and ocean pollution became more prominent, e.g., in 1992, 'deformed fish' were found near one of Taiwan's nuclear power plants, prompting a nation-wide scare. The power of international environmental protection organisations to affect Taiwan was keenly felt when the country was blamed by them for allowing threatened species of wildlife to be used as food. According to a 1994 survey by Trade Record Analysis of Flora and Fauna in Commerce (TRAFFIC), the volume of swallows' eggs imported into the country had increased: in 1992, two tons of them had come in, equal to 350,000 pairs of nesting swallows. While swallows are not an endangered species, the Taiwanese were soundly blamed for not doing more to protect wildlife over a long period, and the threat of imposition of the Pelly sanction was

voiced (Liu 1995, p.176).

E.4.3 Environmental Policies: From Pollution Control to Environment Management

The preventative spirit of the EIA system as it moved towards legislation helped to inform policy adjustments made during this period. Environmental policy-making came in three main forms at this time. First, the government were active in promoting means to cut back on pollution: in 1994, 154 landfill sites were established and plans were afoot to build 19 incinerators. In addition, the government spent £50 million annually on sewage works.

Second, policy-making assumed a command-and-control approach, i.e., enforcement methods (such as withholding of permits) were established to deal with infractions of prohibited or restricted practices. Penalties were now attached to the standards set for air, water and noise pollution as well as wildlife protection laws. During this stage, standards rolled out in a steady stream to cover the different kinds of pollution level permitted: in 1991, an effluent standard was issued; in 1992, standards on air quality and noise control; and in 1994, standards on atmospheric emissions from power stations. Up to the present day, this kind of policy instrument informs much of Taiwan's attempts at pollution prevention

Third, policies now aimed to provide economic incentives for promoting the installation of anti-pollution equipment. We have already discussed how the Regulations to Encourage Industry to Upgrade of 1990 offered industrial investors cheap bank loans to purchase equipment which would reduce the pollution their factories generated. By 1995, the Pollution Prevention Equipment Credit Project had 83 cases and its expenditure came to £10 million (EPA 1996, p. 354). In addition, dating from July 1995, the government began to impose an air pollution tax: in its first year of operation, it raised £56 million in tax and, due to the offset system, the discharge of sulphur dioxide that year fell by 33, 000 tons (EPA, 1997b, pp. 189-190).

At the national level of environmental policy-making, conservation of the natural landscape assumed importance. By the end of 1995, six national parks were established covering 322,207 hectares in an attempt to protect areas of special beauty or historical significance and certain wildlife habitats. The management of forests also received attention, but came too late to alter the fact that originally wooded hillside land near the cities had already been stripped for residential or industrial use. As matters stand, Taiwan's ancient forests grow smaller daily and several species of forest plant and animal are close to extinction. In addition to the six national parks, the Ministry of the Interior also designated 12 coastal areas as conservation zones. The Ministry of Economic Affairs and the Council for Agricultural Planning and Development announced 18 conservation districts; the Ministry of Transport and Communications organised a north-east scenic area, an east coast scenic area and a Penghu scenic area; and the Forestry Administration of Taiwan Province Government founded six forestry conservation districts. From this list we can see that the authorities responsible for aspects of conservation policy were diverse. Yet, although no single agency carried responsibility for the task, it is clear that even at this stage the notion of environmental protection had expanded to include ecological conservation.

At the level of policy-making addressing global environmental concerns, some advances were also made in this period. The criticism Taiwan had received from the international environmental community over its failure to protect rhinos, tigers and elephants from the ivory, tiger meat and rhino horn trade not only embarrassed Taiwan but resulted in the Pelly sanction been applied in 1994. This further galvanised efforts to address the environment at the global level. In addition to positively enrolling in organisations like CBD, CITES, the Convention on Internationally Important Wetlands (RAMSAR) and the Forest Principle, the Taiwan government participated in the Geneva conference of March 1990 on the Montreal Protocol. It was willing to comply not only with the terms of the Montreal Protocol but also with those passed at the Rio Declaration and the Agenda 21 that emerged from the Earth Summit of 1992. In M

1995, it organised a Policy Guidance Task Force for Global Change Policies to enable Taiwan to meet the terms of these various treaties.

In sum, this period saw environmental issues being actively addressed at the local, national and global level. While the economy remained the primary concern, it was now embedded in a political consensus that environmental protection could not be side-lined when economic policies were being formulated. Though some of the policies were not well implemented because of the diffusion of organisational responsibility for aspects of environmental care, this stage undoubtedly saw an important conceptual transition occur: environmental protection no longer merely meant pollution control but had expanded to incorporate environmental management.

E.4.4 A Spate of Environmental Legislation

By the end of the previous stage (1980-1990), only 13 new environmental laws, with 59 articles, had been passed - 22% of the volume of legislation waiting in the pipe-line. As the context of environmental concerns had expanded from local to national and international levels, the pressure to push through more legislation mounted. "Think Global, Act Local" had become a clarion call as much in Taiwan as in the other countries of the developed world.

Between 1990 and 1995, the government exerted itself to complete the enactment of 119 environmental laws - a nine-fold increase on the legislation of the previous stage, representing a 910% growth overall. This was a truly remarkable achievement for it required that an average of 20 new laws be revised or laid down each year of this stage. Table E-21 shows that there were 29 kinds of legislation on air pollution, followed by legislation on the EIA system (26 in one year alone following the passing of the EIA Act at the end of 1994).

Table E-21: Environmental Legislation

Characteristic	Type	Volume(Bills)
Ex-ante Prevention	EIA Act	26
Prevention & Control	Air quality control	29
	Noise nuisance control	9
	Water pollution prevention	12
	Waste disposal	18
	Hazardous waste management	5
Remedy & Appeal	Environmental Dispute resolution	6
Organisation	Administration organisation	8
Other	Environmental business management	6
Total		119

Legislation and policies mirror each other's precepts and contents. Looking at the environmenta legislation passed in this period, we can see that two principles became incorporated into legislative an policy-making processes: the Polluters Pay Principle and the Prevention Principle. The former i premised on the idea that since the polluters profit from the activity which caused the pollution in the firs place, they should also be the ones to pay for it in the form of government tax. Following the theory o internalisation of external cost, polluters only have a true incentive to reduce their emissions if it affect their financial bottom line (Yeh, 1993, p.92).

Evidence of the operation of this principle is found in legislation dating from this period. For exampl the amended Waste Disposal law included a deposit system whereby producers of PVC containers we required to pay a sum for each container produced or sold, though the sum would be refunded if t producer recycled it within a specified time. As a consequence, recycling of PVC containers reach 66.36% by 1995. Another example is found in the amendment to the Air Pollution law of March 23 1995, which generated £56 million in tax in its first year of operation.[31] The second concept - t prevention principle - is also found in the legislation of this period - most notably, the EIA Act itself.

[31]The sum came to NT$218,740,000 (equal to £56 million) between July 1995 and June 1996.

Laws on the control of pollution enacted at this stage tended to use several instruments (including economic incentives) to achieve their ends. For example, the amended Waste Disposal law imposed a rubbish fee which applied to the producer but which also meant that the consumer usually paid a higher price for goods contained in certain kinds of packaging and this in itself was hoped to persuade consumers to reduce their usage of such packaging. The Air Pollution Prevention law incorporated the idea of a "Pollution bubble" to entice enterprises to improve their equipment and so restrict their emission levels.

E.4.5 The EPA and the Dispersed Administration of Environmental Affairs

E.4.5.1 Environmental Protection Organisations

As we have already seen, the EPA was established in 1987 as a dedicated central administrative office for the control of pollution. By 1988, 12 Taiwanese cities had their own local EPBs; by 1990, there were six more; and by 1991 a further three. Though the establishment of these local branches was a step in the right direction, almost all of them were understaffed. With the exception of Taipei's and Kaohsiung's EPBs, the remaining 21 employed only 719 people between them. Thus, each city or county had on average only 34 environmental administrative staff; every 10,000 of the population was represented by 0.4 of an environmental officer. Because of these staffing shortages, most of the business of environmental protection tended to fall on the central EPA, even down to the overseeing of policy implementation at a level of detail which strictly belonged to local government authorities. To redress the situation, the EPA set up a Supervisory Team on March 24th 1991 and, by 1993, the staffing of the various local EPBs had risen to 1,183 people, an increase of 65%.

The work of environmental management was further handicapped by the fact that local EPBs were not politically independent organisations. Being ruled by the elected mayor, their activities were shaped by the concerns of the political party to which the mayor was affiliated and by the fact that the mayor's re-

election chances depended on delivering concrete instances of local improvements to pollution levels. While this was not bad in itself, it meant that the very structure of the EPBs did not lend itself to long-term planning on wider issues (e.g., local problems which had national or global implications) or longer-term ones (e.g., early intervention strategies as opposed to post-hoc clean-ups). Nevertheless, despite these difficulties, this period marked the devolution of the administration of environmental affairs from remote central government to the local government level where, in principle at least, better controls could be effected.

E.4.5.2 Growth in Expenditure and Staffing Levels

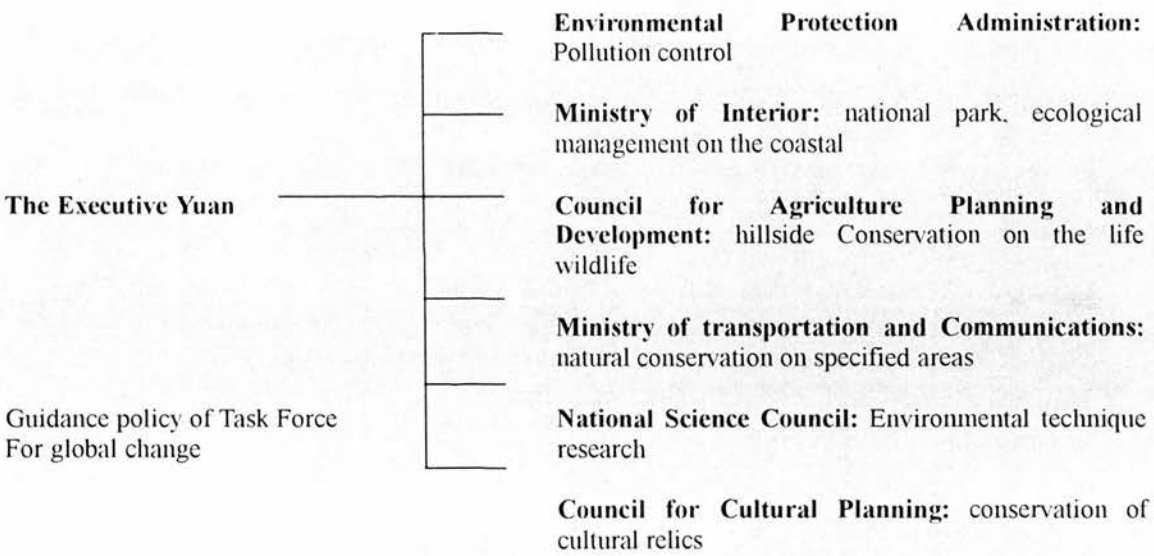
Though appropriately trained staff were still in short supply, their numbers did grow in this period. In 1990, there were only 1.2 environmental staff per 10,000 of the population but by 1995 this had risen to 1.5 - an increase of 25%. The local EPBs did least well from the growth in staff as 40% of all staff were employed at the central or provincial administrative levels.

In 1990, £40.1m was spent on environmental protection rising to £73.8m in 1995 - an increase of 82%. Per capita, this expenditure translates as £20 per person in 1990 and £35 per person in 1995. A full 80% of this expenditure was devoted to the disposal of waste. While this was good in itself, it meant that spending on air and water pollution and on the EIA system was still insufficient during this period.

E.4.5.3 The Lack of Integration of Authorities Administering Environmental Affairs

Though environmental protection was increasingly being seen as comprising two elements - control pollution and ecological preservation - which should not be disassociated from each other, this conceptu unity was not yet reflected in the organisational structures governing environmental administration. FI E-8 shows that the EPA was responsible for the administration of pollution control while conservati affairs fell variously to the Council for Agriculture Planning and Development, the Ministry of Econon

FIG. E-8: Organisation of Environmental Affairs in Central Government



As a result, less progress was made on environmental conservation than on control of pollution. For example, water resource management fell to the Ministry of Economic Affairs despite the fact that water resources, like forests, are natural properties and not economic goods. Water resources are finite yet by placing them under Economic Affairs the notion of their sustainable development went unacknowledged: on the one hand, water was being consumed at too great a rate and, on the other, huge reservoirs were built to make up the insufficiency. As we saw in FIG. E-8, responsibility for conservation was spread across several disparate departments. Over this period, it became clear that this was extremely inefficient and by the end of this stage there were loud calls - both outside the Legislative Yuan and within - for the establishment of a discrete Ministry of Environmental Protection.

E.4.5.4 The Establishment of the Ministry of Environmental Protection

On 13th November 1994, 13 NGOs and 121 legislators called for the establishment of an environment ministry, which was the first time the Executive Yuan had been pushed on this topic by increasingly vocal lobby groups. It was argued, first, that the EPA's level in the hierarchy was too low (the EPA is one level lower than other ministries; its administrator may attend Executive meetings but does not have voting

protection was effected in the policy-making process; and third, that the diffusion of responsibility for the different aspects of environmental protection disabled effective action being taken for there was no single competent authority to oversee environmental affairs. Following the example of several other countries who had, by now, set up environmental ministries (see Table E-22), the call now was for Taiwan to follow suit.

Table E-22: Central Government Environmental Organisations throughout the World

Country	Central Environmental Agent	Country	Central Environmental Agent
Argentina	Ministry of Natural Resources and Human Environment	Papua New Guinea	Department of Environment and Construction
Australia	Commonwealth Environment Protection Agency	Philippines	Department of Environment and Natural Resources
Austria	Ministry of Environment, Youth and Family	Poland	Ministry of Human Environment, natural Resources and Forestry
Banglades h	Ministry of the Environment and Forests	Romania	Ministry of the Environment
Belgium	Ministry of Public Health Environment	Singapore	Ministry of the Environment
Brazil	Ministry of Tourism and the Environment	Spain	Ministry of Public Works, transport and Environment
Canada	National Environmental Protection Agency	Sweden	Ministry of Environment and Natural Resources
China		Switzerland	Federal Office for Environmental Protection
Cuba	Ministry of the Academy Environment	Thailand	Office of National Environment Board
		Turkey	Ministry of Environment
Denmark	Ministry of the Environment	United Kingdom	Department of Environment
Egypt	Ministry of Development and the Environment	USA	Environmental Protection Agency
France	Ministry of the Environment	Germany	Federal Ministry for the Environment Nature Conservation and Nuclear safety
Finland	Ministry of the Environment	Zaire	Ministry of Rural and Conservation of Nature
Greece	Ministry of Environment	Japan	Environment Agency
Hungary	Ministry of Environment and Forests	Korea	Ministry of Environment
Iceland	Ministry of the Environment	Luxembourg	Ministry of Environment and Land Management
India	Ministry of Environment and Forests	Malaysia	Department of Environment
Indonesia	Ministry of Population and Environment	Mexico	Ministry of Social Development
Israel	Ministry of the Environment	Netherlands	Ministry of Housing, Spatial Planning and the Environment
Italy	Ministry of the Environment	New Zealand	Ministry of the Environment
Pakistan	Environmental Protection Agency	Norway	Ministry of the Environment

Data Source: EPA 1996, pp. 497-8

E.4.6 The Formal Establishment of the EIA System

Data Source: EPA 1996, pp. 497-8

E.4.6 The Formal Establishment of the EIA System

The Programme to Strengthen the EIA, which we examined in the previous section, was run as a series of trials and had no powers of enforcement. As this was unsatisfactory over the long term, we have seen how it came about that the Executive Yuan submitted a draft of the EIA Act to the Legislative Yuan in 1990, and that this marked the beginning of the EIA legislative process. In the interim, a Sequential Programme to Strengthen the EIA was announced in 1992 as the original programme was due to expire leaving nothing in its place. This sequential programme was not confined to coverage of nominated development projects, but was to act as a general test of the implementation of the system. It still did not possess powers to enforce its findings nor were its exact review procedures or coverage made explicit which caused some inconsistencies in its use by the local agencies. Despite these inconsistencies, most EIA administrators took the line that the main responsible authority was the Competent Authority and that the EPA was that Authority's professional assistant.

When the draft EIA Act was examined by the joint commission of the Legislative Yuan, it underwent a number of significant changes, some of which we have discussed already. The EPA was now named as the competent authority; penalties for infractions were greatly increased; and government policies which were likely to have significant impacts on the environment became subject to EIA review. These amendments greatly strengthened the power of the EIA system for it now had the power of veto over approval decisions. Table E-23 summarises the main events connected with the establishment of the EIA system between 1990 and 1995.

Table E-23: Main Events in the Establishment of the EIA System (1990-1995)

June 21, 1990	Kaohsiung City Government regulations stipulate that high-rises over 100m attach an E examination
July 1990	Executive Yuan finished the draft EIA Act and submitted it to the Legislative Yu examination
Oct. 1990	The 5th conference of the 86th session at the Legislative Yuan agreed to hand over the dr Act to be examined by the joint commission of the Interior, the Economy and the Judicia
Apr. 1992	Executive Yuan approved Sequential Programme to Strengthen the EIA
Nov. 1994	The 2nd Session of the 2nd Term of the Legislative Yuan held a 2nd reading of the dr Act
Dec. 1994	The Legislative Yuan's 3rd reading
Dec. 30, 1994	President announced the formal passing of the EIA Act

By the close of this stage, both central and local authorities had made strenuous efforts to enforce th system. The kinds of project which came under its remit were expanded to include private ventures such as shopping centres or department stores. As soon as the EIA Act came into law, the EPA set abou making the system's procedures and contents explicit and, therefore, consistent.

E.4.6.1 Main Issues to Arise from the Legislative Process

The legislative process threw up three major adjustments to the EIA system. First, the responsibl authority was shifted from the Competent Authority to the EPA itself. Second, the review procedur were adjusted time and again. Third, the EIA Report changed from two types (EIS and EIR) to three typ (EIS, draft EIR and final EIR), which caused a great deal of controversy during the process of legislation.

In the draft Act, the Competent Authority was held responsible for conducting reviews but, after debat the Legislative Yuan decided that the EPA was better equipped for the task given Taiwan's unsatisfacto administrative apparatus for environmental protection. This view was supported by the vario environmental NGOs. In addition, the Legislative Yuan set great store by the contribution which releva experts could make to the effective execution of the system. For this reason, it was decided that schol or experts should constitute two-thirds of the membership of EIA committees, so as to ensure that t

quality of EIA review reports was appropriately high.

Generally speaking, other EIA systems submit their EIR conclusions to the Competent Authority which then makes the final decision. However, the Legislative Yuan revised the draft so that the body conducting the EIR retained the right of veto over decisions made on particular proposals. This was done both to strengthen the EIA system and to ensure that environmental concerns could never be side-lined in cases where the project's environmental impacts were likely to be significant.

E.4.6.2 Problems Implementing the EIA System

During this period, the EIA system was applied to 377 cases. As its administrators came through the learning curve, they inevitably encountered controversies such as how to handle public participation in terms of its type or frequency; how to handle natural or cultural conservation cases; and how to locate the EIA system relative to national policies on energy and water resource management. The outcome was that the EIA system was somewhat unevenly executed during this trial phase and other organisations questioned the fairness both of the system itself and of the EPA's role in administering it.

For example, Taipei's second landfill project proved controversial. Taipei City government had decided that a second landfill site at Shan Chu Ku in Nankang was required, and a decision was made to commence work in 1993 for completion in 1994. However, local objections were strenuous as previous experience of landfill sites was that they were not only smelly and full of effluent but they also caused traffic congestion in their vicinity. The site's proposed location was then shifted to another neighbourhood - Academia Sinica - and the exact same NIMBY objections were raised by its local residents. However, since the EIA's 1993 review was based on the landfill being located at Academia Sinica the local residents attacked the EIA review findings: they argued that their own independent survey showed that the EIA's findings were politically motivated; that the whole EIA process had been "black-boxed" rather than

made transparent; and that its value was revealed to be fundamentally unfair - mere window-dressing for a choice of site that had already been decided on (Liu 1995, p.112).

Another controversial example was the establishment of the 4th nuclear power plant. As part of its strategy to diversify its electricity generation facilities, the central government had decided in favour of increasing the proportion of power generated by nuclear means. In September 1991, the Taiwan Power Company began construction after the plant's EIR review was passed. Strenuous objections were raised by those living near the site and by environmental NGOs on the grounds that the EIA review had no exposed the extent to which the plant which disturb the area's landscape and ecology. Taipei County government joined in the voices of opposition, e.g., Taipei's magistrate, Yu Ching, questioned the impartiality of the EIA committee. The public demanded that the EIA on this development be done again and were 'full of misgivings' about its execution (Liu 1995, p.114). In the ensuing war of word between the pro- and anti-lobbies, the EIA system itself became a contested issue which, once again called its impartiality into question in the public mind.

E.4.6.3 Administrative Confusion as to the Correct Use of the EIA System

During this trial period, it was quite often the case that a decision on a project was taken prior to the completion of the EIR review. As we saw above, this happened in the controversial cases of Taipei's 2nd landfill project and the 4th nuclear plant project. In the latter case, construction had already begun before the EIA was conducted, and the Director of the Executive Yuan had already decided that the plant's value outweighed the environmental impacts it might have as they were likely to remain within acceptable levels. The Minister of Economic Affairs also stated that there was no alternative to the plant.[32]

What these cases reveal is that the administrative authorities did not, at the time, understand the EIA

[32] Chinatime News, May 22nd, 1994, p.11, Taipei, Taiwan.

proper upstream location in the decision-making process. As a result, the public came to understand the EIA as being another bureaucratic manifestation of the tail wagging the dog. This was very bad news for the credibility of the system and in order to redress that problem the Legislative Yuan added a notable article to the draft EIA Act: "if the conclusions of the EIR review suggest that a project should not get the go-ahead, the Competent Authority may not then approve it" . This article provided the system with teeth, for it now possessed the power of veto. Later, the Legislative Yuan nominated the EPA as the Competent Authority for EIR reviews, enhancing the EPA's expert status. Thus, despite the controversies surrounding the EIA trails, the actual outcomes for the system were extremely fruitful by the conclusion of this stage.

E.5 THE FOURTH PHASE (1995 -): THE EIA SYSTEM IN ACTION

This current era has proved the most challenging for the EIA system. In July 1997 the Asian economic crisis began and Taiwan did not escape unscathed: the New Taiwan dollar depreciated by 20% and the economic growth rate dropped to 5.3%. To offset some of the worst of the buffeting, a series of improvement policies were proposed, most notably the Plan to Increase Domestic Demand. The government has spent £4 billion on urban renewal, infrastructure, privately-owned power plants, etc., and all are closely linked with the question of environmental quality.[33] On 21st of September 1999, an earthquake at 7.6 on the Richter Scale shook Taiwan, causing 7,018 buildings to collapse and costing £6 billion in recovery. The growth rate of the economy then dropped to 5.2%.[34]

Despite these reverses, Taiwan continues to thrive. According to the World Bank 1998 figures, Taiwan enjoys the 4th highest economic growth rate in the world, averaging 8.6% annually over the last 35

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[33]Central Daily News, 17 August 1998, p.3, Taipei, Taiwan.

[34]Central Daily News, 29 September 1999, p.1, Taipei, Taiwan.

years.[35] The average GNP per person has jumped to 23rd highest globally. Throughout this stage, the government has been aiming to accelerate the upgrading of industry and to transform Taiwan into a "technical island" to attract foreign investment. The mid-range goal is to develop Taiwan as the Asian centre for high value-added manufacturing, sea and air transport, telecommunications, finance, media and other services. At the moment, Taiwan is actively gearing up to face a challenging future. This is bringing both a certain dynamism and a certain uncertainty to the country.

In the political arena, the first national presidential election was held in 1996. This took place at the same time as Mainland China carried out military and missile exercises in the seas to the north and south o Taiwan. In 1997, the KMT sustained serious losses in the mayoral/magistrate election, winning only eigh of 21 county and city seats. As a result, the central and local governments are now controlled by tw opposing parties, making it difficult for central government policies to find acceptance at loca government level. In 1998, the central government set out to continue reforms by expanding th administrative structures and devolved powers of central, county and city governments. As part of th catalogue of reform, the Ministry of Environment was finally established and the local EPBs wer enlarged such that each now have two additional divisions.

Environmental policy in this current era has become more international in scope. In December 1997, th Climate Change caucus established a consensus to cut back CO_2 emissions. This led to a dispute with the country about several important national investments such as the 7th petrochemical factory. T government finally announced that from 1998 CO_2 emissions would be one of the items assessed by t EIA, as per the European SEA system. Apart from that, the EIA system has aimed to strengthen

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[35] According to the World Bank's statistics, Taiwan's economic growth rate over the last 30 years has on been topped by Po-Jar-Nah (13%) in Africa, Oman (9.5%) and South Korea (8.9%). See the Central Da News, 26th, November, 1998, p. **?**, Taipei, Taiwan.

preventative function by focusing its attention on how important government policies are formulated: if those policies remain cognisant of environmental implications then they should be advanced. This new focus is assisting the EIA system's evolution from a project assessment system to a "3 Ps" (Policy, Plan and Programme) assessment system.

Overall, this current period has been a social, political and economic roller-coaster. Though the environmental question was the public's greatest concern in 1998[36], and the establishment of the Ministry of the Environment is evidence of the government's serious response to the issue, the Asian economic crisis and the recent earthquake disaster have renewed the public's concern with economic development. Most recently, national policy-making reflects the conviction that neither issue should be prioritised at the expense of the other.

E.5.1 Social, Political and Economic Crisis and Opportunity

Over the past five decades, Taiwan has undergone dramatic social, political and economic change which, in turn, has had a huge effect on the environment. For example, Taiwan's population in 1946 (just after the Japanese colonial period came to an end) was just 6.09 million; by 1998 this had jumped to 21.83 million. Within 50 years, the population has increased 2.5 times. With its rich human resources, Taiwan has been able to satisfy the demands of the labour-intensive industries which characterised the pre-1980s era which, in turn, gave the country its stable economic foundations and its continuing ability to infuse other of its business ventures with a vitalising energy. The average net GNP per person reached US$13,872 (c. £8,700) in 1998, and this is growing annually at a rate of about 14.6%. This achievement makes Taiwan the world leader in this regard.[37]

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[36] A public opinion survey conducted by Taichung City Government indicated that the environment and traffic are the topics the public most care about. See Taichung City Government , *Public Opinion Survey on Government Service Satisfaction* Taichung , Taiwan, 1998 ,p.21.

[37] Second place is held by Po-Jar-Nah (9.2%) and third South Korea (8.9%). See the Central Daily News,

However, hiding beyond the glitter and the grand are many of the sources of Taiwan's current environmental problems. Huge population growth has also meant that population density has increased. In 1998, the figure was 608 people per km^2, making Taiwan's population density the second highest of al counties with over 10 million inhabitants. Moreover, density is highest in the cities which occupy a mere 12.2% of Taiwan's total land area; in urban areas, density rises to 3,800 people per km2 with Taipe topping the league at 9,582 per km2. This kind of population density generates noise and waste air, wate and materials in great quantity. When not carefully handled, environmental quality deteriorate unacceptably. For example, domestic effluent accounts for 40% of Taiwan's total waste water yet sewag works in Taipei and Kaohsiung only treat 9% of that and, even worse, less than 1% of it in Taiwa province. As a result, municipal sewage which is drained before being properly treated is the major caus of pollution of Taiwan's rivers.

As for the side-effects of economic development, Taiwan has lots of factories and in 1998 the numb rose, for the first time, to over 100,000, i.e., 2.71 factories per km^2. Factories naturally produce pollutii emissions which damage the environment. The amount of TSPs generated by factories accounts for 10 of Taiwan's total, and industrial effluent accounts for 30% of total waste water.[38] Furthermore, th energy consumption in 1998 was 73 million tonnes of oil equivalent - a 17-fold growth compared energy requirements 50 years ago. Transport demands have grown as well. The length of roads built h almost doubled from 16,000 kilometres in 1960 to 33,000 in 1998. As the number of vehicles on t roads have also rocketed, their CO and HC emissions are now the main source of atmospheric pollution Taiwan.

26th November 1998, p.4, Taipei, Taiwan.

[38] See EPA, *The Environmental White Paper*, 1998, p74.

As industry has thrived, so too has the amount of construction work; each year, an additional 150,000 houses and 100,000 commercial buildings are built. Yet TSP emissions from the building trade alone account for 17% of Taiwan's total and the noise and vibration of their construction add to the general cacophony. The more building there is, the greater the demand for construction sites: outer suburban mountain slopes, forests and cultivated fields are gradually being converted into residential or commercial building zones. As a result, Taiwan's forests have shrunk by over 2 million hectares, (about 5.5% of a reduction) compared to 15 years ago. As for urban land, 54% is for residential use, 2% commercial, 6% industrial, 22% agricultural and 29% protected. Agricultural land shrinks by 1% yearly and protected areas by about 2% annually (CEPD 1996, p.15). On 12th December 1997, the Legislation Yuan passed a draft document altering the regulations on how freely agricultural land could be put to other purposes. The buying and selling of this kind of land is now much easier than before; the land area which can now be opened up for other uses has reached 650,000 hectares (about two-thirds of Taiwan's total agricultural land). This is having a great impact on the use of agricultural land.[39]

Throughout this period, Taiwan economy has been undergoing a transformation: the upgrading and development of new production techniques is receiving a great deal of attention and economic incentives are being used to promote R&D on automation. In addition, concerted efforts are being made to save energy and resources (e.g., recycling of solid waste and waste water) and to reduce pollution.

E.5.1.1 Taiwan's shift from an Asia-Pacific Regional Operations Centre (APROC) to a Technical Island

In the face of international economic turmoil, the Executive Yuan has actively planned to make the best possible use of Taiwan's advantaged APROC position in the global marketplace. It is hoped that by using Taiwan's strong manufacturing foundations, excellent geographical location, huge marketing potential, proven managerial ability and extensive industrial networks, the country may continue to advance its

[39] Central Daily News, 13th December 1997, p.2, Taipei, Taiwan.

economic liberalisation and internationalisation programme. The aim is to persuade international or national enterprises that Taiwan is the best investment springboard into the East Asian markets.

The APROC includes centres for manufacturing, shipping and air transits, finance, telecommunications and medical care. Among these centres, the first three relate to the use made of land resources. For example, the manufacturing centre is to be developed into a comprehensive series of high value-added industrial estates all of which will affect how land is used. Or again, the plan for the air transit centre is premised on converting the area around Jiang-Kieh-Shyr international airport into an air city, which wil affect the region扱 land resources.

Using APROC as a staging post, the aim is then to consolidate improvements in Taiwan's level o sustainable economic development, to generate wealth which can be returned to the public purse, and t foster the kinds of talent-based industry which will enable the country to become a technical island b 2010.[40] However, the establishment of science parks has often been disputed by environmental group: For example, the Bin-Narn industrial estate requires 300,000 tonnes of water daily and the Tainan scienc park 160,000 tonnes - such a great quantity, in fact, that the Mei-Nurng dam needed to be built. Thus w can see that the decision to build these parks was not decisively influenced by their environment: impacts, for, in the case of the Bin-Narn development, there was an additional environmental proble raised, i.e., that it would destroy the natural habitat of the threatened Black-Faced Spoonbill. Clearly, eve science-based industry is not environmentally cost-free.

E.5.1.2 Changes in how Policy is Formulated

In 1996, the Taiwanese enjoyed their first opportunity to directly elect a president. Mainland China fearing that this prefigured the declaration of an independent Taiwan - initiated military exercises in t

[40] At present, Taiwan possesses 17 science parks, which occupy 3,300 hectares of land.

seas off Taiwan in an attempt to influence the election's outcome. The post was won by Deng-Huei Lee (a KMT candidate) with 54% of the vote. It appeared as if the status quo of policy-making would remain undisturbed for a while longer. However, as we have already seen, the mayoral/magistrate election of 1997 effectively ousted the KMT from local government for they only won eight out of 21 county and city seats.

The DPP, who were now the majority party at the local government level, lobbied the central government for further decentralisation of administrative powers. They also opposed certain central government decisions - most notably, the approval it had given to the German company, Bayer, to invest £1b in a TDI factory in Taichung (see Section 5.6.3).

With the central and local government administrations opposing each other, important topics were hotly contested prior to agreement being struck on the precise formulation of policy. In the 4th legislative election of 1998 the KMT only barely retained a majority (51%) forcing it to engage with the opposition to an unprecedented level. As a result, the formulation and implementation of environmental policy has become immensely more complicated.

E.5.1 3 Rocketing Land Prices and the Growing Gap between Rich and Poor

Amongst the "miracles" associated with Taiwan's economy[41], the historically narrow gap between rich and poor is notable. However, since 1990, the price of real estate has soared and, with speculators using land as an rapid-return investment opportunity, the gap between rich and poor is widening. The difference is especially marked between the rich cities and the poor rural areas, due in part to urbanisation and in part to unbalanced public investment across different regions of Taiwan.

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[41]In July 1998, Taiwan's foreign exchange reserves, at US$83.6 billion, were rated third highest in the world after Japan's and Mainland China's.

Both public investment levels and population densities have tended to cluster at the north and south of Taiwan. (As we saw earlier, Taipei's density is almost 10,000 people per km^2.) On the one hand, the environmental carrying capacity of the cities is overloaded. On the other, rural villages suffer from lack of infrastructure, migration to the cities, and changed land use, e.g., the over-planting of Bin-Lang on a mountain slope seriously damaged the area's ecology.

E.5.1.4 The Enlargement of Domestic Demand

The Asian economic crisis of 1997/8 did profound damage to many Asian countries' financial systems. Taiwan was not the worst affected; though its currency was devalued by 20%, it still fared better than Indonesia's (at 61.2%) and Korea's (at 53.88%).[42] Nevertheless, Taiwan economic growth rate dropped from 6.5% to 5.3%. The Executive Yuan's response to the crisis was to attempt to enlarge domestic demand and to stimulate the economy by means of several large-scale public investment projects. Between 1998 and 1999, the government invested £4 billion in a motorway, a large shopping mall, water resource engineering, etc. As this activity was primarily geared to re-energise domestic demand, the programme of change lacked an integrated approach to the management of environmental resources.

E.5.2 The Increasing Load Being Placed on the Environment

Taiwan's high level of economic activity coupled with its high population density is increasing the load on the environment daily.[43] We will examine this under the following headings:

E.5.2.1 The Worsening Environmental Load

As we have seen, by 1998, Taiwan's population density was 608 people per km^2, with over 77% of its people city-dwellers (see Table E-24). While average urban population is 3,800 people per km^2, Taipei has reached 9,582 people per km^2 and Kaohsiung's 9,340. This situation is generating immense quantities

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[42]Central Daily News, 5th January 1998, p.3, Taipei, Taiwan.

[43] See EPA, *Environmental Information on Taiwan, ROC* (Taipei, 1999), p.19.

of waste air, water and materials, substantially degrading the quality of life available in cities.

Table E-24: Taiwan's Population Statistics

Year	Population (person)	Growth rate of total population (%)	Density of population (person/km^2)	Natural growth rate (%)
1950	7,554,399	2.1	210	4.33
1960	10,792,202	3.5	300	3.95
1970	14,675,964	2.4	408	2.72
1980	17,805,067	1.9	494	2.34
1990	20,352,966	1.22	565	1.14
1995	21,304,181	0.84	591	0.99
1998	21,803,001	0.83	608	0.94

E.5.2.2 Factories and Pollution

The number of factories in Taiwan has risen from 21,301 in 1970 to 100,200 in 1998 - an average of three factories per km^2, and a five-fold increase on the 1970 figure (see Table E-25). Most are located in or near residential areas, thus compounding the damage their industrial pollution does to the environmental quality of city-dwellers. Almost all (96%) are small- to medium-sized and so are not sufficiently capitalised to afford the installation of high-quality anti-pollution equipment.[44]

Table E-25: Indices of Taiwan's Economic Growth

Year	Economic growth rate (%)	Average GNP per person		Number of factories	Factory density (km^2)
		US$	Stg.		
1950	9.50	145	91	NA	NA
1960	6.47	151	94	NA	NA
1970	11.27	360	225	21,280	0.59
1980	6.60	2,666	1,666	60,011	1.67
1990	5.39	8,111	5,069	92,978	2.58
1995	6.03	12,396	7,748	97,012	2.69
1998	5.30	13,060	8,163	100,200	2.78

Notes: £1 = US$1.6. NA means no data available

[44]See EPA, 1997a, p.356.

E.5.2.3 Increased Vehicular Pollution

In 1947, there were only 20,000 vehicles in Taiwan but, by 1998, this had risen to 15,860,000 - an average of 440 vehicles per km^2. This figure is double the number of 1987, i.e., the doubling occurred in the space of 11 years. Furthermore, the length of road has increased to 33,000 kilometres from 16,000 kilometres in 1960. As many routes are through ecologically sensitive mountain areas, road construction has taken quite a toll on environmental quality. Though modern transport trends clearly introduce a level of convenience which would have been unimaginable even 50 years ago, a price is paid in terms of the CO, HC and nitrogen oxide emissions from vehicle exhausts.

Cars are not the only culprits. With rising living standards, tourism is a major growth industry and this is having dramatic effects on the level of air transport Taiwan generates. In 1956, there were 6,213 landings and take-offs. By 1998, this volume had grown 114 times to 700,000 (see Table E-26), with a consequen increase in the noise and vibration endured by those living near airports.

Table E-26: Statistics on Taiwan's Traffic

Year	length of road (km)	No. of auto. vehicles (per 1000)	Density of auto. vehicles (vehicle/ km^2)	Frequency of air transport (plane)	Passage by air transport (person)
1961	16,291	60	1.6	8,296	136,791
1971	15,746	960	27	74,993	3,207,929
1980	17,522	5410	279	121,660	9,701,436
1990	20,042	1,0050	279	251,823	18,722,679
1995	32,197	1,3200	367	632,888	43,727,468
1998	34,251	1,5860	440	700,888	44,258,911

E.5.2.4 Mounting Waste and the On-going "Rubbish Wars"

Taiwan's volume of rubbish has risen from 4.8 million tonnes in 1985 (0.74kg per person) to 9.45 millic tonnes in 1998 (1.18kg per person). The operational life of landfill sites is becoming shorter as they fill u at an ever speedier rate. According to 1998 EPA landfill data, of 316 county and village landfill sites Taiwan, 82 are already full (17.7% of Taiwan's total), and sites which have more than two years

capacity left only account for 47.2% of the total, i.e. more than half will be full by the turn of the century.[45] New sites are very difficult to come by because nobody wants one located in their immediate vicinity, ensuring that policy decisions on solid waste disposal are exceptionally fraught. So called "rubbish wars" are now quite commonplace.[46]

E.5.2.5 The Use of Agricultural Pesticides

Agricultural methods have undergone radical change as pressure mounts to increase the productivity of a given area of cultivated land and the growth in use of pesticides, in particular, has severe environmental implications. In 1985 the volume of use of agricultural chemicals (e.g., pesticides, disinfectants, herbicides, etc.) was 33,667 tonnes but, by 1998, this had risen to 37,880 tonnes.[47] This long-term usage inflicts chronic damage on the environment. In addition, the use of chemical fertilisers to increase yield or the size of crop or to shorten the growing season has also increased. In 1951, the volume of fertilisers used stood at 343,892 tonnes rising to 1,387,630 tonnes in 1998 - more than a four-fold increase.

Consumer demand for meat and poultry has also risen. As Table E-27 shows, the number of pigs being fed for slaughter was 4,826,000 in 1980 rising to 10,511,000 in 1998 - a growth rate of 117%. Assuming that the pollution generated by one pig equals that of 4/6 people, pig farming is an almost unnoticed yet significant source of pollution for its quantity is twice to three times as high per unit as that generated by the human population.

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[45] EPA, *The Plan for Handling Rubbish* Taipei, 1998 , p.1.

[46] In March 1997, rubbish remained uncollected for 45 days in Tao-Yang city because a new landfill site had not yet been completed and local residents near the old (full) site prevented the city council from continuing to use it in the interim.

[47] EPA, *Environmental Information on Taiwan R.O.C.* Taipei, 1999, .p.23.

1971	NA	839,968	3,079
1980	33,667	1,335,889	4,826
1990	35,208	1,353,417	8,565
1995	37,137	1,382,139	10,509
1998	37,880	1,387,630	10,511

Notes: NA means no data available

E.5.2.6 Increased Energy Consumption

Taiwan's energy consumption in 1998 came to 73,508,000 kilolitres of oil equivalent, 17 times the level of 1961 (at 4,204,000). Petrol products and electricity are the main forms of consumption. Petrol products, which are closely linked to high-pollution industries such as oil refining and petrochemicals, are a major source of atmospheric pollution. As for electricity, average consumption per person in 1981 was 2,187 KWH but, by 1998, consumption had risen by 2.8 times to 6,305 KWH per person. As Table E-28 shows, 62% of Taiwan's electricity is generated by fossil-fuelled power stations. Coal-fired, oil-fired and gas-fired power generation produces pollutants such as HCs and nitrogen oxides which contribute to the formation of acid rain.

Table E-28: Taiwan's Energy Consumption (Unit: 10^3 Kilolitres of Oil Equivalent)

Year	**quantity of energy consumed**	**Electricity**				**average electricity consumption per person (degree)**	**average water consumption per person (m^3)**
		Amount	Water power	Fossil-fuelled	Nuclear power		
1961	4,204	1,259	702.7	556.3	0	NA	NA
1971	10,981	3,510.9	569.7	2,851.2	0	NA	NA
1981	27,793	9,760.2	1,115.7	6,160.4	2,484.1	2,187	75.80
1990	51,226	20,108.1	1,861.0	10,386.0	7,469.8	4,085	109.93
1995	69,267	27,631.3	2,018.8	16,939.3	8,029.2	5,702	120.81
1995	73,508	28,150	2,025	17,225	7,900.0	5,912	123.90

Notes: NA means no data available

Data Source: EPA, 1997a, p.24 and EPA, 1997b, p.79

E.5.2.7 Building Dams to Manage the Demand for Water

The demand for water has increased enormously from 15,072 million m3 in 1971 to 18,560 million m3 in 1998, an increase of 24%. Domestic water requirements can only be met by building dams and withdrawing underground water. The volume of underground water used has climbed from 4,105 million m3 in 1985 to 7,129 million m3 in 1998, an increase of 73%.

Over-pumping of surface water led to serious subsidence along the coast at Chia-Yi which caused sea water to flood the land. Yet if surface water is not an option, the only method for abstracting underground water is by building dams and these too have serious environmental effects. Reservoirs change the natural flow of submerged water which in turn alters what happens downstream. As we saw earlier, local residents objected to the construction of the Mei-Nung dam which was built to meet the water requirements of the Bin-Nan industrial estate and the Tainan Science Park.[48]

E.5.2.8 The Impacts of Global Environmental Protection

Now that problems like climate change and depletion of the ozone layer have gained international scientific credibility, global environmental protection has a global focus and is being actively promoted by the UN. In April 1995, the US Secretary of State, Warren Christopher, outlined an ideal whereby environmental protection would be treated as a leading diplomatic goal for the US (EPA, 1997a, p.1). Since the UN Conference on the Human Environment held in Stockholm in 1972, environmental issues have clearly arrived on the international political agenda; the following year the United Nations

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[48] On 31st August 1998, the public hearing on the Mei-Nung Dam project had to be abandoned because of the level of public protest.

Environment Programme (UNEP) was established. The intention was that UNEP would serve as an "International environmental watchdog", taking responsibility for monitoring global environmental change (Elliott 1999, pp.23-4). Apart from the international environment protection treaty, the international multi-trade organisation has also established an Environment Department in an attempt to combine multi-trade activities with environmental protection.

At present, there are about 180 international environment protection agreements, 20 of which include trade regulations. Agreements such as CITES, the Montreal Protocol, the Basel Convention, etc. have had an impact on how Taiwan proceeds with global environmental protection; several members of parliament and lobbyist NGOs push the government to achieve the goals set by these agreements, while other members of parliament and lobbyists for industrial and commercial interest groups query these treaties' power to impose trade sanctions. That latter group consider trade sanctions as trade protection in another guise (Industry and Commerce News, 11 Dec 1998, p.2).

Despite the opposite views held on these treaties, Taiwan cannot ignore global environmental protection issues partly because its environmental problems have been neglected for such a long time and more especially because it is a country oriented towards international trade. We have already discussed the embarrassment and trade sanctions it suffered as a result of its role in the trade of rare wild animals (Chio 1995, p.60). Swimming with the international tide, the government has begun to promote the slogan 'think global, act local', most especially in relation to the terms of the Montreal Protocol which is an international agreement to phase out the production and consumption of ozone depleting substances such as CFC11. By now, Taiwan has complied with this provision (EPA 1997b, p.335).

Another issue which is receiving positive attention in Taiwan is emissions of greenhouse gases - most notably, CO_2 which accounts for 57% of the sources causing climate change (Houghton 1990, p.10

However, CO_2 is mainly produced by burning fossil fuels and Taiwan has especially well-developed petrochemical industries, e.g. petrochemicals, steel-making, etc. Therefore, the Climate Change Convention is certain to have a marked effect on the future fate of constructions such as Bin-Nam industrial estate and Hai-Do and Peng-Hu fossil-fuelled power plants.

In 1995, five of Taiwan's major products were boycotted by CITES because of the country's careless regard for wild fauna and flora.[49] The Basel Treaty, which controls the cross-border movement of hazardous waste, has prohibited the Organisation for Economic Co-operation and Development (OECD) from exporting hazardous waste (including any recyclable kinds) to non-OECD countries since 31st December 1997. This is having a huge influence on Taiwan's export of industrial waste and its import of waste as a secondary material, e.g., in 1999, the Taiwan Chemical Corporation exported hazardous waste to Cambodia, which was heavily criticised by environmental NGOs.

E.5.3 The Emergence of Environmental Policy Premised on Sustainable Development

With the end of the Cold War, international trade has become much more important to each country's economic development yet in chasing niche markets within that global economy it has too often happened that local resources are abused, contributing to the havoc that is being wreaked on the global ecosystem. For this reason, sustainable development has become the keynote of current environmental policy world-wide and it is seen as the best way of laying the foundations for economic development in the next century (Chen 1997, p.11).

As discussed earlier, in 1992 the Earth Summit passed Agenda 21 which sketched out how sustainable development must be the way forward for the future. In signing up to Agenda 21, countries attempt to put that notion into practice. Towards that end, the Executive Yuan established the Policy Guidance Task

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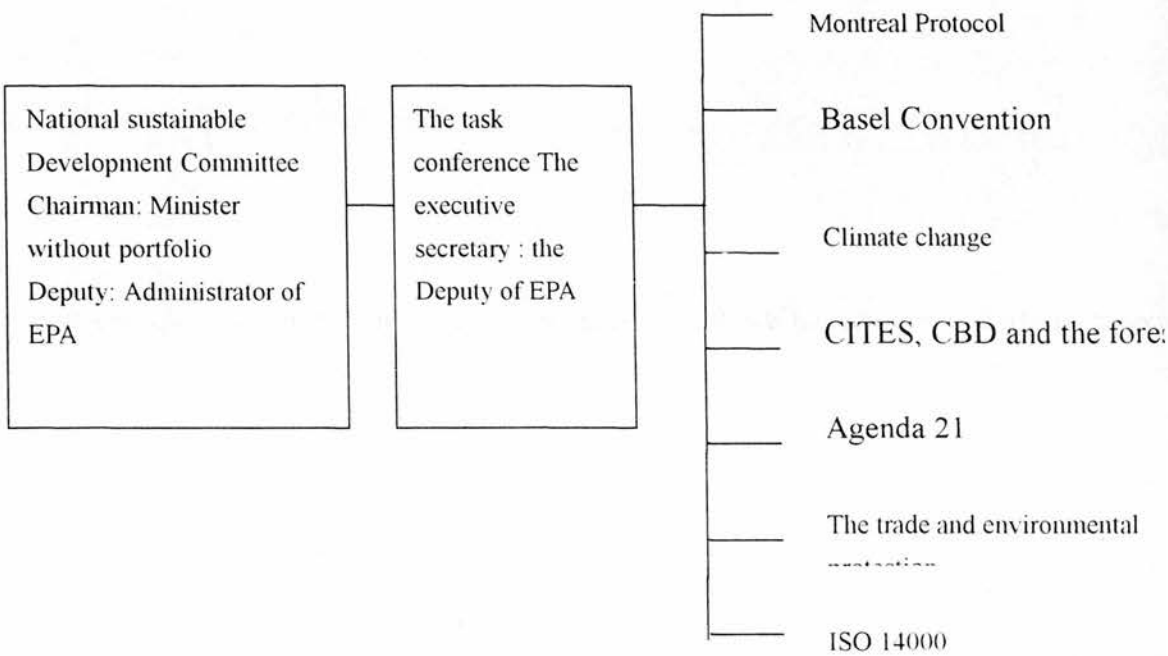
[49] See EPA, *Environmental White Paper* Taipei, 1997b, p.175-182; p.334-338.

Force for Global Change in 1994 and, in 1997, this task force was re-named as the National Committee for Sustainable Development (see FIG. E-9). Its sub-divisions include teams working on CITES, the Montreal Protocol, the Basel Convention, climate change, CBD, Agenda 21, ISO 14000 and trade and environmental protection.

FIG. E-9: The Structure of the National Committee for Sustainable Development



In 1998, the EPA published its mission statement on national environmental protection, declaring it purpose to be the prevention and control of pollution, the conservation of environmental resources, activ participation in both local and global environmental affairs, and the pursuit of sustainable developmen (EPA, 1998, p.5). In addition to statements made by the EPA and the Executive Yuan, the Legislativ Yuan has also declared that Taiwan actively promotes and attempts to improve sustainable developmen Clearly the notion of sustainable development is emerging as the consensual basis to environmenta protection, and is attracting the attention of several different economic sectors in Taiwan (Jeh, 1997 p.32).

E.5.3.1 Think Global, Act Local

To meet its over-arching goal, the global environmental protection movement is pursuing four types of strategy:

- the detailed terms of international environmental treaties are becoming both more concrete and more restrictive;
- countries which do not abide by them can be penalised, for treaties often have powers of sanction included in their articles;
- industrialised countries are expected to provide financial and technical resources to developing nations so that the latter can also address their environmental problems quickly; and
- R&D on environment-friendly techniques and products is encouraged so that "green products" may become the mainstay of consumption in the future (EPA 1997b, p.175).

In 1997, the Executive Yuan published a White Paper in which it declared that Taiwan would actively participate in advancing appropriate R&D, contribute to the detailed formation of treaty terms, adopt co-operative methods, and strengthen the public's awareness of the concept of 'think global, act local'.[50] Aided by this declaration of intent, the EPA has set up local Environmental Education Centres as the interface between global and national environmental concerns and local community-based action. These Education Centres aim to remind local residents associations, schools etc. that their communities are best placed to recapture or protect the best aspects of their history, culture and landscape and that it will be through their local actions that an environment can be recreated which is truly fit to live in.[51]

E.5.3.2 Changing Perceptions of Economic Development and Environmental Protection

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[50] See EPA, *Environmental White Paper* Taipei, 1997, p.178.

[51] This environmental policy which takes local community action as its administrative unit was announced by the EPA in 1997.

After several decades of prioritising economic development, Taiwan has now matured into a highly-educated and relatively wealthy society which can afford to embrace other policy goals. In 1992, environmental articles were added to Taiwan's constitution - a clear indicator that economic and scientific development would take environmental concerns into account. According to a survey conducted by the Ministry of Economic Affairs in 1995, only 12.5% of companies thought that environmental standards were too high[52], suggesting that even in industrial circles - where opposition to environmental protection measures might be expected to be strongest - a consensus has emerged that industrial growth need not be compromised by a concern with environmental quality. Government policy has adjusted accordingly: the Essential Policies on Current Environmental Protection clearly indicates that policy-making on economic development now treats environmental protection as a priority consideration.

Briefly, we can summarise the evolution of environmental policy as an initial concern with public sanitation. As industrial pollution was increasingly understood to be a major source of environmental damage, policy was then adjusted to address the prevention and control of pollution. Later, ecological conservation rose to prominence as a policy issue partly as a outcome of a series of natural catastrophes. For example, in July 1996, torrential rain caused a mud and rock slide in central Taiwan which buried 3 houses and caused other serious damage. It transpired that the houses were vulnerable to collapse as they had been built to a poor design on a hill slope. The most recent policy adjustment, as we have just seen, flowed from the international environmental movement which is finding expression in Taiwan, as elsewhere, in the concept of sustainable development.

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[52] See EPA, *Yearbook of Environmental Protection Statistics Taiwan ROC*, p.332/3, 1996.

E.5.4 Parliamentary Inefficiency Delays Environmental Legislation

E.5.4.1 The Legislative Yuan Undervalues Environmental Issues

With the EPA's inception in 1987 came a raft of legislative, organisational and educational plans to reduce pollution and, later, to promote environmental protection. Using economic incentives, it set out specific targets for meeting its goals in a phased way. In 1997 it announced the White Paper on the Environment; in 1998 the National Plan for Environmental Protection. Its mid- and long-term plans imitate the environmental policies formulated in the advanced countries. By 1998, 134 statutes and regulations had been passed in relation to environmental affairs, though only 11 of them needed to be passed by parliamentary review as most were types of administrative order. Currently, 13 environmental laws or amendments are still waiting to be reviewed by parliament.

Though the 1990-1995 stage was exceptional for its rich harvest of environmental legislation, most of the legal codes did not need to be processed through the Legislative Yuan (only seven did, in fact, require this legislative route). After 1995, parliamentary debate on environmental legislation slowed down considerably for, as we have already seen, Taiwan's political system was beset with the distractions of frequent elections, financial crises and parliamentary reform, e.g., the reformation of the Central National Assembly. Tabling the series of urgent debates which these factors brought in their train, the Legislative Yuan has neither had the time nor the pressure of urgency to pursue environmental law.

Given Taiwan's social, political and economic upheavals of recent years, it is not surprising that the newsworthiness of environmental issues has drifted from peak position both for the general public and for the Legislative Yuan. Table E-29 shows that in 1997/98 only 6.4% of parliamentary questions concerned the environment, i.e., on average, only one question posed per 17 members. Questions raised on domestic affairs, social welfare and education were much more prominent in this session: on average, every fifth or

sixth question related to one of these topics.

Table E-29: Statistics of Parliamentary Questions (4th and 5th Conference of the 3rd Session, 1997/98)

Policy Issues	Times	% of total questioning times 8620 times(%)	Ranking
environmental protection	555	6.4	7
economic affairs	876	10.2	4
defence	485	5.6	8
education	1534	17.8	2
domestic affairs	1178	13.7	3
social welfare	1716	19.9	1
policing	835	9.7	5
Mainland China	372	4.3	11
cultural construction	145	1.7	19
agriculture	330	3.5	13
diplomacy	300	3.5	17
labour	364	4.2	12
sanitation	445	5.2	9
traffic	680	7.9	6
public business	319	3.7	16
overseas Chinese affairs	37	0.4	21
political system	324	3.8	15
personnel system	330	3.8	13
financial system	409	4.7	10
judicial system	182	2.1	18
examining system	126	1.5	20
Total questions	8620		

Notes: The total number of questions comes to 8,620. Some questions cover more than one issue. Th table is based on the statistical database of the Legislative Yuan's questions (http://www.ly.gov.tw/).

Of the 555 questions on environmental policy listed in Table E-29, Table E-30 shows that 42% of the referred to local issues rather than broader environmental concerns. This level is not surprising sin members must respond to their electorate; issues of concern within their constituencies will, of cours find expression in parliament. Differentiating between types of environmental issue, we find th conservation of ecosystems accounted for the greatest proportion at 18%. This is because two mountai side catastrophes occurred in 1996 and 1998[53], which led to a high level of public discussion at the ti

[53] In August 1996, a typhoon caused a rock and mud slide in Nam-Tour county which drowned a whole

about ecological conservation. Table E-30 also shows that the disposal of rubbish was another prominent topic. Though waste disposal is, in fact, a local government issue which should not reach the national assembly level, the series of "rubbish wars" in Taiwan in recent years has ensured that the topic is now a national concern.[54]

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village. In July 1998, a flood in the south caused a serious landslide at A-Li Mountain and again additional mudslides in the Nam-Tour area

[54] In 1997, a landfill site was barricaded by the pubic in Taur-Yuam City, preventing the disposal of rubbish there. It was later found in the hillside surrounding Kaohsiung and Taichung, prompting another round of the on-going rubbish war.

Table E-30: A Breakdown of Types of Parliamentary Question Raised on Environmental Issues (same period as Table E-29 above)

Sectors	Issues	Times	% of total questioning times-550 times(%)	Ranking	total(%)
ocal	Air pollution	34	6.2	8	42.0
	Disposal of Rubbish	66	12.0	2	
	Landscape	57	10.4	3	
	Noise	22	4.0	10	
	Soil contamination	6	1.2	16	
	Water contamination	45	8.2	5	
	Ecosystem conservation	102	18.5	1	
ational	Fallen geological strata	14	2.5	11	41.0
	River pollution	17	3.1	12	
	Processing nuclear waste	4	0.7	18	
	Environmental education	6	1.1	16	
	Resources recycling	38	6.9	7	
	Usage and management of water resources	44	8.0	6	
nternational	cosystem of ocean	11	2.0	14	19.8
	xtinction of some species in he world	11	2.0	14	
	eforestation and depletion of atural resources	48	8.7	4	
	lobal warming	25	4.5	9	
	epletion of ozone layer	2	0.4	19	
	cid rain	12	202	13	

Notes: The percentage of total questioning time on each issue is obtained by dividing the total on environmental issues by 550. Some questions cover more than two topics. This table is based on the statistical database of the Legislative Yuan questions (http://www.ly.gov.tw).

E.5.4.2 Parliamentary Delays on Environmental Legislation

The legislative process in Taiwan is divided into the stages of proposal and review. The proposal stage is further sub-divided into proposal at the Executive Yuan and at the Legislative Yuan. For the latter, an issue can only be proposed if a set quota of legislators sign up for it. For the former, a ministry may submit the proposal and after it is reviewed by the Yuan's administration, it can then be submitted to the Legislative Yuan for review. At present, most bills are proposed by the Executive Yuan. The first stage in the Legislative Yuan's deliberations is to schedule the order in which different bills will be reviewed prior

to a First Reading taking place. After the First Reading, the bill is then handed to a relevant committee for further review. At present, environmental proposals are deliberated on by a committee comprised of representatives of Internal Affairs, Economic Affairs and Legislation.[55] The Second and Third Readings then follow.

Because of inefficiencies in the Legislative Yuan, hundreds of proposals have piled up in the proposal bottleneck and environmental bills - amongst others - remain trapped in the in-tray. Table E-31 shows that the Environmental Protection Bill has been languishing for over 10 years (4,225 days); the Vibration Control Bill has been delayed for nine years (3,577 days); and the amendment to the Drinking Water Management Regulation for 3,220 days.

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[55] See Yeh, *Environmental Policy and Law* Taipei, 1993, p.112.

Table E-31: Duration of Legislative Progress on Environmental Laws

Laws	Date reporting to Executive Yuan	Date of handing in to Legislative Yuan	Date of promulgation	Total duration of examination by Legislative Yuan (day)
Environmental protection	13/2/1988	31/5/1988	unannounced	4225+
Vibration control	21/6/1989	31/3/1990	unannounced	3577+
Prevention of soil contamination	22/4/1991	6/5/1992	unannounced	2789+
regulation on drinking water control	3/3/1990	5/3/1991	unannounced	3220+
environmental medicine control	20/11/1989	4/10/1990	unannounced	3371+
EIA Act	21/3/1989	21/8/1990	30/12/1984	1,672
toxic chemical materials control	7/12/1987	2/3/1988	16/11/1988	259
clearing waste materials	2/11/1987	20/5/1988	11/11/1988	174
water pollution prevention	22/5/1989	23/10/1989	6/5/1991	559
resolution of pollution disputes	12/12/1988	18/5/1989	1/2/1992	986
air pollution prevention	25/5/1989	14/11/1989	1/2/1992	807
noise control	8/6/1988	9/12/1988	1/2/1992	1147
organisation of EPA environmental inspection	24/11/1987	8/2/1988	24/5/1989	471
training of EPA environmental protection staff	26/1/1989	22/8/1989	7/12/1990	470

Notes: The total examination days of those still unannounced are counted till 1st January 2000. Where there is an announcement date, the total examination days are counted up to that point (the announcement date differs from the date on which the Legislative Yuan passed the proposal by less then 10 days).

Data Source: EPA, 1997a, p.648-654 and Yeh, 1993, p.114, Table 5

These environmental laws are closely related to the quality of everyday life, e.g., the drinking water management regulation, or the vibration control bill (especially in light of the boom in the construction industry). As for the law of environmental protection - the so-called "constitution of the environment" - it concerns the overall structure of environmental protection. Generally speaking, the more important the law, the longer it takes to be examined, e.g., the EIA Act took 1,672 days. On the whole, environmental legislation is not the highest priority for the Legislative Yuan, being superseded by a more pressing concern with passing laws on economic affairs.

E.5.4.3 The Delegation of Legislation and Stricter Enforcement Regimes

Owing to the bottleneck at the Legislative Yuan, the work is often delegated to an administrative authority as an executive order, i.e., the Legislative Yuan empowers an authority to set environmental standards, plan the areas to be subject to control, publish the toxic materials, etc.[56] Of the 134 judicial orders and regulations which currently exist, 123 of them were delegated in this manner. When the EPA is given the authority to establish legal codes, not only can the long queues of the Legislative Yuan be avoided but regulations can be quickly and flexibly adjusted according to the EPA's expert knowledge of the current situation.

When it comes to the enforcement of regulatory laws on the environment, the penalties for infractions have become much stricter; many carry monetary and/or criminal penalties. In 1995, £20 million was collected in fines. The law relating to water contamination is the one which has attracted the most criminal prosecutions: in 1995, there were 50 such cases resulting in 35 people receiving sentences of two

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[56] See Yeh, *Environmental Policy and Law* Taipei, 1993, p.118.

to six months imprisonment. There have also been 18 prosecutions against breach of the Drinking Water Act. 10 of which have resulted in similar sentences.[57]

E.5.5 The Administration of Environmental Affairs and the Reformation of Government

E.5.5.1 The Establishment of the Ministry of the Environment

We have already seen why pressure was building from the mid-'80s for the establishment of a Ministry of the Environment. When the EPA was formed in 1987 to handle environmental pollution, it suffered from two drawbacks: first, that it was a first-level subordinate organisation and lacked the clout of full ministerial power (especially when ranged against the might of the Ministry of Economic Affairs) and, second, that responsibility for aspects of ecological conservation and environmental integrity resided in several disparate ministries quite unrelated to the EPA's primary concern with pollution. What was lacking, therefore, was sufficient administrative authority and sufficient administrative integration. Increasingly, it was felt that the establishment of a Ministry of the Environment would redress those two short-comings and would also demonstrate the government's commitment to environmental protection. In November 1994, 13 environmental NGOs and 121 legislators jointly signed just such a proposal (an exceptionally large alliance of interest groups which broke the record within the Legislative Yuan, in fact).

In 1997, the IMD's statistics on global competence were announced and they revealed that Taiwan had dropped from 18th position to 23rd.[58] One of the main reasons for the slippage was administrative inefficiency. Thereafter reform of the system was geared at simplifying and rationalising government.

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[57] See *Yearbook of Environmental Protection Statistics Taiwan ROC*, p.326-329, EPA, 1996.

[58] Central Daily News 22nd April 1998, p.3, Taipei, Taiwan.

Apart from the decision to reduce the four-tier structure of government to three[59], organisational adjustments were made within and between departments. In April 1998, environmental protection groups again demanded the establishment of a Ministry of the Environment. On April 22nd 1998, the Prime Minister, Vincent C. Hsiao, directed the Task Force on Governmental Reform to set about establishing such a ministry. After 38 meetings, it was agreed to set up the Ministry of Environmental Resources which would take responsibility for environmental protection, the prevention and control of pollution, the protection of wild flora and fauna and the management of national parks. However, the conservation of water and soil in mountainous areas and national land planning were items excluded from its remit.

The imminent prospect of a new Ministry of Environmental Resources is another milestone for environmental protection. With its local agencies executing policies which have been formulated at the ministerial centre, it symbolises a new level of integration for environmental decision-making and consequent effective action. Furthermore, the trial establishment of the International Co-operative Bureau pulls global environmental concerns into the frame also. Table E-32 time-tables the main changes which the organisation of environmental affairs has undergone since 1971.

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[59] Government was originally divided into four levels (centre, province, county/city and village) but under the new system, the provincial level has been dropped.

Table E-32: Changes to the Administration of Environmental Affairs

March	1971	The establishment of the Environmental Sanitation Department in the Health Ministry
January	1982	The establishment of an Environmental Protection Bureau in the Health Ministry
July	1982	The establishment of an EPB in Taipei and Kaohsiung cities
August	1987	ex-EPB promoted to Environmental Protection Administration
January	1988	EPB of Taiwan Province promoted to Environmental Protection Department
July	1991	Local EPBs established in 21 counties and cities around Taiwan
November	1994	13 environmental NGOs and 121 legislators jointly sign a proposal to establish a Ministry of the Environment
July	1997	Local EPBs grow by two additional divisions
April	1998	The Prime Minister declares that a Ministry of the Environment will be established
August	1998	The Task Force for Governmental Reform decide on the form of the Ministry of Environmental Resources.

E.5.5.2 Strengthening the Hand of Local Environmental Agencies

Though local EPBs had been set up at county and city level since 1991, their success in implementing policy was limited. Firstly, they were understaffed. Taiwan had only 1,256 people working in the field of environmental protection - on average, less than 60 per county and city. Taiwan's environmental staff level per ten thousand of population was only one-third of the US's or the UK's. Secondly, the specific achievements of particular local EPBs depend on the stance adopted by the head of local government, e.g., the head of Yir-Larn county, a fervent environmentalist, resisted the central government's decision to build a sixth petrochemical factory. However, other local government heads have also been known to take a lax stance towards hillside developments which are environmentally sensitive. In addition, as local government administrations are supervised and have their budgets reviewed by public representatives, it is easy for the work of local environmental agencies to be affected by the views of those representatives or their local affiliations.

For these reasons, it has always been hard for local EPBs to have a high hit-rate. Recognising this, the Administrative Yuan agreed in 1997 to augment each of them by two additional divisions (Water Pollution Control and Environmental Inspection), thus adding an extra 600 staff nation-wide. While this is an

improvement, Taiwan's environmental affairs remain understaffed compared with the US and the UK. Table E-33 shows that, per ten thousand of population, Taiwan has only one person working in the field compared with two in the other countries.

Table E-33: Comparative Staffing Levels for Environmental Work

Countries	Central (per 10,000 pop.)	Local (per 10,000 pop.)
Taiwan	0.8-1.0	0.9-1.1
The US	0.46-0.6	2.1-2.14
The UK	0.8-1.2	1.8-2.1

Notes: Taiwan data is based on 1999 figures. US statistics are taken from EPA records; the UK's from DETR.

E.5.6 The EIA in Action

Since the passing of the EIA Act in 1995, local government has set about regulating how EIA committees should be organised for reviewing proposed projects, while the EPA has established the 21 types of project which come under the scope of the Act. The appointment of the EIA Committee Chair is the responsibility of the head of the county or city administration. As a result, review findings are critically shaped by the political affiliation and/or personal environmental stance of those executives. Some tend to be environmentalists first and last, suggesting that reviews conducted under their authority will come to strict conclusions; others are more mindful of industrial and commercial interests, suggesting that in these jurisdictions review procedures will be simplified and shortened so as to ensure that the region's investment environment is not threatened. However, regardless of the possible biases in the system at the detailed level, the EIA Act has undoubtedly aided the progress of the EIA system in Taiwan.

Between 1995 and the end of 1998, an average of about 89 cases a year submitted to an EIA. Of these, about 30% referred to high-rise buildings, new town developments and urban renewal projects, followed

by factories at c. 13 cases per year. The current average annual caseload indicates that a great many more cases are coming under the viewfinder of the EIA system since the passing of the Act.

Table E-34: The Development of the EIA System in Taiwan

December	1965	EPC translate American EIA system. EIA concept introduced to Taiwan for the first time
June	1978	Administrative Yuan convene first technical committee and suggest that the EIA system should be implemented as soon as possible
March	1980	Administrative Yuan ask Tai Power Company to submit an EIR on planned nuclear power plant
July	1980	The 1,692nd committee of the Administrative Yuan decide on some EIA trials and ask the Sanitation Agency to gradually establish an EIA system.
August	1980	Implementation of IA pilot plan at Da-Yuarn industrial parkî
July	1983	Draft EIA Act finished and reported to the Executive Yuan.
October	1983	The 1,854th committee of the Executive Yuan reject the draft
October	1985	Announcement of the Programme to Strengthen the EIA
January	1986	Regulation on conservation and use of hillside amended and announced. Article 30 regulates that mountainside developments need an EIA review - the first law passed by the Legislative Yuan on EIA execution.
July	1990	Executive Yuan finish EIA Act and hand to Legislative Yuan for examination
April	1992	Executive Yuan announce Subsequent Programme to Strengthen the EIA
November	1992	Joint Interior/Judicial/Economic parliamentary committee review EIA Act
December	1994	Parliament pass EIA Act on Third Reading
30th December	1994	President announces the EIA Act as law
November	1995	EIA standards on high-rises announced
December	1995	Main points for establishing an EIA review committee in Taichung City announced. The EIA system officially becomes law in local government
20th September	1997	Implementation of Operational Regulations of Government Policy EIA
27th May	1998	National Energy Committee decide CO_2 emissions need examination in important cases

E-5.6.1 The Emergence of a Consensus about the System

Every EIA review takes at least half a year, some as long as three years. As this process extends projects' development time and increases their costs, enterprises under review frequently contest the EIA's terms. Environmental protection groups - though positive about the system - are equally argumentative since they fear that the review procedures may be biased. As for the public representatives, most are anti-EIA because they think the system will negatively affect investment decisions. Most departmental budget-holders within the administration are also chary of the system on the grounds of its cost; to enable the project to be finished as soon as possible, they proceed with the EIA as superficially as they dare for fear of delaying schedules.

We can see that various internecine disputes about the system necessarily characterise how it is implemented, though they are no longer anything near as frequent as they were in the early EIA days. The reason for this is that the system has already proved its value though it took some natural disasters to truly bring the message home. Taiwan suffered from two strong typhoons, which caused serious flooding, landslides and mud and rock slides. Part of Shihn-Yih village in Nan-Tou county was buried and 35 buildings destroyed. Lin-Ken Grant Residency - a hillside community in Taipei county - also fell over in a landslide and 105 houses were completely destroyed. On examination, it became evident that in both cases the choice of site was potentially dangerous and the development plans were insufficient, and that both had been built prior to the establishment of the EIA system. The toll wreaked by these typhoons shocked the public into a recognition that the EIA system was necessary. In addition, US experience demonstrates that the cost of an EIA review increases construction costs by only 3% whereas the cost of post-disaster recovery represents 40% of the original cost of construction (Liu 1995,p.20).

E.5.6.2 Enlarging the EIA System; Introducing the SEA System

Despite the progress the EIA system has made, there are still some systematic problems with it, most notably how alternatives are assessed and how public participation is structured. Most EIA reviews occur at the point where the location and design of the proposed development have already been decided. Under these circumstances, all the review can do is modify the detail rather than permit a systematic investigation of alternatives. For example, in 1992 the proposal to build the Taichung Regional Shopping Mall was once of the items on the 6-year national construction plan of the time yet it was 1996 before the EIA committee came to review it, by which time most of the crucial design decisions had already been made.

Another criticism raised is that the system cannot address the cumulative impact of several developments (Therivel et al., 1996, p.8) since its unit of study is the individual project. This also limits the system's effectiveness. In Western countries, a SEA (Strategic Environmental Assessment) is conducted to compensate for the EIA system's limitations; the SEA aims to assess the "3Ps" of a project rather than its downstream progress.

In 1994, when the draft EIA Act was entering its Second Reading in the 24th conference of the Legislative Yuan, Bai-Xian Perng - a member of parliament - noted that some of the government important policies (e.g., vehicle exhaust emission standards, industrial effluent standards, urban renewal plans, formation of national parks, etc.) deal with issues which may have greater environmental implications that the development projects which the EIA systems targets. He argued that these kinds of issue should also be subject to some kind of EIA. His argument found favour and the 4th Article of the EIA Act states that governmental policiesî come within the range of the EIA system.

Based on the EIA Act, the EPA began drafting a manual for operating the SEA system and released a document - Operational Regulations for EIA Review of Governmental Policy - in September 1997 which marked out guidelines for implementing a SEA. However, as the detailed procedures for a SEA have not yet been established, the SEA system is not yet in use as a specific review mechanism.

E.5.6.3 An EIA Case Study

Bayer, a German company, planned to set up a tolylene di-isocyanate (TDI) factory in Tao-Yuan but, finding it difficult to find a site, switched the choice of location to Taichung port. For the factory to go ahead, agreement had to be found at the top three levels of government. At the highest level, the central

Ministry of Economic Affairs was involved in the foreign investment decision. Next, the proposal required the permission of the provincial government and council because it owned the land which Bayer wished to rent and because this administrative level is where factory approvals are issued. Finally, the local government of Taichung county was involved for the issuing of the building license agreement. FIG. E-10 outlines how the application proceeded. In total, the Bayer application needed to be passed by six authorities or committees; if even one of these was to withhold permission, the project would not go ahead.

The Bayer investment came in three stages: first, the investment was £230 million and productivity was estimated at 100,000 tonnes of TDI; next, MDI was to be produced and TDI productivity enlarged; and finally MDI and other forms of productivity were to be reinvested. Since Bayer is the 11th largest company in the world and its proposed investment huge, the project was welcomed by the central government. However, the local public had a different response, especially the residents of four villages nearby the factory. In November 1997 at the local county governor election a DPP candidate, Yong-Lia Liao, declared himself against the Bayer factory and said he would hold a referendum on it if he were elected. He won the election and held his ground on the promise of a referendum.

Most local people were against the project because of their fears of the effects of TDI production on public health and the local environment. However, by October 1996 the EIA committee of Taiwan Province had passed the Bayer's EIS and had requested that a second stage evaluation be carried out. The EIS review came to five decisions:

1. because the proposed site was on reclaimed land, the risk assessment of the stability of the soil should be reinforced;

2. Bayer must provide copies of the factory's safety system and environmental monitoring system so that local residents would have a transparent understanding of what exactly were the risks;
3. Bayer must hold public briefings and communicate with local residents;
4. the risk assessment of Taiwan's geological characteristics (typhoons, earthquakes, etc.) must be strengthened as such events may cause the emission of hazardous pollutants; and
5. Bayer's responses to the suggestions of the review committee must be included as part of the EIR.[60]

Bayer then held 60 public briefings to allay doubts about the factory's safety and its anticipated polluting emissions. While some were now satisfied, most locals (including the heads of the four villages nearest the site) remained adamantly opposed. When the Provincial Council met to review the case, a huge crowd of protesters gathered outside. After the public briefings had been conducted, Bayer's draft EIR was passed and the project now had the status of an approved proposal with some conditions attached. The draft EIR review had 19 suggestions attached including issues on the operation of the factory's safety system and that the factory's level of hazardous emissions must be lower than the legal standard requires.

The local public rejected the EIA committee's EIR review findings and it seemed certain that a referendum would be held. However, on 19th March 1998, Bayer announced its withdrawal of £1b of investment, ending the episode except for the acrimonious post-mortem exchanges between the various Taiwanese protagonists.

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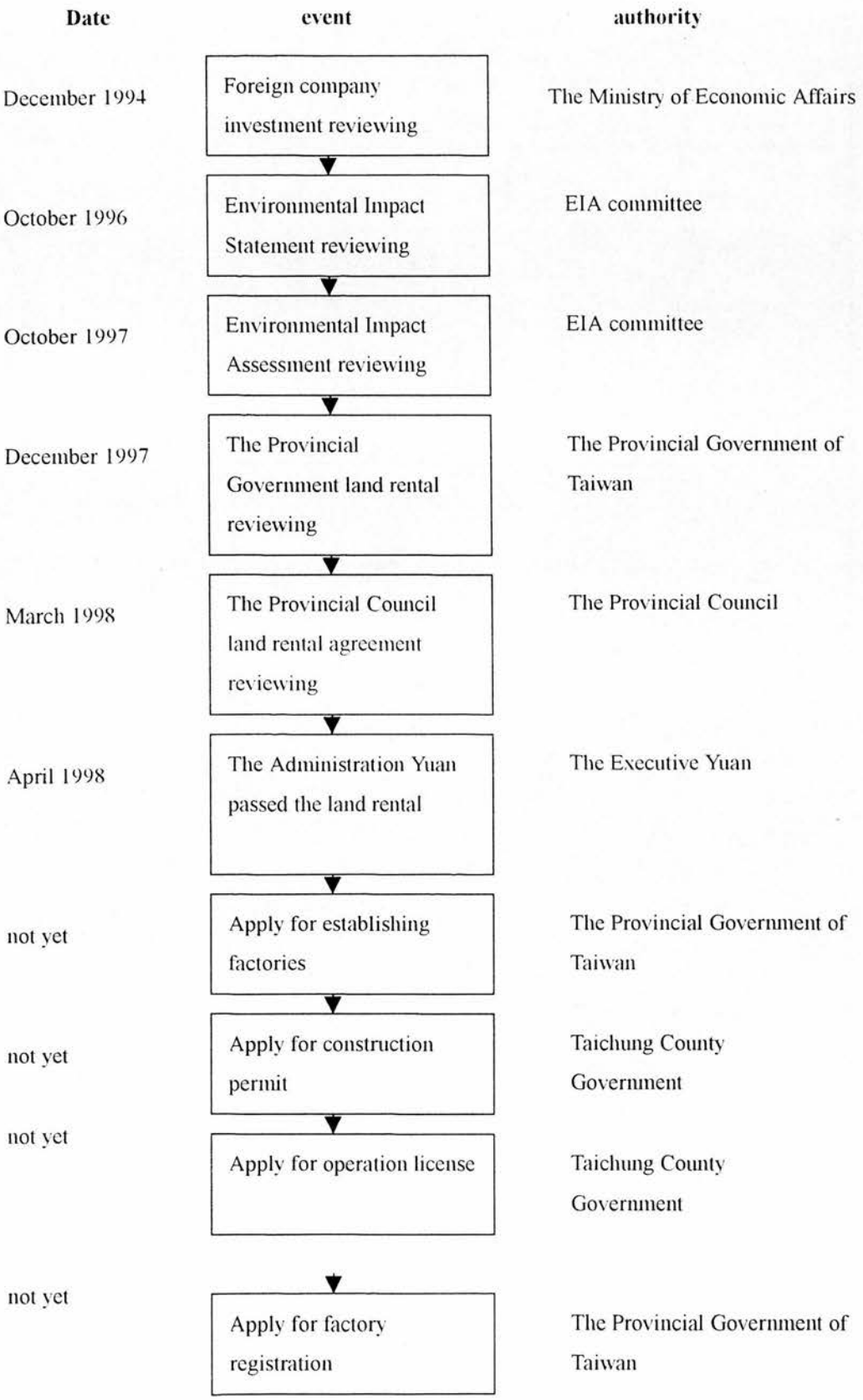
[60] These EIS review conclusions were announced by the Environmental Protection Department of Taiwan Provincial Government on 1st October 1996.

Table E-35: The Timetable of the Bayer Investment

July 1993	Bayer ask for support for a TDI investment at Guan-Yin Industrial Park in Tao-Yuan
August 1993	Bayer withdraw from that location when there is difficulty finding a site
September 1993	Bayer and the Ministry of Economic Affairs sign a co-operative contract of Asia Pacific Production and Sales Centre
January 1994	Bayer return to Industrial Bureau to re-propose the Tao-Yuan plan. Promised investment increases from £40m to £200m
March 1994	Bayer change location to Taichung port. The Industrial Bureau intend to rent the land to them
July 1994	Bayer visit Taiwan Provincial Government. Its governor, James Song, instructs the Construction Department to co-ordinate
December 1994	The investment review committee of the Ministry of Economic Affairs passes Bayer £200m investment
July 1995	The Ministry of Transport and Communications decide to provide Bayer with a 72-hectare site
September 1996	A high-ranking conference held in the Executive Yuan to co-ordinate Bayer investment
October 1996	Bayer hold 60 public briefings in Taichung county
October 1996	The EIA committee pass the EIS and begin the 2nd assessment stage
October 1997	The EIA committee pass the EIR and outline 19 conclusions
December 1997	The Foundation for Environmental Quality suggest that the EIA should be done by a third party
December 1997	The Provincial Government pass the land rental agreement with a 50-year expiry date
February 1998	A public opinion survey by TVBS shows that 64.8% agree and 15.8 % oppose
February 1998	The Provincial Council deliberates on Bayer land rental, a source of conflict between members of parliament
March 1998	The Provincial Council pass the land rental
March 1998	The head of Taichung County insists on holding a referendum to decide whether a construction permit should be issued
19th March 1998	Bayer announce that it is giving up the investment and withdraw £1b
May 1998	Taichung County Council cancel the referendum budget

FIG. E-10: A Flow Chart of Bayer Application



Bayer was a controversial case because of the huge investment sums involved and the hazardous nerve gases which could be released as a result of an emergency situation occurring in the production of TDI and MDI. Although Bayer repeatedly noted that the coefficient of the risk assessment of a factory emergency was below one death per million years of operation, the public continued to distrust the factory's industrial safety system. Even Bayer's passing of the EIS and EIR stages did nothing to assuage public fears. As a result, the very credibility of the EIA system was called into question. After Bayer withdrew, Taichung County Council cancelled the budget for the referendum of May 1998 thus forestalling this form of public participation - a pity, since public briefings are not two-way communications. This case is a good example of how the EIA review process occurs after the key decisions have been made, i.e., central government had already welcomed the factory and both the precise location of the site and the items to be produced in the factory were already determined. As a result, the EIA committee in this case had no alternatives presented to it from which an informed choice might be made.

APPENDIX F : ASSESSING ENVIRONMENTAL IMPACTS OF SO-GO BUILDING

The So-Go building is situated in the western area of Taichung City, at the intersection of Taichung-kan Road and Mei-tsui Road. This is the booming commercial centre of the city, with important roads connecting to outlying areas. The site area for this building is 4,694 square metres. It is 21 storeys high and has a total floor area of 79,523 square metres(Kua-San Company 1993, p.1.1.1). A department store occupies the first 16 floors while the upper storeys are used as office premises and mechanic operating rooms.

The building was constructed in 1994 and formally opened on November 11th 1995. Its Environmental Impact Assessment (EIA) report was approved in 1993 - the first time that the EIA system was applied to a high-rise building project of this kind.

F.1 A DESCRIPTION OF THE SO-GO BUILDING

F.1.1 The Building's Location

F.1.1.1 The Site Location

The building, located in the commercial centre of Taichung City at the intersection of Taichung-kan Road and Mei-tsui Road (see Figure 9-1, chapter 9), is surrounded by important roads -Taichung-kan Road, in particular - which link the city with outlying districts. It is only 1.5 km from the motorway and 3 km from downtown. This area is classified as a commercial zone in the city's urban plans. Both older and newly-built office blocks are located along both sides of Taichung-kan Road.

Since 1986, several new office blocks have been constructed along Taichung-kan Road. Twelve high-rise buildings (i.e. 15 storeys or higher) were opened in 1992 alone. As a result, this region is characterised by its concentration of office blocks. While there are two three-storey buildings on this site, the demands on space imposed by an urban environment mean that they are no longer appropriate for the area. By now, 88% of the available land in the vicinity has been developed.[1]

F.1.1.2 Status Quo of Urban Development

The growth and development of a city is hugely influenced by the incessant changes in urban activities. If urban development can be effectively controlled and resources invested efficiently, then the development process can be managed to the benefit of the whole area.

The population of Taichung City has grown from 470,317 to 916,381 over the past three decades (see Table F-1). Limited by how the city's planners had then zoned the urban areas, the rate of population growth slowed prior to 1980. Since that time, annual population growth is around 2% due to the active promotion of reclaiming land and of creating new urban hubs. By 1999, the population will reach 930,000. Analysing each part of the city, we can see that the inner city population has fallen while that of the western districts - Peitun, Nantun and Hsitun especially - has grown rapidly. This western region has now become the centre of a booming economy and a commensurate boom in office block developments.

Taichung's secondary and tertiary industries are well developed. Secondary industries account for 24% of employment while tertiary industries account for 68%. The industrial structure has gradually transformed itself into a service-oriented economy in line with the trend seen elsewhere in large metropolitan areas.

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[1] The average residence occupancy rate refers to the proportion of developed buildings to land that can be utilised for construction. The rate for this area is quoted from the EIA report of Kua-San Company (p.2-1-1, Kua-San Company, 1993).

F.1.1.3 Status Quo of the Traffic Adjacent to the Site

Because of the growth of the population and its economy, traffic management has become an issue of close concern. The distribution of roads around the site are shown in Fig. F-1 (see above). Taichung Kan Road is to the north of the site; Mei Tsui Road to the east; Alley 18 to the south; and Chon Mei Street to the west. The road system which is relevant to the site's location includes main thoroughfares such as Taichung Kan Road; Mei Tsui Road; Jiang Shin Road; Chong Ming South Road; His Tun Road; Gon Yi Road; In Tsai Road; and various streets and alleys nearby.

Taichung Kan Road is an important East-West route in Taichung. It connects the motorway, the Taichung Industrial Park and Taichung Harbour in the west with the inner city in the east, and is 40m to 60m wide. Jiang Shin Road is an inner circular road connecting the southern, northern and western areas through its North-South axis. It joins with Mei Tsui Road and commuters can access Zhon Hwa County in the south via Fu Hsin Road. Chon Ming South Road, a central circular road which is 30m wide, links the northern areas, Peitun and the southern areas. In Tsai Road, an inner circular road, is the major downtown North-South route. Features of the individual roads are described in Table F-2 below.

Table F-2 : Features of Main Roads around the Site

Name of Road	Width of Road (m)	Function	Volume (PCU)	Number of Lanes	V/C	Level of Service
Taichung Kan Road	60	Connecting Road	7984	8	1.09	F
Jiang Shin Road	20	Regional Road	2033	4	0.71	C
Mei Tsui Road	20	Regional Road	2061	4	0.88	E
Chon Ming South Road	30	Connecting Route	4366	4	0.71	C
In Tsai Road	20	Regional Road	2469	4	0.85	D

Note: PCU means passenger car unit V/C mean volume / capacity

F.1.2 The Construction Plan

The So-Go building is located in Taichung Kan Road. It has 21 floors above ground level and four underground floors and reaches a total height of 91 metres. The block houses a department store (which occupies the lower basement up to the 16th floor) and various offices (from the 17th floor upward). The plant rate of the building covered is 73.59%[2] and the total floor area is 79,523 square metres.

F.1.2.1 Allocation Principles and Design Concepts

With the exception of a parking lot in the north-western side of the site, the 21-floor building has a square block-like shape. As mentioned, its major application use is as a department store, with the lowest three underground floors being allocated as parking bays. The main gate faces Taichung Kan Road and Mei Tsui Road. The service entrance faces onto a six-metre wide alley, and the entrance/exit driveway for the parking area faces onto the 10-metre wide Chon Mei Street.

The principles underpinning the design of the building are safety, convenience and comfort. Special evacuation stairwells are allocated at the four corners of the building. Not only are they obviously located and signposted, but they are also safe and easy for customers to use. Elevators, built as vertical mobile lines, are at the main gate facing the intersection of Mei Tsui Road and Taichung Kan Road and are intended to be used by people who want to ascend directly to the higher floors. Escalators for transporting shoppers are installed at the centre of the building and they offer a continuously linked connection between all floors, including the lower basement.

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[2] The rate of building covered refers to the area of the ground floor divided by that of the sit. According tc Taiwan's urban planning regulations, this rate in a commercial zone cannot exceed 80%.

To manage and control the building efficiently, a central control station is located on the ground floor to monitor thefts and fire hazards and it is equipped to take appropriate preventive action. A freezing and treatment room disposes of 7.5 tons of rubbish each day.

The building is designed to appear natural, poised, tasteful and friendly. Special events can be hosted in the square in front of the department store. The colour scheme is warm and all the lower floors have demarcation barriers to reduce the scale of the space to a comfortable level. In the upper floors, lighter colours are used for the facades, which have horizontal inlet and outlet ports for air-conditioning. This three-dimensional internal landscape is truly a breakthrough in the design principles which typically underpin mall shopping with few windows (see Fig. 9-2, chapter 9).

F.1.2.2 The Plan for Mobile Traffic Lines

Many people visit department stores; the average number of trips is 13,733 daily. Thus, it is important to ensure ease of mobility in entering and exiting buildings. The So-Go building uses the principle of separating people and vehicles. It has distinct traffic management plans for pedestrians, cars, and motorbikes and for entry/exit routes to the parking bays.

In the pedestrian mobile lines, customers usually come by public transport and then walk along Taichung Kan Road and Jiang Shin Road. These customers enter the So-Go building by the pedestrian underpasses in Taichung Kan Road and Mei Tsui Road, a route which carries few implications for the vehicular traffic flow on those roads.

Entry and exit routes into parking lots often cause traffic congestion at those points. To reduce this hazard, the optimum choice is to place the access routes at locations which would otherwise carry relatively little traffic. The So-Go building uses the 10m wide Chon Mei Street as its vehicular entry/exit

route and as this is a local and non-thoroughfare street, this choice reduces traffic problems. As a centre of merchandise trading, the volume of usage of the car parks in the So-Go building has reached 309 cars per hour.

F.1.2.3 The Structural Plan of the System

As the building is sited on an earthquake belt whose risk status is in the mid-range, its plane is close to rectangular and it possesses a rigid frame with a brace. The structure of each floor is the same although the 15th and 16th floors are designed so that they can be re-assembled into one space with double the ceiling height for multi-functional conference uses. As Fig. 9-3 and 9-4 (chapter 9) show, the outline structure of the building is as follows:

- **Number of Floors** 21 above ground, four underground
- **Height** :4.6m floor-to-ceiling from the lower basement to the 4th floor. The ground floor is 5.4m tall, while the other floors vary from 4.2m to 4.9m. The total depth of the basement is 20.9m and the total height above ground is c. 91m.
- **Building Scale:** the 2nd and 3rd floors are about 60m long and 54m wide. The 4th through to the 21st floors are about 60m long and 50m wide.
- **Structural System** :the four basement floors and the ground floor are constructed with SRC columns, beams and shear walls, and have wave-like decks. Floors above the ground level are built as a rigid frame braced by steel columns and beams, using RC slabs.
- **Foundation :** floating foundation
- **Outer Wall:** metal curtain wall
- **Inner Wall :** light separate wall
- **Excavation of Basement :** in compliance with open cut

F.1.2.4 The Landscape Plan

As Taichung Kan Road is critical to the city's financial and commercial life, and the So-Go building is coincidentally situated at its heart, So-Go's architecture must cope with the wide roads around the area and blend in with the street's existing buildings. Consequently, the So-Go project needed to strike a balance between the 'look' of its landscape while being mindful of the building's volume and height.

Located at the central point of Taichung Kan Road - implying that So-Go is the street's natural visual focus - the architects' aim was to design So-Go as a regional landmark for shoppers. Thus, the building takes advantage of a three-dimensional shape within the confined square space of Taichung Kan Road. Its characteristics indeed make for a strong visual statement (see Fig. 9-5, chapter 9).

To cope with the mass gathering of people in the shopping areas, as well as to enable festivals to be staged out front, the pavement along Taichung Kan Road was narrowed by 15 metres; evergreens have been cultivated at the main square; and the ground outside is paved with marble to reinforce a humane and friendly urban atmosphere.

F.1.2.5 The Disaster Prevention Plan

The Disaster Prevention Plan is sub-divided into four categories: preventive facilities; alarm equipment; fire-fighting equipment; and escape facilities. The core issue in the first instance is to prevent problems from escalating into disaster scenarios (the main thrust of the Preventive Facilities section of the plan). In the event of difficulties, the Alarm Equipment section of the plan calls for early intervention. The Escape Facilities section presents solutions for the safe and speedy evacuation of the area if it were to become necessary, while the Fire-fighting Equipment section devises methods to minimise casualties and fatalities.

Table F-3 outlines the specific nature and location of the fire prevention and fire-fighting armoury. The central control station, with its electronic monitoring equipment, lies on the ground floor. Two designated lifts for use in emergencies can move from the lowest basement levels up to the highest floor. Emergency escape stairways and exit points are scattered throughout the building to facilitate multi-directional routes to safety.

Horizontal and vertical fire blocks are set into the building's structure. On every floor, the maximum walking distance to an escape route is limited to 35 metres. Should fires occur, the air inlet ports of the designated emergency stairwells automatically pressurise so as to prevent the in-rush of smoke and so facilitate a smooth evacuation of the area. From the 10th storey down, the outer walls of the building are equipped with escape windows, which enable evacuees to reach the ground directly.

Table F-3: Fire Alarm & Fire Protection Equipment

Use Item	Parking lot	bazaar	Public place(office)	Indoor(office)	Roof
Fire alarm system	●	●	●	●	
Emergency P.A. System	●	●	●		
Emergency Exit Signs	●	●	●		
Emergency Power Supply	●	●	●		
Exitway Lighting	●	●	●	●	
Stand Pipe System	●	●	●		●
Automatic Sprinkler System		●	●	●	
Automatic form System	●				
Smoke control System	●	●	●		

Data Source: Kua-San Company, 1993, P. 4-6-2.

F.2 PREDICTIONS ABOUT THE ENVIRONMENTAL IMPACT OF THE DEVELOPMENT

F.2.1 The Physical Environment

F.2.1.1 The Topography and Geology

The general terrain of this region is flat. There are two three-storey detached houses in the immediate vicinity. While some of the land around is open as yet, there are many developed streets in the area. During the construction of So-Go (which was excavated to a depth of 20.9 metres) the local topography changed in the process. The construction and refilling work involved in undertaking the project served to generate new shapes and spaces. The new building complies with the design principle of creating elegant curves and conveys a sense of space and greenery. Thus, the original features of the terrain have been completely transformed and a beautiful visual landscape has taken its place.

Geologically, the soil on this site is a mix of pebbles, grit, stones and rock and thus acts as bedrock with good load-bearing capacity. However, although the site was excavated to a depth of 20.9 metres, the work was somewhat constrained by the existence of roads near the site. For this reason, the adverse cast method was used in the construction of the foundations to reduce the likelihood of subsidence and to allay any negative knock-on effects from the movement of terrain nearby. Once the ground floor was built, it served a dual purpose as the depository for building stocks and as the operational area for the remaining construction work. Accordingly, the maximum differential settlement was about 2.9 cm with a diagonal variable of 1/897, which is within the allowed range. As a result, the task of building So-Go actually had very little impact on the existing soil and geology of the site(Kua-San Company, 1993, p.7.5.1).

The volume of surplus soil came to 98,700 cubic metres as the site area was 4,694 square metres and the excavated depth was to 20.9 metres. If the coefficient of the consolidation of soil is 1.15, then the volume

of the residual soil comes to 113,500 cubic metres. As the construction of the foundations took 100 days, 1,135 cubic metres of soil were produced daily. This soil was sent to a gravel plant for re-cycling and was reprocessed as sand and stone for use as concrete (Kua-San Company, 1993, p.6.6.3).

F.2.1.2 Hydrology and Water Quality

The natural water table of the site runs three to four metres underground during the dry season and one to two metres underground during the rainy season. Thus, the water level needed to be siphoned below the excavation surface during construction. Areas adjacent to the site and within the building were required to draw off water, section by section. So, prior to each stage of construction, the underground water level had to be reduced to approximately three metres below the excavation surface. The estimated radius for lowering the water level was within 500 to 1,000 metres. However, as the pumping out of underground water was a temporary measure, the construction work did not appear to have a huge impact on the integral underground water near the area.

Each day, about 200 construction staff worked on the site with about 50 of them living there also. Their estimated water consumption per person per day was about 30 litres and 350 litres respectively, resulting in a daily waste water rate of 22 cubic metres. Their sewage was treated and disposed of through the waste water treatment facilities.

During the operational phase of the project, underground water does not need to be drawn off as its level is no longer relevant. However, the building in use generates 400 cubic metres of sewage daily (Kua-San Company, 1993, p.4.2.5), meaning that the volume of waste water is 0.0046 cubic metres per second. After being sterilised and treated at the sewage disposal plant, it drains into the Mei Chuan river.

In addition, as the ground surface is paved over, drainage is affected. In the rationalised formula (Q = C x I x A / 360), the coefficient of run-off (1) is 1.0; the area of the water-gathering basin (A) is 0.65 hectares; and the intensity of rainfall (I) is 343 mm/hr in the Taichung area. From this formula, we know that the volume of surface water is 0.6 cubic metres per second. The capacity of the rainwater sewers near the site is 3.6 cubic metres per second. Thus, the run-off volume of the storm drains is more than adequate for the site.

F.2.1.3 Air Quality

F.2.1.3.1 Air Quality during the Construction Phase

The construction phase can be subdivided into three processes: land clearance, underground excavation and construction of the superstructure. The emission factor set down by the Environmental Protection Administration (EPA) is multiplied by the duration of the construction work and by the area being redeveloped. As Table F-4 outlines, this formula indicates the amount of particulate pollutants produced at each of the construction stages.

TABLE F-4: Emission factor of Total Suspended Particulates(TSP)during Construction phase

			Emission Factor	Construction Duration (Day)	Construction Area (m^2)	Total Exhaust Volume (kg)	Emission factor Of TSP ($g/m^2/s$)
Underground Excavation stage	excavation		0.1206 kg/m^3	100	4100	11903	1. 1.0084x 10^{-3}
	Bare surface Of the earth Inside the Construction Site		4.257x 10^{-4} kg/m^2/day	100	1200	51	1.4757x 10
Construction stage		Construction Period	424 kg/m2/ month	300	3100	13144	4.9074x 10
		Bare surface Of the earth Inside the Construction Site	4.257x 10^{-4} kg/m2/day	300	600	77	1.4781x 10
	Depositing field of surplus soils & Construction materials		4.257x 10^{-4} kg/m2/day	300	200	26	1.4781x10

Notes: a. Emission factors are quoted from the statistics data provided by EPA in 1996.

b. Daily operating time is sited on eight hours.

The air pollution produced by building plant can be estimated by combining the exhaust output of all the construction machinery being used, resulting in a figure of 0.2205 g/s of TSP (Total Suspended Particulates); 1.0684 g/s of CO; 2.77 g/s of Nox; 0.3112 g/s of Sox; and 0.1749 g/s of HC. Based on this estimate, particulate pollutants seem to generate the largest exhausts (Kua-San Company, 1993, p.9.3.6).

Simulating the influence of TSPs on the environment during the underground excavation stage, we find that air pollution was mainly confined to areas at or near the construction site. The maximum average annual growth was 1.7 ug per cubic metres, found around the south-western side of the site. The maximum average daily growth was 4.9 ug per cubic metres, found at the south of the site (Kua-San Company, 1993, p.9.3.7). This is shown in Table F-5 below.

Table F-5 : Concentration of TSP Simulation during Construction Period

Stage	Average Time	Background Concentration (a) (ug /m^3)	Background Concentration (b) (ug /m^3)	Synergistic Concentration (μg /m^3)	Air Quality Standard (μg /m^3)
Excavation Stage	24 hours on the average	186		190.9 190.0	250
	annual average		126	127.7	130
Construction Stage	24 hours on the average	186		188.9	250
	annual average		126	127.1	130

Notes:(a) The background concentration is the maximum value measured on the site site.

(b) The background concentration is the annual averaged TSP of air quality in Taichung in 1993.

Data source: Kua-San company, 1993. P9-3-5

The particulate pollution problem improved significantly during the construction of the superstructure, as this mostly involved manipulating a steel frame structure. The maximum average daily growth fell to 2.9 ug per cubic metre and the maximum average annual growth to 1.1 ug per cubic metre. It probably goes without saying that the annual average value found at this third phase of construction was quite close to the normal standard of air quality.

F.1.3.2 Air Quality during the Transportation Phase

Transportation vehicles generate air pollution through their exhausts and the TSPs they emit. The formula for calculating the TSP level of the exhausts is described as follows:

$$Q = (Q1 + Q2) \times V$$

- Q1 refers to TSPs emitted by vehicles, at an emission factor of 3.00 g/km per car.

- Q2 refers to other sources, including the surface dust on cars and roads which is thrown into the air as the vehicles move.

$$Q2 = (3 \times 10\text{-}6)\ S \times L \times W$$

- S refers to the mud on the surfaces of vehicles (5%).
- L refers to the dust on the road (150 lb/mile).
- W refers to the weight of the vehicles (20 tons).

Thus Q2 = 12.8 g/km.

- V refers to the frequency of vehicles per day.

Surplus soil amounts to 113,500 cubic metres (8 cubic metres per car). With the construction phase taking 100 workdays, this results in 140 daily trips and a round trip makes 280 in total.

Q = (3.00 x 12.8) x 280/8/3600 = 0.153 g /km.sec. = 153 ug /km.sec.

Exhaust of waste air :

- Q = emission factor x daily trips

If the velocity of vehicles is 40 km/hr and the emission factor for SOx, NOx and CO are 1.303 g/km/per car; 16.92 g/km/per car; and 7.31 g/km/per car respectively, then

SOx = 1.131 x 10-2 g/s/km

NOx = 1.468 x 10-1 g/s/km

CO = 4.772 x 10-2 g/s/km

The dispersion of each air pollutant can be estimated through the following formula.

$$C = \frac{2Q}{(2\pi)^{1/2}\ \mu\ \sigma_2 \sin\theta} \text{ EXP } [-1/2\ (H/\sigma_2)^2]$$

The results are shown in Tables F-6 and F-7. The increased concentration of TSPs is 14.2 ug per cubic metre. SO2 is 0.34 ppb; NOx is 6.8 ppb; and CO is 3.7 ppb within 50 metres of Taichung Kan Road (Kua-San Company 1993, p.9.3.7).

Table F-6 : Emission factors of Air Pollutants from Transportation Trucks

unit : g/km

Velocity of speed (km/hr)	Particulate Pollutant	SO_x	NO_x	CO
10	3.00	1.303	27.45	22.27
15	3.00	1.303	24.47	17.7
20	3.00	1.303	22.11	14.32
30	3.00	1.303	18.82	9.88
40	3.00	1.303	16.92	7.31
50	3.00	1.303	16.07	5.81
60	3.00	1.303	16.13	4.95
70	3.00	1.303	17.09	4.52

Data source: EPA, 1993, p.3.141.

Table F-7: Dispersion Concentration of Air Pollutants Resulting from Transportation trucks during Construction Stage

Type of Pollutant / Distance (m)	TSP (μg/m³)	SO_x (ppb)	NO_x (ppb)	CO (ppb)
10	51.10	12.6	23.1	12.8
20	30.8	0.75	13.8	7.8
30	22.10	0.54	10.0	5.6
40	17.1	0.44	8.1	4.4
50	14.2	0.34	6.8	3.7
60	12.7	0.31	5.7	3.2
70	11.2	0.27	5.2	2.8
80	10.4	0.25	4.2	2.5
90	9.4	0.23	4.0	2.2
100	8.1	0.21	3.6	2.0

Data source: Kua-San Company, 1993 P. 9-3-8.

F.2.1.3.3 Air Quality during the Operational Phase

Estimated exhaust pollutants derived from increased traffic volume during the operational phase of the SO-Go building are outlined in Table 8. This estimate takes the velocity of a car as being 40 km/hr with emission factors of TSP, SOx, NOx and CO as being 0.2075 g/km, 0.116 g/km, 2.07 g/km and 29.39 g/km respectively. Table 8 shows that the concentration of various pollutants is highest on Taichung Kan Road and that the maximum increased concentration during peak hour is 59.33 PPb of Nox.

Table F-8 : Increased Concentration of Air Pollutants in Adjoining Roads during Operational Stage

Name of Road	From - To	Maximum Increased Concentration Per Hour During Peak Hour			
		TSP ($\mu g/m^3$)	SO_2 (ppb)	NO_2 (ppb)	CO (ppm)
Taichung Kan Road	Mei Tsui Road – Avenue	10.65	2.31	56.20	1.31
	Mei Tsui Rd. – Chon Ming Rd.	11.36	2.34	59.33	1.39
Mei Tsui Road	Taichung Kan Rd. – Chang Chun St.	3.16	0.77	16.80	0.41

Data source: Kua-San Company, 1993, p 9-3-9.

F.2.1.4 Wind Field

The impact of the construction on the surrounding micro-climate mainly refers to changes in the direction and velocity of the wind field. Generally speaking, the atmosphere at the top of a tall building has a higher dynamic pressure than is found on the ground (1 ~ 2 m.), and the velocity of the wind is faster too. As air is obstructed by the building, the air current will flow towards either side and down towards the site of the building. In addition, the air has a stronger momentum coming as it does from a higher stratum. Therefore, wind velocity increases at the site of the building. This is hardly a problem when the prevailing wind is a soft breeze. But if the building is designed inappropriately, turbulent currents and

strong winds can be felt by pedestrians when the weather picks up a bit. So this issue of the wind field should be taken most seriously in designing the building to minimise pedestrians' discomfort.

How a pedestrian reacts to the feel of the wind varies depending on the regional climate and on the person's age, health, clothing etc. In addition, whether pedestrians experience the breeze as comfortable or not will also vary depending on what they are actually doing on the street. For example, a wind velocity of 0 ~ 17 km/hr is comfortable while sitting; 0 ~ 25 km/hr while standing; and 0 ~ 32 km/hr while walking. A wind velocity of between 32 ~ 95 km/hr makes people feel uncomfortable; when it rises above 95 km/hr it feels dangerous. Wind tunnel studies indicate that if the wind velocity is between 0 ~ 32 km/hr more than 80% of the time (about 5.6 days per week), then it can be judged to be within the 'comfort zone' where activities such as sitting, walking and standing are agreeable or acceptable. If the wind velocity exceeds 32 km/hr more than 20% of the time (about 1.5 days per week), then the windy place will be experienced as uncomfortable. And if the wind velocity exceeds 95 km/hr more than 0.1% of the time (i.e. about four such events occurring per year), then the windy place will be deemed to be dangerous.

As the height of the So-Go building is under 100 metres, there was no requirement for a wind tunnel testing process to be instigated. However, we can take as a reference the results of the wind tunnel tests conducted on a high-rise opposite So-Go which was built at the same time. These tests found that there is an 87% chance of ground-level gusts of less than 30 km/hr and a 76% chance of ground-level gusts of less than 22 km/hr.[3] This shows that changes of wind velocity still lie within the comfort zone. That is to say, the wind field in the neighbourhood will not produce strong and turbulent gusting.

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[3] Wind scales are in compliance with the Beaufort Scale, modified by the RWDI company in Canada. These serve as the measure for judging the wind tunnels of buildings. For the wind tunnel results, refer to Chung-Kan Company1993.

F.2.1.5 Noise and Vibration

The noise problem was most evident during the construction phase of the project, coming primarily as it did from the transportation vehicles and plant machinery. As the noise made by the construction machinery ceased as each stage of the work was completed, its impact was temporary. Generally speaking, if the change of sound intensity is less than 3dB(A), this will be barely detectable by the human ear, while an increase of 10db(A) is broadly perceived as a doubling of loudness (Morris et al. 1995, p.50). Consequently, a 0 ~ 5dB(A) level of increased noise due to construction work is deemed to have only a slight impact which requires no mitigation measures. If the increased noise level lies between 5 ~ 10dB(A), then we can consider it to have a medium impact which might need mitigation measures. More than 10dB(A) of an increase is regarded as having a major adverse impact which will certainly require noise mitigation measures or the use of alternatives.[4]

Excavators and dump trucks are the main machinery deployed during the construction stage. The noise produced by an excavator at a distance of five metres is 97.8dB(A) and the distance between the excavating site and the nearest building is 20 metres. Thus, as Table F-9 shows, the attenuated noise level is 85.8 dB(A).

Table F-9 : Maximum Noise levels of Various Operating Machinery in Different Distances During Construction Stage , Unit : dB(A)

Name of Operating Machinery	**Noise level 5 metres from Sound source**	**Noise level 10 metres from Sound source**	**Noise level 20 metres from Sound source**	**Noise level 40 metres from Sound source**
Generator	93.6	87.6	81.6	75.6
Water Pump	83.9	77.9	71.9	65.9
Electric Welding Kan	86.4	80.4	74.4	68.4
Dump Truck	84.1	78.1	72.1	66.1
Pick-up Truck	87.0	81.0	75.0	69.0
Belt Crane	89.7	83.7	77.7	71.7
Excavator	97.8	91.8	85.8	79.8
Bulldozer	87.8	81.8	75.8	69.8
Roller	80.0	74.0	68.0	62.0

[4] Refer to You-Jiuh Company , 1997, pp.7-26.

Data source: You-Jiuh Company, 1997 P. F-27.

In 1993, the level of background noise at this spot was measured to be 64.4 dB(A).[5] From this, we can derive the following formula for noise attenuation:

$$Leq = L1 + 10 \log10 (1+10 -(L1-L2)/10) \text{ (adding two noise sources)}$$

$$Leq = L0-10 \log (Dn/Do) 2 \text{ (noise attenuation)}$$

- Leq: noise level of the receiver
- L1 and L2: noise source
- Lo: noise level of sound source
- Dn: distance between noise source and receiver
- Do: measured distance of noise source

From the formula, we discover that the noise level of the adjacent building was 73.4 dB(A) and that the noise level increased to 9 dB(A) - a level which lies within the medium impact category and which therefore requires preventive measures to be taken (Kua-San Company 1993, p.9.1.8).

The removal of surplus earth required the use of 140 trucks daily. In all, about 160 vehicles were back and forth at the site each day when we include vehicles delivering building materials during the construction phase. Each day, over the course of an 8-hour day, 20 vehicles per hour travelled into and out of the site. The noise made by these vehicles can be estimated using the formula described in the EPA's Noise Control Manual.

$$Lí = 10 \times \log (1/3600) \times \{[3600 \sim (N \times T) \times 10Leq/10] + N \times T \times 10Lc/10\}$$

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[5] This noise level data was requested by the EIA Committee and was made available to the EIA Review team when the So-Go Building was being assessed by them.

- Li: Leq level of hourly operation
- N: entry and exit number of vehicles
- T: delay span of transportation vehicles on sensitive roads (assume 8 seconds)
- Lc: noise level of transportation vehicles at a spot one metre away from the road of 75 dB(A), assuming the vehicles' speed is 40 km/hr.

The calculated results are shown in Table F-10. The greatest noise was experienced between 10am and 11am, at a noise level of 5.0 dB(A) (Kua San Company 1993, p.9.1.11).

Table F-10 : predicted noise levels and hourly variations in increased noise from transportation vehicles during the construction phase

Unit : db(A)

Period	Leq	Predicted level	Increased level
8:00 ~9:00	59.3	63.5	4.2
9:00 ~10:00	58.1	63.1	5.0
10:00~11:00	58.0	63.0	5.0
11:00~12:00	62.7	65.0	2.3
13:00~14:00	61.5	64.4	2.9
14:00~15:00	60.3	63.9	3.6
15:00~16:00	64.1	65.9	1.8
16:00~17:00	61.5	64.4	2.9

Notes: 1. Measuring spots are at Alley 18 and Mei Tsui Road.
2. The predicted level is calculated with 20 vehicles per hour.
Data source: Kua San Company 1993, p.9.1.9

As for vibration, the construction period suggests several possible sources. However, being short-term, they are often ignored. General vibration activities include earthwork, excavation work and the use of

various other plant. Table F-11 lists the vibration levels of particular construction machinery as measured at different distances, using measures devised by the Environmental Administration of Japan.

Table F-11 : Suggested Vibration levels of building plant

Name of Constructing Machinery	Vibration level (dB)	
	5 Metres	10 Metres
Board Breaker	84	79
Large-scale Breaker (pneumatic)	-	70
General Breaker (pneumatic)	68	61
General Breaker (oil pressed)	-	70
Steel-balled Destroyer	71	69
Bulldozer	75	71
Drill for Ground Digging	53	53
Hole Excavator	65	57
Reverse Machine	-	58
Press-in Excavator	55	55
Hammer of Diesel Oil	82	80
Vibrating Hammer	90	82
Falling Hammer	85	79
Dump Truck (20 tons)	58	56

Data source: Kua-San Company, 1993 P. 9-2-4.

The formula for the attenuation process of distance is as follows[6]:

$$VLr = VLo - 20 \log (r/ro)n$$

VLr: the vibration level of the spot at r metres from the vibrating source; r (m)

VLo: the vibration level of the spot at ro metres from the vibrating source; ro (m)

Since the geology of Taichung is pebbles, grit, rock and stones, every doubling of distance results in an attenuated level of 3-5 dB. Of all the machinery used at the site, the bulldozer had the greatest vibration level of 75 dB (from a distance of five metres). The vibration level of buildings 20 metres away from Alley 18 was 60 dB. This level has some impact on the human body, but not enough to affect sleeping as Table F-12 shows.

Table F-12 : Vibration impacts on buildings and people's ordinary living environment

Vibration level	Weather Administration Of Japan	JIS of Japan	
	Scale of Earthquake	Physical Impact	Sleeping Impact
Under 55dB	Scale 0 – senseless	Frequent slight gravity	---
55 – 65dB	Scale I – slight vibration	Start to feel vibration	No sleeping impact
65 – 75 dB	Scale II-light vibration	---	Shallow sleepers are Aware.
75 – 85 dB	Scale III-weak vibration	Factory workers sense Uncomfortable for Eight (8) hours.	Deep sleepers are Aware.
85 – 95 dB	Scale IV-medium vibration	Human body starts to have physical impact.	Deep sleepers are Aware.
95 – 105 dB	Scale V-strong vibration	Significant physical Impact	---
105 – 110 dB	Scale VI-violent vibration	---	---
Above 110 dB	Scale VII-extreme vibration	---	---

Data source:You-Jiuh Company, 1997, P. 7-29.

During the operational phase of the building, the main sources of noise are the air-conditioning, vehicles and general din from office premises. As the air-conditioning, cooling tower and machinery facilities are installed on the 20th and 21st floors, these do not have a significant impact on the building's users. Noise emanating from offices can be absorbed and improved through their interior trim. As for the noises from vehicles, the increased volume can be calculated using the method mentioned above, and results in an estimation of about 5 ~ 10 dB(A).

F.2.1.6 Waste and Residual Soil

Waste can be classified into general rubbish and specific types of effluent and discarded materials. The daily waste produced by the builders during the construction stage amounted to only 100 kg (200 people x 0.5 kg = 100 kg). Waste during the operational phase mainly comes from customers and employees. It is estimated that the number of shoppers visiting So-Go every day is around 14,000 and the building also houses 1,000 employees. This results in 0.4-0.5 kg of rubbish per shopper per day and 0.7 kg per

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° This formula is quoted from that applied by the Environmental Administration of Japan. Refer to the Kua-San Company, 1993, p. 9-2-3.

employee per day. Therefore, the daily waste for the building as a whole is between 6,300 and 7,700 kgs. Let us assume 7,100 kgs as an average estimate.

The car parks cover 9,843 square metres of ground. Assuming each square metre generates 0.005 kg of rubbish per day, 50 kgs need to be disposed of daily from the parking bays alone (Kan-San company 1993, p.4.4.2). Offices take up 6,362 square metres of space. If we assume that one person occupies 10 square metres, and that 623 employees are in the building on any given day, and that the daily rubbish produced by each person is 0.5 kg, the daily waste from the offices therefore comes to 320 kgs. As a result, during the building's operational phase, 7,500 kgs of rubbish need to be disposed of in the incinerator each day.

Specific wastes primarily refer to materials left over from the construction of the building and to the sludge produced at the sewage treatment plant during the operational phase. Discarded building materials such as metal, plastic and glass are recycled and reused. The sludge generated by the building in use amounts to about 14 cubic metres per day and this is assigned for treatment.

Residual soil refers to the earth that was shifted during the initial excavation of the site. It is estimated that the total amount of residual soil produced was 98,700 cubic metres, or 987 cubic metres of waste soil each day the building was under construction. This was delivered to a gravel plant for reprocessing into sand and stone prior to recycling.

F.2.1.7 Insolation

As high-rise buildings begin to dominate the urban landscape, cities' citizens are increasingly asserting their right to adequate sunlight. This concern about insolation refers to the beneficial psychological effect which warm sunlight has on residents and pedestrians as well as to the comfort people experience when

they are engaged in outdoor urban activities in the sun. Sunshine varies with the sun捉 path through the heavens. The sun passes through the intersection of the ecliptic and equator in the Spring equinox and again in the Autumn equinox. During this period, the sun rises in the east and sets in the west. After the vernal equinox, the sun moves northward along the ecliptic and reaches its most northerly point at the Tropic of Cancer at the Summer solstice (+23.5 degrees). During this period, the sun rises in the Northeast and sets in the Northwest. Following the autumnal equinox, the sun moves southward along the ecliptic and reaches its most southerly point at the Tropic of Capricorn at the Winter solstice (-23.5 degrees). During this period, the sun rises in the Southeast and sets in the Southwest. According to Article 24 of the Building Code, there should be more than one hour of effective insolation around the building on the Winter solstice.

The level of effective sunlight is assessed in compliance with the idea of the boundary of the sunlight/shadow frame. When the southern, south-eastern and south-western sides of a building receive sunlight, this results in a commensurate shadow boundary on the ground. It is the level of ambient light during the winter which is of greatest concern as the noon-time sun is then at its lowest angle of elevation. Therefore, the light falling on land adjacent to the north, north-eastern and north-western sides of a proposed high-rise building project should be taken into consideration during its construction.

The length of the insolation shadow from a building is related to the angle of elevation of the sun and the height of the building. It is calculated according to the following formula:

$$Sc = H/ (\tan SA)$$

Sc: length of shadow (m)

H: height of building (m)

SA: angle of elevation of the sun

The So-Go building is 91 metres tall and the projected length of its shadow during its operational phase can be calculated with the angle of elevation of the sun in winter as Table F-13 indicates.

Table F-13 shows that even on the Winter solstice (23rd December) when the noon-time sun is at its lowest angle of elevation and when So-Go therefore casts its longest shadow, the insolation duration can still last more than four hours on the buildings and lands around it (see Fig. 9-7 , chapter 9).

Table F-13: Analysis Chart of Insolation on Winter Solstice Day (December 23rd) at So-Go Building

Time	Azimuth of Sun	Height of Sun	Length of Sun Projection
0700 1700	SE 62° 33' SW	3° 05'	1689.4
0800 1600	SE 55° 16' SW	14° 49'	344.1
0900 1500	SE 45° 54' SW	25° 24'	191.6
1000 1400	SE 33° 41' SW	34° 12'	133.9
1100 1300	SE 18° 07' SW	40° 13'	107.6
1200	0°	42° 24'	99.7

Figure : sunshine analysis

Data source : Kan-San company , 1993, p 8-5-12

Note: The height of the building is 91 metres.

F.2.1.8 Interference of Electric Wires

Areas of electric wave disturbance are affected by the location, the building's distance, the transmitting capability of the broadcasting station, the terrain and nearby buildings etc. Generally speaking, the phenomenon of electric wave interference is identical with the behaviour of insolation obstruction. It can be divided into blocking obstacles and reflecting obstacles; the former being analogous to insolation obstructions and the latter to the glare caused by reflection. Both types are affected by buildings themselves and their specific locations and also by inappropriate materials being used on outer walls.

The prediction of the affected range of electric waves is determined by the height and width of buildings; by the elevation height; by the frequency of the electric wave of the broadcasting station; and by the distance between the broadcasting station and the target building (see Fig. 9-8, chapter 9).

The blocking distance resulting from the proposed building is D2 and its width is Wo. The calculation formula is as follows[7]

$$D2 = 1/ (1/d2 + 1/d2o) \qquad Wo = W + V_{D2}$$

- d2: the blocking distance (m) resulting from the horizontal transmission method of the electric waves (angle of elevation is 0o)

$$D2' = fw(H-h_2)/ 6\{Ex_1 * Ex_2/(H-h_2) + 16 (H-h_2) /W\} \; 10^{-(sl/10)}$$

- d20: the blocking distance (m) of optical theory

$$d20 = H-h2/ (b1-H)\, d1$$

- W: width of the building (m) vertical to the direction of electric waves
- H: height (m) of the proposed building
- f: frequency (MHz)
- h1: elevation height (m) of the electric wave broadcasting station
- h2: height (m) of the signal receiving antenna
- d1: distance (m) between the broadcasting station and the proposed building
- Ex1: intensity rate of the roof of electric wave between the building and the signal
- receiving spot (taking the impact of the ground reflecting waves into consideration)

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[7] The method for calculating the blocking of electric waves is to assume that the height of the building is less than half of the transmitting/launching station's height. Refer to Wu, 1992, p. 156.

The dispersion of each air pollutant can be estimated through the following formula.

$$C = \frac{2Q}{(2\pi)^{1/2}\ \mu\ \sigma_2 \sin\theta} \text{EXP}\ [-1/2\ (H/\sigma_2)^2]$$

The results are shown in Tables F-6 and F-7. The increased concentration of TSPs is 14.2 ug per cubic metre. SO2 is 0.34 ppb; NOx is 6.8 ppb; and CO is 3.7 ppb within 50 metres of Taichung Kan Road (Kua-San Company 1993, p.9.3.7).

Table F-6 : Emission factors of Air Pollutants from Transportation Trucks

unit : g/km

Velocity of speed (km/hr)	Particulate Pollutant	SO_x	NO_x	CO
10	3.00	1.303	27.45	22.27
15	3.00	1.303	24.47	17.7
20	3.00	1.303	22.11	14.32
30	3.00	1.303	18.82	9.88
40	3.00	1.303	16.92	7.31
50	3.00	1.303	16.07	5.81
60	3.00	1.303	16.13	4.95
70	3.00	1.303	17.09	4.52

Data source: EPA, 1993, p.3.141.

Table F-7: Dispersion Concentration of Air Pollutants Resulting from Transportation trucks during Construction Stage

Type of Pollutant / Distance (m)	TSP ($\mu g/m^3$)	SO_x (ppb)	NO_x (ppb)	CO (ppb)
10	51.10	12.6	23.1	12.8
20	30.8	0.75	13.8	7.8
30	22.10	0.54	10.0	5.6
40	17.1	0.44	8.1	4.4
50	14.2	0.34	6.8	3.7
60	12.7	0.31	5.7	3.2
70	11.2	0.27	5.2	2.8
80	10.4	0.25	4.2	2.5
90	9.4	0.23	4.0	2.2
100	8.1	0.21	3.6	2.0

Data source: Kua-San Company, 1993 P. 9-3-8.

F.2.1.3.3 Air Quality during the Operational Phase

Estimated exhaust pollutants derived from increased traffic volume during the operational phase of the SO-Go building are outlined in Table 8. This estimate takes the velocity of a car as being 40 km/hr with emission factors of TSP, SOx, NOx and CO as being 0.2075 g/km, 0.116 g/km, 2.07 g/km and 29.39 g/km respectively. Table 8 shows that the concentration of various pollutants is highest on Taichung Kan Road and that the maximum increased concentration during peak hour is 59.33 PPb of Nox.

Table F-8 : Increased Concentration of Air Pollutants in Adjoining Roads during Operational Stage

Name of Road	From - To	Maximum Increased Concentration Per Hour During Peak Hour			
		TSP ($\mu g/m^3$)	SO_2 (ppb)	NO_2 (ppb)	CO (ppm
Taichung Kan Road	Mei Tsui Road – Avenue	10.65	2.31	56.20	1.31
	Mei Tsui Rd. – Chon Ming Rd.	11.36	2.34	59.33	1.39
Mei Tsui Road	Taichung Kan Rd. – Chang Chun St.	3.16	0.77	16.80	0.41

Data source: Kua-San Company, 1993, p 9-3-9.

F.2.1.4 Wind Field

The impact of the construction on the surrounding micro-climate mainly refers to changes in the direction and velocity of the wind field. Generally speaking, the atmosphere at the top of a tall building has a higher dynamic pressure than is found on the ground (1 ~ 2 m.), and the velocity of the wind is faster too. As air is obstructed by the building, the air current will flow towards either side and down towards the site of the building. In addition, the air has a stronger momentum coming as it does from a higher stratum. Therefore, wind velocity increases at the site of the building. This is hardly a problem when the prevailing wind is a soft breeze. But if the building is designed inappropriately, turbulent currents and

strong winds can be felt by pedestrians when the weather picks up a bit. So this issue of the wind field should be taken most seriously in designing the building to minimise pedestrians' discomfort.

How a pedestrian reacts to the feel of the wind varies depending on the regional climate and on the person's age, health, clothing etc. In addition, whether pedestrians experience the breeze as comfortable or not will also vary depending on what they are actually doing on the street. For example, a wind velocity of 0 ~ 17 km/hr is comfortable while sitting; 0 ~ 25 km/hr while standing; and 0 ~ 32 km/hr while walking. A wind velocity of between 32 ~ 95 km/hr makes people feel uncomfortable; when it rises above 95 km/hr it feels dangerous. Wind tunnel studies indicate that if the wind velocity is between 0 ~ 32 km/hr more than 80% of the time (about 5.6 days per week), then it can be judged to be within the 'comfort zone' where activities such as sitting, walking and standing are agreeable or acceptable. If the wind velocity exceeds 32 km/hr more than 20% of the time (about 1.5 days per week), then the windy place will be experienced as uncomfortable. And if the wind velocity exceeds 95 km/hr more than 0.1% of the time (i.e. about four such events occurring per year), then the windy place will be deemed to be dangerous.

As the height of the So-Go building is under 100 metres, there was no requirement for a wind tunnel testing process to be instigated. However, we can take as a reference the results of the wind tunnel tests conducted on a high-rise opposite So-Go which was built at the same time. These tests found that there is an 87% chance of ground-level gusts of less than 30 km/hr and a 76% chance of ground-level gusts of less than 22 km/hr.[3] This shows that changes of wind velocity still lie within the comfort zone. That is to say, the wind field in the neighbourhood will not produce strong and turbulent gusting.

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[3] Wind scales are in compliance with the Beaufort Scale, modified by the RWDI company in Canada. These serve as the measure for judging the wind tunnels of buildings. For the wind tunnel results, refer to Chung-Kan Company1993.

F.2.1.5 Noise and Vibration

The noise problem was most evident during the construction phase of the project, coming primarily as it did from the transportation vehicles and plant machinery. As the noise made by the construction machinery ceased as each stage of the work was completed, its impact was temporary. Generally speaking, if the change of sound intensity is less than 3dB(A), this will be barely detectable by the human ear, while an increase of 10db(A) is broadly perceived as a doubling of loudness (Morris et al. 1995, p.50). Consequently, a 0 ~ 5dB(A) level of increased noise due to construction work is deemed to have only a slight impact which requires no mitigation measures. If the increased noise level lies between 5 ~ 10dB(A), then we can consider it to have a medium impact which might need mitigation measures. More than 10dB(A) of an increase is regarded as having a major adverse impact which will certainly require noise mitigation measures or the use of alternatives.[4]

Excavators and dump trucks are the main machinery deployed during the construction stage. The noise produced by an excavator at a distance of five metres is 97.8dB(A) and the distance between the excavating site and the nearest building is 20 metres. Thus, as Table F-9 shows, the attenuated noise level is 85.8 dB(A).

Table F-9 : Maximum Noise levels of Various Operating Machinery in Different Distances During Construction Stage , Unit : dB(A)

Name of Operating Machinery	**Noise level 5 metres from Sound source**	**Noise level 10 metres from Sound source**	**Noise level 20 metres from Sound source**	**Noise level 40 metres from Sound source**
Generator	93.6	87.6	81.6	75.6
Water Pump	83.9	77.9	71.9	65.9
Electric Welding Kan	86.4	80.4	74.4	68.4
Dump Truck	84.1	78.1	72.1	66.1
Pick-up Truck	87.0	81.0	75.0	69.0
Belt Crane	89.7	83.7	77.7	71.7
Excavator	97.8	91.8	85.8	79.8
Bulldozer	87.8	81.8	75.8	69.8
Roller	80.0	74.0	68.0	62.0

[4] Refer to You-Jiuh Company , 1997, pp.7-26.

Data source: You-Jiuh Company, 1997 P. F-27.

In 1993, the level of background noise at this spot was measured to be 64.4 dB(A).[5] From this, we can derive the following formula for noise attenuation:

$$Leq = L1 + 10 \log10 (1+10 -(L1-L2)/10) \text{ (adding two noise sources)}$$

$$Leq = L0-10 \log (Dn/Do) 2 \text{ (noise attenuation)}$$

- Leq: noise level of the receiver
- L1 and L2: noise source
- Lo: noise level of sound source
- Dn: distance between noise source and receiver
- Do: measured distance of noise source

From the formula, we discover that the noise level of the adjacent building was 73.4 dB(A) and that the noise level increased to 9 dB(A) - a level which lies within the medium impact category and which therefore requires preventive measures to be taken (Kua-San Company 1993, p.9.1.8).

The removal of surplus earth required the use of 140 trucks daily. In all, about 160 vehicles were back and forth at the site each day when we include vehicles delivering building materials during the construction phase. Each day, over the course of an 8-hour day, 20 vehicles per hour travelled into and out of the site. The noise made by these vehicles can be estimated using the formula described in the EPA's Noise Control Manual.

$$Li = 10 \times \log (1/3600) \times \{[3600 \sim (N \times T) \times 10Leq/10] + N \times T \times 10Lc/10\}$$

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[5] This noise level data was requested by the EIA Committee and was made available to the EIA Review team when the So-Go Building was being assessed by them.

- Li: Leq level of hourly operation
- N: entry and exit number of vehicles
- T: delay span of transportation vehicles on sensitive roads (assume 8 seconds)
- Lc: noise level of transportation vehicles at a spot one metre away from the road of 75 dB(A), assuming the vehicles' speed is 40 km/hr.

The calculated results are shown in Table F-10. The greatest noise was experienced between 10am and 11am, at a noise level of 5.0 dB(A) (Kua San Company 1993, p.9.1.11).

Table F-10 : predicted noise levels and hourly variations in increased noise from transportation vehicles during the construction phase

Unit : db(A)

Period	Leq	Predicted level	Increased level
8:00 ~9:00	59.3	63.5	4.2
9:00 ~10:00	58.1	63.1	5.0
10:00~11:00	58.0	63.0	5.0
11:00~12:00	62.7	65.0	2.3
13:00~14:00	61.5	64.4	2.9
14:00~15:00	60.3	63.9	3.6
15:00~16:00	64.1	65.9	1.8
16:00~17:00	61.5	64.4	2.9

Notes: 1. Measuring spots are at Alley 18 and Mei Tsui Road.
2. The predicted level is calculated with 20 vehicles per hour.
Data source: Kua San Company 1993, p.9.1.9

As for vibration, the construction period suggests several possible sources. However, being short-term, they are often ignored. General vibration activities include earthwork, excavation work and the use of

various other plant. Table F-11 lists the vibration levels of particular construction machinery as measured at different distances, using measures devised by the Environmental Administration of Japan.

Table F-11 : Suggested Vibration levels of building plant

Name of Constructing Machinery	Vibration level (dB)	
	5 Metres	10 Metres
Board Breaker	84	79
Large-scale Breaker (pneumatic)	-	70
General Breaker (pneumatic)	68	61
General Breaker (oil pressed)	-	70
Steel-balled Destroyer	71	69
Bulldozer	75	71
Drill for Ground Digging	53	53
Hole Excavator	65	57
Reverse Machine	-	58
Press-in Excavator	55	55
Hammer of Diesel Oil	82	80
Vibrating Hammer	90	82
Falling Hammer	85	79
Dump Truck (20 tons)	58	56

Data source: Kua-San Company, 1993 P. 9-2-4.

The formula for the attenuation process of distance is as follows[n]:

$$VLr = VLo - 20 \log (r/ro)n$$

VLr: the vibration level of the spot at r metres from the vibrating source; r (m)

VLo: the vibration level of the spot at ro metres from the vibrating source; ro (m)

Since the geology of Taichung is pebbles, grit, rock and stones, every doubling of distance results in an attenuated level of 3-5 dB. Of all the machinery used at the site, the bulldozer had the greatest vibration level of 75 dB (from a distance of five metres). The vibration level of buildings 20 metres away from Alley 18 was 60 dB. This level has some impact on the human body, but not enough to affect sleeping as Table F-12 shows.

Table F-12 : Vibration impacts on buildings and people's ordinary living environment

Vibration level	Weather Administration Of Japan	JIS of Japan	
	Scale of Earthquake	Physical Impact	Sleeping Impact
Under 55dB	Scale 0 – senseless	Frequent slight gravity	---
55 – 65dB	Scale I – slight vibration	Start to feel vibration	No sleeping impact
65 – 75 dB	Scale II-light vibration	---	Shallow sleepers are Aware.
75 – 85 dB	Scale III-weak vibration	Factory workers sense Uncomfortable for Eight (8) hours.	Deep sleepers are Aware.
85 – 95 dB	Scale IV-medium vibration	Human body starts to have physical impact.	Deep sleepers are Aware.
95 – 105 dB	Scale V-strong vibration	Significant physical Impact	---
105 – 110 dB	Scale VI-violent vibration	---	---
Above 110 dB	Scale VII-extreme vibration	---	---

Data source:You-Jiuh Company, 1997, P. 7-29.

During the operational phase of the building, the main sources of noise are the air-conditioning, vehicles and general din from office premises. As the air-conditioning, cooling tower and machinery facilities are installed on the 20th and 21st floors, these do not have a significant impact on the building's users. Noise emanating from offices can be absorbed and improved through their interior trim. As for the noises from vehicles, the increased volume can be calculated using the method mentioned above, and results in an estimation of about 5 ~ 10 dB(A).

F.2.1.6 Waste and Residual Soil

Waste can be classified into general rubbish and specific types of effluent and discarded materials. The daily waste produced by the builders during the construction stage amounted to only 100 kg (200 people x 0.5 kg = 100 kg). Waste during the operational phase mainly comes from customers and employees. It is estimated that the number of shoppers visiting So-Go every day is around 14,000 and the building also houses 1,000 employees. This results in 0.4-0.5 kg of rubbish per shopper per day and 0.7 kg per

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[6] This formula is quoted from that applied by the Environmental Administration of Japan. Refer to the Kua-San Company, 1993, p. 9-2-3.

employee per day. Therefore, the daily waste for the building as a whole is between 6,300 and 7,700 kgs. Let us assume 7,100 kgs as an average estimate.

The car parks cover 9,843 square metres of ground. Assuming each square metre generates 0.005 kg of rubbish per day, 50 kgs need to be disposed of daily from the parking bays alone (Kan-San company 1993, p.4.4.2). Offices take up 6,362 square metres of space. If we assume that one person occupies 10 square metres, and that 623 employees are in the building on any given day, and that the daily rubbish produced by each person is 0.5 kg, the daily waste from the offices therefore comes to 320 kgs. As a result, during the building's operational phase, 7,500 kgs of rubbish need to be disposed of in the incinerator each day.

Specific wastes primarily refer to materials left over from the construction of the building and to the sludge produced at the sewage treatment plant during the operational phase. Discarded building materials such as metal, plastic and glass are recycled and reused. The sludge generated by the building in use amounts to about 14 cubic metres per day and this is assigned for treatment.

Residual soil refers to the earth that was shifted during the initial excavation of the site. It is estimated that the total amount of residual soil produced was 98,700 cubic metres, or 987 cubic metres of waste soil each day the building was under construction. This was delivered to a gravel plant for reprocessing into sand and stone prior to recycling.

F.2.1.7 Insolation

As high-rise buildings begin to dominate the urban landscape, cities' citizens are increasingly asserting their right to adequate sunlight. This concern about insolation refers to the beneficial psychological effect which warm sunlight has on residents and pedestrians as well as to the comfort people experience when

they are engaged in outdoor urban activities in the sun. Sunshine varies with the sun捘 path through the heavens. The sun passes through the intersection of the ecliptic and equator in the Spring equinox and again in the Autumn equinox. During this period, the sun rises in the east and sets in the west. After the vernal equinox, the sun moves northward along the ecliptic and reaches its most northerly point at the Tropic of Cancer at the Summer solstice (+23.5 degrees). During this period, the sun rises in the Northeast and sets in the Northwest. Following the autumnal equinox, the sun moves southward along the ecliptic and reaches its most southerly point at the Tropic of Capricorn at the Winter solstice (-23.5 degrees). During this period, the sun rises in the Southeast and sets in the Southwest. According to Article 24 of the Building Code, there should be more than one hour of effective insolation around the building on the Winter solstice.

The level of effective sunlight is assessed in compliance with the idea of the boundary of the sunlight/shadow frame. When the southern, south-eastern and south-western sides of a building receive sunlight, this results in a commensurate shadow boundary on the ground. It is the level of ambient light during the winter which is of greatest concern as the noon-time sun is then at its lowest angle of elevation. Therefore, the light falling on land adjacent to the north, north-eastern and north-western sides of a proposed high-rise building project should be taken into consideration during its construction.

The length of the insolation shadow from a building is related to the angle of elevation of the sun and the height of the building. It is calculated according to the following formula:

$$Sc = H/ (\tan SA)$$

Sc: length of shadow (m)

H: height of building (m)

SA: angle of elevation of the sun

The So-Go building is 91 metres tall and the projected length of its shadow during its operational phase can be calculated with the angle of elevation of the sun in winter as Table F-13 indicates.

Table F-13 shows that even on the Winter solstice (23rd December) when the noon-time sun is at its lowest angle of elevation and when So-Go therefore casts its longest shadow, the insolation duration can still last more than four hours on the buildings and lands around it (see Fig. 9-7 , chapter 9).

Table F-13: Analysis Chart of Insolation on Winter Solstice Day (December 23rd) at So-Go Building

Time	Azimuth of Sun	Height of Sun	Length of Sun Projection
0700 1700	SE 62° 33' SW	3° 05'	1689.4
0800 1600	SE 55° 16' SW	14° 49'	344.1
0900 1500	SE 45° 54' SW	25° 24'	191.6
1000 1400	SE 33° 41' SW	34° 12'	133.9
1100 1300	SE 18° 07' SW	40° 13'	107.6
1200	0°	42° 24'	99.7

Figure : sunshine analysis

Data source : Kan-San company , 1993, p 8-5-12

Note: The height of the building is 91 metres.

F.2.1.8 Interference of Electric Wires

Areas of electric wave disturbance are affected by the location, the building's distance, the transmitting capability of the broadcasting station, the terrain and nearby buildings etc. Generally speaking, the phenomenon of electric wave interference is identical with the behaviour of insolation obstruction. It can be divided into blocking obstacles and reflecting obstacles; the former being analogous to insolation obstructions and the latter to the glare caused by reflection. Both types are affected by buildings themselves and their specific locations and also by inappropriate materials being used on outer walls.

The prediction of the affected range of electric waves is determined by the height and width of buildings; by the elevation height; by the frequency of the electric wave of the broadcasting station; and by the distance between the broadcasting station and the target building (see Fig. 9-8, chapter 9).

The blocking distance resulting from the proposed building is D2 and its width is Wo. The calculation formula is as follows[7]

$$D2 = 1/ (1/d2 + 1/d2o) \qquad Wo = W + V_{D2}$$

- d2: the blocking distance (m) resulting from the horizontal transmission method of the electric waves (angle of elevation is 0o)

$$D2' = fw(H-h_2)/ 6\{Ex_1 * Ex_2/(H-h_2) + 16 (H-h_2) /W\} \ 10^{-(sl/10)}$$

- d20: the blocking distance (m) of optical theory

$$d20 = H-h2/ (b1-H) \ d1$$

- W: width of the building (m) vertical to the direction of electric waves
- H: height (m) of the proposed building
- f: frequency (MHz)
- h1: elevation height (m) of the electric wave broadcasting station
- h2: height (m) of the signal receiving antenna
- d1: distance (m) between the broadcasting station and the proposed building
- Ex1: intensity rate of the roof of electric wave between the building and the signal
- receiving spot (taking the impact of the ground reflecting waves into consideration)

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[7] The method for calculating the blocking of electric waves is to assume that the height of the building is less than half of the transmitting/launching station's height. Refer to Wu, 1992, p. 156.

- Ex2: urban attention rate

From Figs. 9-9 (chapter 9), 9-10(chapter 9) and 9-11(chapter 9), we know that this building is 91 metres high and 54 metres wide; that the broadcasting station is situated at the top of Da Du mountain, which is about 600 metres high; and that the distance between Da Du and So-Go is about four kilometres. As Fig. 9-8 (chapter 9) shows, the basic blocking length is 500 metres (LO). Fig. 9-9 (chapter 9) reveals that the modified coefficient is 0.35 (C1). Fig. 9-10 (chapter 9) shows that the modified value under the frequency of 220 MHZ is 1.3 (C2).

Thus, the blocking length is as follows:

$D2 = L_0 \times C_1 \times C_2 = 500 \times 0.35 \times 1.3 = 227.5$ (m)

And the blocking width is:

$Wo = W + \sqrt{(D2)} = 54 + \sqrt{(227.5)} = 69$ (m)

Figure 9-12 (chapter 9) shows the extent of the electric wave blocking range by So-Go.

F.2.2 THE ECOLOGICAL ENVIRONMENT AND ENERGY

F.2.2.1 Depletion of the Environment for Fauna

This building is at the heart of a urban region and both the site itself and adjacent streets and blocks are all earmarked for redevelopment. As this is not a woodland environment - and, hence, not a natural habitat for wildlife - no particular species are threatened by the So-Go project. The only wildlife in evidence are some ordinary birds on the pavements.

It is possible that the vibration and noise pollution produced in the construction phase (though largely confined to the immediate vacinity of the site) nevertheless reduced the chances of birds flying nearby. However, this kind of disturbance was only temporary, and peace has since been restored.

Now that So-Go is in use, open spaces inside the site are preserved, and plants and trees have been cultivated along the pavements and in the locality's public park. Therefore, we can expect that the numbers of insects and birds will increase in the future and that the So-Go project should not have any significant impact on the pre-existing animal ecology.

F.2.2.2 Ecological Environment for Flora

As the site used to be grassland surrounding two old houses, it goes without saying that the grass and plants were removed during construction. However, as these were not rare or ancient species, So-Go has not had a significant impact on the local flora. To mitigate the increased dust landing on the trees lining the transportation routes during the construction phase, a water sprinkling system was put in place to reduce the impact. In addition, six trees lining the pavement in front of the site were especially protected during the course of the construction work. All in all, the process of building So-Go has had very little impact on the pre-existing floral ecology.

F.2.3 Energy Depletion

Two thirds of the island of Taiwan is steeply mountainous, with its rivers cascading into the oceans. Thus, despite abundant rainfall, only 21% of Taiwan's water supply comes directly from rain water. It is the water in the rivers, dams and underground which constitute the main reservoirs for domestic and commercial use.

During the construction of So-Go, 200 construction staff worked at the site every day - 50 of them actually lived there. They consumed 50 litres and 350 litres of water respectively each day. As a result, the daily water consumption was 22 CMD.

At the operational stage, the numbers of people using the building are estimated in terms of the functional use of different floors (e.g. shops, offices, car parks) and the estimated requirement for water is then based on those numbers. For example, one customer uses up 25 square metres of floor area in the car park (0.04 person per square metre); 1.5 customers occupy one square metre of space on the ground floor and the lower basement; and one customer occupies one square metre of space in the rest of the shopping floors. As Table F-14 outlines, 366 CMD of water are required every day.

Table F-14 : Estimation Table of Daily Water Requirement

Floor	Use	User	Effective Floor area (m_2)	Person / m^2	Liter/Per Day.Per Person	Demand M^3/Per Day	Total (M^3/Per Day)	Remarks
B4-B2	Parking Lot	Customer	9843	0.04	5	2	365.493 M	(not including cooling water of air-conditioning)
B1	Bazaar	Customer Employee	2576.90 2576.90	1.5 0.045	5 110	19.327 12.756		
1 F	Bazaar	Customer Employee	2005.77 2005.77	1.5 0.045	5 100	15.043 9.026		
2 F	Bazaar	Customer Employee	2113.10 2113.10	1.0 0.03	5 100	10.566 6.340		
3 F	Bazaar	Customer Employee	2106.30 2106.30	1.0 0.03	5 100	1.503 6.319		
4-10 F	Bazaar	Customer Employee	15279.46 15279.46	1.0 0.03	5 100	76.398 45.839		
11 F	Bazaar	Customer Employee	1950.21 "	1.0 0.03	5 100	9.751 5.851		
12-14 F	Bazaar	Customer Employee	6548.34 "	1.0 0.03	5 100	32.742 19.645		
15 F	Bazaar Offices	Customer Employee	569.58 " 1633.19	1.0 0.03 0.1	5 100 100	2.848 1.709 16.332		
16 F	Bazaar Offices	Customer Employee	547.69 " 722.70	1.0 0.03 0.1	5 100 100	2.738 1.643 7.227		
17-19 F	Bazaar Offices	Customer Employee	2571.96 " 3976.38	1.0 0.03 0.1	5 100 100	12.860 7.716 39.674		
20 F	Operating Room		1424.92					
21 F	Operating Room		518.63					

Data source: Kua-San Company, 1993 P. 4-2-4.

As for power requirements, once the building is completed, lights and sockets require 4,000 KW of power; general power uses up 1,500 KW; power for the air-conditioning accounts for 2,700 KW; and spare power (10%) comes to 800 KW. Consequently, the total power requirement is 9,000 KW. Power distribution rooms are installed on the lower basement and on the 9th floor to supply power to the whole building.

So-Go's delicatessens and restaurants are the main consumers of natural gas, using 150 cubic metres per day. If we assume that meal times span five hours, the requirement for natural gas is 30 cubic metres per hour. This figure is calculated as follows:

600 Kcal/meal x 2,225 people = 133,500 Kcal

1,335,000 / 8,900 Kcal/m3 = 150 m3

F.2.3 THE LANDSCAPE AND RECREATIONAL ENVIRONMENT

The western area of Taichung does not possess any especially noteworthy features in its landscape, though there are a few interesting buildings on Taichung Kan Road. As building sites are generally quite ugly to look at with their machinery; their stock-piles of building materials; their piles of earth; their assemblage of pre-fab huts and temporary houses; their bare steel structure etc., something more restful on the eye was needed for passers-by during the construction phase. The colour of So-Go's blocking fences around the site during construction was chosen to blend in with the background. And, the construction phase being relatively short, any impact on the environmental landscape was only temporary.

Because So-Go is almost 100 metres high and is located at a critical route to the city centre, it is an important visual focus-point. Indeed, the very shape of this building changes the street's landscape in an

important way for it was designed quite explicitly to develop a new kind of skyline in the locality. Two different volumes of design idea method of the upper and the lower building is adopted, so the facades are more flexible and changeable. Open spaces are retained to prevent pedestrians from feeling overwhelmed by its towering bulk and So-Go's skyline draws on - and substantially contributes to - the region's characteristic 'look'. Its use of colour is interesting, for it mixes dark and light patterns to diminish the gigantic feel of the edifice so as to generate an image of friendliness. So-Go was designed to look elegantly modern. The contours of its exterior are revealed and it suggests an evening-time ambiance through its nocturnal lighting equipment. Its graceful architecture and plentiful open spaces improve the environmental landscape greatly.

F.2.4 THE IMPACT ON TRAFFIC

F.2.4.1 Impact on Traffic during the Construction Phase

It took 400 days to build So-Go. As the entry and exit of construction vehicles and some of the building activities altered traffic flows, the level of the service quality (LOS) of surrounding roads was also affected. The traffic implications during the construction stage can be assessed by looking first at the knock-on effect of the entry/exit of construction vehicles and then at the impact of road occupation by construction plant during building work.

As mentioned before, So-Go is 91 metres high with a total floor area of 79,523 square metres. Building something this size engenders significant new traffic. During excavation, 160 trucks used the site daily if we include the lorries which were delivering materials to the site, generating traffic of 20 vehicles per hour. To allay some of the resulting snarls, the construction vehicles - with the exception of the earthwork trucks - were instructed to make their deliveries in off-peak hours. In addition, their routes to and from the site were distributed over three roads (50 metres wide, 20 metres wide, and 10 metres wide respectively).

When construction vehicles need to occupy the roads for a period, the traffic flow of certain lanes is blocked, forcing cars to change into other lanes. This necessity not only interrupts smooth traffic flow, but also reduces the number of available lanes. Together these diminish traffic capacity, influencing the level of service quality on the roads. To tackle this problem, it is advisable to build a supporting platform inside the construction site for storing machinery and materials. As far as possible, construction activities should only be performed within the site. However, building So-Go did impose some additional congestion on the slow lane of Taichung Kan Road during the construction period.

The area for disposing of excess soil is located in the Nan Tun district. During excavation, about 18 trucks per hour travelled back and forth - a rate of one earthmover per three minutes. To minimise their disruptiveness, these vehicles attempted to avoid using the roads at peak hours.

F.2.4.2 Predictions of Traffic Volume when So-Go is Operational

Land development spawns many kinds of economic activity which, taken together, create multi-functional transportation needs. These influence the traffic on the regional road system near the development. Thus, predicting the increase in traffic at or near So-Go is the main issue in assessing the building's impact on the local transportation infrastructure. The Aggregate Sequential Demand Model is the method most generally adopted for this purpose. It is divided into four procedures: trip generation; trip distribution; modal split; and network assignment. This model also combines the possible volume of journeys to the site with trips into the neighbouring road systems and further analyses the combined impact on regional roads after the site is developed. Figure F-13 outlines the process of assessing the impact So-Go has on traffic flow.[8]

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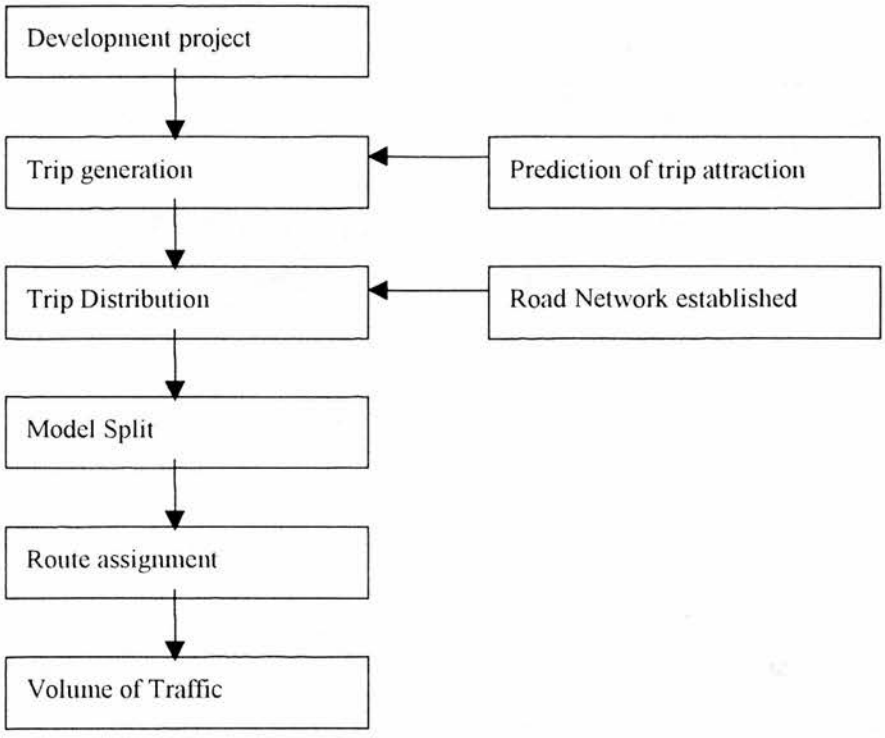
[8] Refer to Kua-San Company, 1993, p. 3-2-1 to 3-2-13.

FIG F-13 (flow chart of aggregate sequential demand model)



The purpose of this assessment is to estimate the number of journeys into and out of the site once it is operational. The analysis first depends on establishing the building's intended purpose and size. Then the number of trips per hour during peak hours to and from the commercial site are found. From this, the number of peak-hour journeys to and from all the relevant land area can be calculated. The formula is as follows.

$$T = \Sigma_j A_j * t_j$$

- T: the number of trips generated in the future
- Aj: the floor area of type 'j' of land use in the future
- tj: the number of trips of type 'j' land use per unit of floor area

The result:

- shops: 36,269 square metres * 0.1031 = 3,739 (people)
- offices: 6,332 square metres * 0.201 = 127 (people)
- total: 3,866 people

This finding indicates that So-Go will generate 3,866 trips per hour during peak hours. According to the report "the Mass Rapid Transit (MRT) System Project of Metropolitan Taichung" the coefficient of the peak time is 0.22. Consequently, So-Go will attract 17,572 (person) trips per day after the site is developed.

Table F-15 shows the rate at which trips are generated per hour during peak hours at a major commercial building. Table F-16 lists the distribution rates of the modal split for uses of the various shops and offices.

Table F-15 : Trip Rates per Hour during Rush Hours at Major Business Locations

Item Location	People & Trips During Survey Time (people/2 hrs)	Total Area Of Floors (100 m^2)	Trip Rate Per Hour During Rush Hour (people/100 m^2/hr)	Average Value
Lai Lai Dept. Store	1479	182.82	4.04	10.31
Long Hsin Dept. Store	3515	157.74	11.14	
Evergreen Dept. Store	2129	67.65	15.74	
National Hotel	743	200.20	1.86	1.48
Plaza Hotel	361	165.16	1.10	
Sun Tun Hun	57	13.87	2.06	3.62
New World Boutique	453	43.74	5.18	
Bank of Communications	306	2.00	76.50	44.29
Citibank	223	2.40	46.46	
Chinatrust Commercial Bank	732	36.96	9.90	
Bank of Shi Hwa	418	92.40	2.26	2.01
Kuo Tai Building	873	248.40	1.76	
Lotus Garden Restaurant	458	32.67	7.01	5.83
Jin Bee Yuan Restaurant	56	22.44	1.25	
Tsui Heng Cun Restaurant	133	7.20	9.24	

Data Source : taichung City Government, 1993, p.138

TABLE F-16: Distribution Rates of Model Split for Various Land Applications

Application Type / Model Split	Residence %	Dept. Store Supermarket %	Hotel %	Boutique Shop %	Financial Bank %	Business Building %	Large Restaurant %
Bus	6.8	8.52	0.81	0.00	0.83	0.90	0.11
Taxi Cab	0.6	10.61	10.58	1.21	4.06	3.82	12.02
Private Car	16.2	21.33	55.23	46.65	40.65	46.77	73.96
Motorbike & Bike	54.1	44.59	0.54	16.77	35.48	48.33	5.02
Others	22.3	14.95	32.84	35.37	18.98	0.18	8.89
Total	100	100	100	100	100	100	100

Data source: Taichung City Government, 1993, p.140

Table F-17 indicates the trips made via each modal type to So-Go's shops and offices during peak hours. Motorbikes are the most popular mode of transport, accounting for 1,728 trips, followed by private cars which account for 856 trips. Public transport is the least used mode, accounting for only 321 journeys - less than 10% of the total number of trips made. Table F-18 shows the loading rates of each of the major modes of transport.

TABLE F-17 :Statistics of People & Trips of Each Model Split Type per Hour at the Base during Rush Hour

Unit : people . trip

Application Of Building	Mass Transportation	Taxi Cab	Private Car	Motorbike	Others (walking)	Total
Office	2	5	59	61	0	127
Bazaar	319	397	797	1667	559	3739
Total	321	402	856	1728	559	3866

TABLE F-18: Loading Rate of Every Model Split

Type of Model Split	Bus	Taxi Cab	Private Car	Motorbike
Loading Rate	22	1.6	1.6	1.3

Data source:, You Jiuh Constructing Company, 1997, P. 7-36.

Based on those rates, Table F-19 indicates the increase in the volume of traffic broken down by mode of transport. It is estimated that 1,244 Passenger Car Units (CPUs) per hour visit and leave the site at peak hour every day. As the principle of consistent traffic flow is adhered to, the increased traffic volume is distributed onto roads near the site.

Table F-19 : Increasing Volume of Traffic after Developing the Base

Model Split	Bus	Taxi Cab	Private Car	Motorbike	PCU
Office	0	3	37	47	54
Bazaar	15	248	498	1282	1190
Total	15	251	535	1329	1244

Note: PCU stands for Passenger Car Unit. Based on a small private car, a big truck is 1.6 PCU and a motorbike is 0.3 PCU.

F.2.4.3 Assessment of Traffic Impact when So-Go is Operational

Estimating the distribution of journeys to and from the building means comparing the present distribution in the area with the distribution found once So-Go is fully up and running. As Table F-19 shows (see above), So-Go's offices and shops are the main reasons for journeys there during peak hours - generating about 1,244 PCU trips per peak-hour.

Apart from the specific traffic increases that So-Go generates, we must also consider the natural growth of traffic volume. Taken together, these two indicate the likely traffic flow per hour during peak hours that we can expect to see on the neighbourhood's main roads and intersections. We will look at the relevant roads and intersections separately, and consider them in terms of their pre- and post-So-Go status.

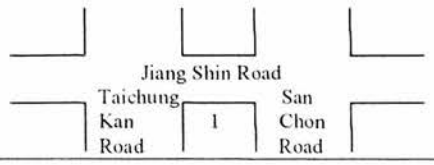
F.2.4.3.1 Assessment of the Service Level on the Roads

From analyses of the results of traffic volume discussed above, we find the value of volume/capacity (V/C), which stands for the volume of traffic per peak-hour in relation to the estimated capacity prior to and after So-Go's development. From this value we can deduce the Congested Time Function and then the travelling velocity per peak-hour at each stage can be calculated. Table F-20 outlines the service level on nearby roads during peak hours pre- and post-development of the So-Go site. Table F-21 classifies the various graded levels of service on roads.

Table F-20: Analysis of Level of Service (LOS) during Rush Hours prior to & after the Development of the Base

Name of Road	Section of Road	Traffic Volume Before Developing (PCU)	Predicted Travel Rate (KPH)	Level Of Service (LOS)	Traffic Volume After Developing (PCU)	Predicted Travel Rate	Level Of Service (LOS)
Taichung Gun Road	Chon Ming South Rd. – Park Path (fast lane)	5589	17.4	F	6209	12.7	F
	Chon Ming South Rd. – Park Path (slow lane)	2395	17.1	F	2672	12.4	F
Jiang Shin Road	Taichung Gun Road – San Chon Rd	2033	24.58	C	2236	24.02	C
Mei Tsui Road	Taichung Gun Road – Gon Yi Road	2061	22.56	C	2267	19.80	D
In Tsai Road	Taichung Gun Road – Gon Yi Road	2469	23.93	C	2713	23.25	C
Ming Yi Street	Chon Ming South Rd. – Park Path	360	32.69	B	726	24.79	C

Note: Data prior to development is based on, Taichung City Government, 1993, pp. 82-84.

	1	No	22	35	1.60

As Table F-23 indicates, the proportionate demand and supply (D/S) of parking space on both sides of Taichung Kan Road is 2.36. Surveys have found that many drivers violate the parking rules by leaving their cars on pavements and slow traffic lanes, a pattern of behaviour which is also frequently found on minor roads. Cars parking spaces are vertical in front of the majority of shops on Mei Tsui Road. This lay-out not only takes up more of the available road area and worsens the problems at the intersection, but it also affects the flow of traffic during peak hours. Parking spaces adjacent to the site are obviously insufficient since the rate of demand and supply (D/S) exceeds 1.2, which shows that the parking problem has become critical in this area.

F.2.4.5 Parking Impact Assessment

The analysis of parking requirement varies depending on what the land is to be used for, e.g. shops, offices, etc. So, taking account of this, the parking requirements for cars and motorbikes during peak hours are related to the frequency of journeys; the distribution of the modal split; the average parking time; and the average number of passengers per car, etc. The formula for estimating parking requirements is as follows:

$$Pij = \frac{Di \times Mj \times T}{Fj}$$

- Pij: rate of parking requirement for modal split type' j' for use' i' during peak hours
- Di: trips generation rate of journeys for use 'i' during peak time
- Mj: distribution rate of modal split type' j'

- T: average parking time (50 minutes for mall shopping)
- Fj: average loading rate of modal split type 'j'

The estimated result is listed in Table F-25. Four hundred and fifty two (452) car parking spaces are required and the parking space requirement for motorbikes is 1,115. As Table F-24 shows, the Taichung Municipal Government conducted a survey in 1992 of parking rates in all kinds of buildings during peak hours. It is estimated that the parking requirement for visits to shops and offices is 633 spaces (see Table F-25). The Building Code prescribes the minimum requirements of parking spaces for all types of building. As Table F-25 shows, 285 spaces is in compliance with this code. In addition, based on the EIA's Principles for High-Rise Buildings in Taichung, cars require 366 spaces and motorbikes 548.

Table F-24 : Rates of Parking Requirement during Rush Hour for All Buildings

Application	Rate of Parking Requirement during Rush Hour (parking space/hr/100 m^2)
Residence	0.49
Department Store, Supermarket	1.64
Hotel	0.51
Boutique	1.04
Financial Bank	11.80
Office Building	0.62
Large Restaurant	2.56

Data source: Taichung City Government, 1993, p.148, Table 5-3.

Table F-25 : Comparison of Estimated Parking Requirement of SoGo Building

Application	Prediction Model Of Taichung Government (parking space)	Estimation Model of Trips (parking space)	Requirement of Legal Regulation (parking space)	EIA Principle of High-rise Buildings in Taichung (parking space)
Bazaars in Dept. Store	594	415	242	312
Office	39	37	43	54
Total	633	452	285	366

Notes: a. 1,115 parking spaces for motorbikes are also included in the estimation model of trips.

B. The EIA principle of high-rise buildings in Taichung also requires 548 parking spaces for motorbikes additionally.

The So-Go building provides 368 car parking spaces and 550 motorbike parking spaces. These are located on the lowest three levels of the basement. Though this provision meets the EIA's guidelines laid down in their Principles for High-Rise Buildings in Taichung, it still cannot satisfy the estimated parking requirements of So-Go's visiting shoppers and office employees. Nor does it measure up to the number of parking slots the Taichung Municipal Government's survey identified were necessary. However, there is a public car park to the west of the So-Go site which, through joint development, could provide an additional 120 spaces. Consequently, we can conclude that the full tally of parking spaces supplied in or near this site is 486.

In addition, Taichung Kan Road is one of the scheduled route stops of the Mass Rapid Transit (MRT) system. As a result, people wanting to visit So-Go should find the MRT system attractive to use once the MRT is completed.

As vehicles using So-Go's parking facilities have to come and go via the building's own entry/exit route, bottlenecks occur there all the time. For this reason, So-Go's access route is located on a 10-metre wide non-thoroughfare road. This provision should go some way towards ameliorating the traffic burden on the major roads nearby.

F.2.4.6 The Impact of the Public Transport System

When So-Go is fully operational, it will attract 3,866 trips in peak hour. However, 8.52% of those visits to So-Go's department store and 0.9% of those to its office premises are made via public transport, as we saw in Table 16 above. There are 20 bus routes operating in the near vacinity of So-Go, with bus stops spaced every 50 metres along their routes. So, every hour public transport can provide an average of 113 bus journeys carrying 3,955 passengers, who are travelling to the western district from all over Taichung.

As a result, the current public transport system around So-Go is capable of satisfying additional demands even after the site is fully developed.

F.2.5 THE IMPACT ON THE SOCIO-ECONOMIC ENVIRONMENT

F.2.5.1 Land Use

So-Go's impact on the use of land can be divided into its construction and operational stages. During construction, as the site's original old houses and surrounding gardens were demolished, the area was transformed into a working building site, complete with its temporary housing etc. In particular, the terrain was changed beyond recognition during the laying of the foundations. The final product of a 91-metre tall high-rise permanently altered the use being made of the land. As the site is located in Taichung's commercial heart, this building not only became a new visual focus but also promoted the development of further high-rises around the neighbourhood. During construction, the visual impact of the building work was ameliorated by the attractive fencing erected around the site.

Once completed, the land is primarily designated for use as a commercial centre. However, plenty of open space is also provided for pedestrians, shoppers and office staff. Therefore, in addition to So-Go's business functions, this land now also serves as a place for recreation and entertainment.

F.2.5.2 The Impact on the Economic Environment

F.2.5.2.1 Employment

In 1992, the population of Taichung was 794,960 with a growth rate of 2.68%. The population density was 5,221 people per square kilometre. Sub-divided into districts, the population of the central and eastern districts actually declined; by -2.56% and -0.97% respectively in 1992. However, the

population grew in the other six districts of the city. The growth rate in the western district, where the site is located, was 0.97% in 1992 - a rate far lower than the average for Taichung City as a whole. The rate of of unemployment was 1.63%.

The kinds of employment offered by Taichung - the central metropolis of mid-Taiwan possessing the assets of a superb geographical location and a convenient transportation system - are those associated with a busy commercial and industrial hub. Tertiary industry is well-developed, employing 63.25% of all the workers in this city. Most citizens are employed in business, transportation, finance, insurance, real estate and service industries.

In 1986, there were 32,312 stores and shops in Taichung. By 1992, this number had increased to 37,053. However, by 1995, the number had fallen to 21,431 indicating the impact of the economic recession on commercial activities.

During construction, So-Go required 200 building workers, augmenting the employment opportunities in that sector. However, as the building phase only lasted 400 days, this was a temporary increase which did not greatly impact on the integral employment structure.

Once operational as shops and offices, So-Go offers close to 500 employment opportunities (see Table F-26). As this figure only represents 0.13% of employment in Taichung in 1995, it cannot be considered as having a significant impact.

Table F-26 So-Go's employment opportunities

Type	Floor (m^2)	Rate of employment attracted (persons/m^2 day)	Employed persons (persons/day)	Local (%)	Non-local (%)
Department store	33537	0.01	336	90	10
Office	6332	0.007	44	15	85
Restaurant	1531	0.015	23	90	10
Recreation	1201	0.009	11	40	60
Parking	9844	0.002	20	90	10
Total			434	89	11

Note: a. The rate of employment attracted is according to the EIS (appendix p8-1) of Taichung Regional shoping Mall

b. local labour is employees already in residence in the site daily commuting zone being recrwited , the rate according to Morris, 1995 , p23 Predicted employment of SoGo Building

F.2.5.2.2 Economic Activities

During the construction phase, So-Go's impact on economic activities included the consumption of building materials and the employment offered to construction-related workers such as plumbers, electricians and interior decorators. At the operational stage, the remaining construction workers and the employees of So-Go's shops and offices live and consume near the site, which probably has a positive effect on the immediate local economy. It is estimated that £6m of business tax can be generated annually from So-Go when it is up and running.

F.2.5.2.3 Land Prices

Land is scarce and precious in Taiwan because of its narrowness and its dense population. This is even more the case in its urban areas. Under the inexorable logic of demand and supply, the price of land is rising as land resources gradually diminish, especially in areas possessing well-developed public infrastructures. So-Go's shoppers and office employees promote further local economic activity and expedite the development of land around the district. Thus the price of land near the area should also

increase.

F.2.5.2.4 Living Standards

As a large number of consumers will be attracted to this building after its completion, So-Go is bound to have some impact on the living standards of the district. However, as this impact is most likely to be highly localised in its effect, So-Go will probably have a negligible impact on living standards in Taichung as a whole.

F.2.5.3 Impact on the Social Environment

F.2.5.3.1 Population Structure

In 1992, the population of Taichung was 794,960 rising to 853,221 in 1995, with a growth rate of 2.5%. The size of households fell from 3.70 to 3.42 and the gender ratio decreased rapidly in 1992 from 101.57% to 99.96%[1].

So-Go's 200 construction workers (50 of them living on the site) will migrate to other sites once the building work is finished. Their temporary presence has no obvious impact on the numbers or structure of the local population.

The operational stage employs 434 employees (see Table F-26 above) - a mere 0.4% of the western district's population. The daily shoppers and clients come to 17,572 which represents a much bigger proportion (16%) of the western district's population. However, as most of these are commuters, their impact on the local population is negligible.

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[1] The gender ratio is calculated from the no. of men/ no. of women x 100%. Refer to Taichung City Government, 1996, p.53.

F.2.5.3.2 Public Facilities

Public facilities in the area include car parks, schools, parks and the transport infrastructure. Most of the roads near the site are already developed though their capacity is a cause for concern since most of the V/C ratios are more than 0.9 affecting their levels of service.

We have already seen from the survey conducted by the Kua-San Company in 1992 that parking facilities in the district are obviously insufficient. The rate of demand and supply is mostly above 1.5[2], which means that there are only two parking spaces for every three cars wanting to use them. Taichung Kan Road is the worst affected; its rate of demand and supply is around 2.36.

As for educational facilities, there are six primary schools and five junior high schools in the area, with an average area of 1.93 square metres per person in the former and 1.75 square metres per person in the latter (see Table F-27 below). There facilities are sufficient for the moment. However, it is estimated that 10% of employees (approx. 45 people) will move into this district as Table F-26 shows above.

Table F-27 public facilities in the western district

Public Facility	**Total No.**	**Area**	**Area for Each Person (m^2/person)**	**Minimum Required Area For 1 Person (m^2/person)**	**Result**
Junior High School	5	17.5	1.75	1.3	Sufficient
Elementary School	6	19.3	1.93	1.6	Sufficient
Park	13	22.5	2.25	2.5	Insufficient
Gym/Stadium	1	4.6	0.46	0.7	Insufficient
Parking Lot	10	4.3	0.43	0.50	Insufficient
Children Playground	4	3.8	0.38	0.8	Insufficient

Note: The minimum required area for each person is based on the lowest standard prescribed in the periodic review and performance regulations of the urban project.

[2] Refer to Kua-San, 1993, pp. 3-1-28 to 3-1-30.

There are 13 parks in this region covering a total area of 22.5 hectares (see Table F-27). The average park area per capita is 2.2 square metres, which is insufficient. But, as population numbers are not likely to rise significantly, this is not likely to become a serious issue for the district.

For playground and sport facilities, there is a stadium in the western district with a total area of 4.6 hectares and an average area of 0.46 square metres for each local resident. It goes without saying that the land designated for recreational use is not enough.

F.3 MITIGATION MEASURES

F.3.1 Mitigation Measures

geologic feature: Excavation of the basement results in release of pressure horizontally and vertically, which might cause the adjacent territory to move sideward and sink, or even do damage to houses and public facilities. Thus, mitigation measures during construction are divided into two aspects.

(a) **preliminary construction and drainage:** Earthwork excavation reduces the pressure of the land, which causes the earth layer to bloat and the ground bulge. Thus, the earthwork should be based on the principle of divided layers in separate areas to reduce the axial pressure decreasing speed. Besides, earth blockade ought to be implemented prior to excavation to prevent soils from moving sidewards. Furthermore, the maximum moving distance occurs at the spot of 19.2 meters underground through the analysis of the Rido model. Consequently, slope of the building is about 1/1800, which is within the acceptable extent. After carrying out the mitigation measure, the bouncing feature/flexibility caused by excavating is as follows.

$$\triangle i = \frac{qB\,(1-V^2)}{E} = 44\ (cm)$$

The angle variance resulted from differential moving is below 1/800, which means its damage and threat to the building has already been reduced to the acceptable category.

(b) tracing & monitoring: To reduce the impact on adjacent houses and public facilities to rational extent, incessant monitoring during construction needs to be performed to control the difference between actuality and estimation and to take other mitigation measures if necessary. A monitoring system for safety should include following items.

hydrology

Water pollutants will be produced during constructing and operating stages, which pollutes the quality of water. During construction, wastewater of vehicle cleaning and construction workers will be drained into the Mei Chuan river, which pollutes the quality of water, too. According to the inspection of water quality in 1996[13], the capacity of oxygen dissolution (COD) in Mei Chuan river was less than 30 mg/l, required volume of biological oxygen (BoD_5) was less than 8.5 mg/l and suspense solid (SS) was less than 70 mg/l, which indicated it belonged to an intermediate polluted river. As the wastewater of this building will deteriorate water quality of Mei Chuan river, mitigation measures need to be taken to reduce pollution.

(a) mitigation measure during construction stage: There are about 22 CMD of wastewater during constructing stage. To avoid draining polluted water into Mei Chuan river directly affecting its water quality, a package of wastewater treatment facilities will be adopted and then hand it to the sewage company. In addition, slurry from construction and wastewater from tire cleaning will be

precipitated, treated and disposed at the sand pool and then drained to the drainage facilities.

(b) mitigation measure during operation stage: There will be 400 CMD of wastewater in this building daily, with a COD of 300 ppm, a BoD_5 of 180 ppm and an SS of 110 ppm. Direct drainage will impose serious impact on the quality of water in the river. In order to lessen the impact, a wastewater treatment facility will be set up. The quality of water after treatment has a COD under 60 ppm, a BoD_5 under 27 ppm, an SS under 25 ppm, an amount of intestinal bacillus less than 500 unit/ml and a PH value between 6 to 9.

Noise

(a) mitigation measure during construction stage: The sensitive belt around the base is the southern residence area, which is at the opposite side of the construction site divided by a 6-m wide of road. As a result, noise during construction will definitely affect the nearby residents. Based on the environmental prediction results mentioned above, the increased amount of noise from constructing machinery is 9 dB(A), whose most affected area is the southern residence. Therefore, mitigation measures have to be taken. A 3-m high of sound-proof wall will be established at the south of the construction base and 3 – 5 dB(A) of noise amount is estimated to be able to reduce. Consequently, the increasing amount of noise from constructing machinery can be decreased below 5 dB(A).

Besides, the increasing amount of noise from transportation vehicles is about 5 dB(A), whose most affected area is the residence area beside the 6-m wide road, too. The period of earthwork excavation has the maximum frequency of traveling vehicles. According to the aforementioned prediction, the increasing amount of noise from vehicles of waste soils is 5 dB(A), whose impact

is slight. Nevertheless, there will still be some significant impact on the southern residence area. As a result, transportation vehicles will be asked not to drive on the 6-m road in front of the residence area as much as possible during construction stage. In this way, impact of noise can not only be reduced, the threat of traffic safety for residents will be diminished as well.

(b) mitigation measure during operating stage: As this district belongs to type II noise control area, the standard of noise control is 65 dB(A) day and night and 50 dB(A) at late night. The source of noise during operation comes from business places since this building is served as a department store, which will interrupt the neighborhood undoubtedly. And the business hours last until 10:30 pm, which shall impose impact on the evening quietness as well. As a result, sound absorbing materials will be utilized inside the building to decrease noise.

In addition, the air-conditioning facility is also the major source of noise in this building. Consequently, the freezer of the central air-conditioning system will be installed in the machine room (20 F), sound-proof device will be set up in the machine room and a sound-proof wall will be set up around the cooling water tower.

As for the noise from the shopping crowd, main entrance will be designed to face Taichung Gun Road and Mei Tsui Road, which will prevent the noise impact on the residence areas of western and southern sides of the building.

traffic impact

(a) mitigation measure during construction: The traffic impact during construction mainly refers to the impact of the level of service on current roads, which is resulted from traffic flow of

transportation vehicles. The other impact refers to the occupation or closing-down of the road because of construction procedures or materials, which will affect traffic flow and generate a bottleneck of traffic. Thus, mitigation measures during construction include excavation and construction in different areas in different periods, enough space inside the base to allow the operation of construction machinery as well as the storage of construction materials and avoidance of traveling transportation trucks during rush hours to reduce traffic flow.

(b) **mitigation measure during operation:** The traffic impacts during operation stage refer to parking of derived vehicles, obstruction of traffic flow due to pick-up/dump trucks and the impact on nearby roads and residents because of entrance/exit of vehicles at the parking lot. For reducing parking impact of derived vehicles, vehicles of customers and employees should not be parked along the sides of nearby roads because entrance and exit of residents and the capacity of traffic flow will be affected.

For the impact of goods unloading vehicles, unloading on the ground will not be applied, instead, the unloading area will be located at the basement to prevent the occupation of roads by goods unloading vehicles, which affects traffic flow.

As for mitigation measure against the impact of entrance/exit of vehicles at parking lots, the entrance/exit of the parking lot in this building will be set up on the 10-m wide of road to avoid impact on residents living beside the 6-m wide road. Furthermore, to shorten waiting time, the entrance/exit of the parking lot is expanded to reduce traffic impact.

landscape

Being located at the central area of Taichung Gun Road, this building is a visual focus on the way to downtown. However, this 21-floor building is a contrast to lower buildings on the eastern and western sides. A 12-m area of space, facing Taichung Gun Road, will be reserved to reduce the pressure of the building upon pedestrians. The open space can not only provide a passage for pedestrians, but also be utilized for planting tall evergreen trees to ease up the sense of coldness exposed by the towering architecture.

obstacle of electric waves

Based on the prediction and analysis mentioned above, the blocking extent of electric waves is the edifice on the eastern side of the building, with a blocking length of 227.5 meters, a width of 69 meters and a number of 208 households.

There are 3 major control measures against electric wave blocking problem caused by high-rise buildings. The first one is the modification design of the main body of the building. The second one is to improve the function and performance of the signal receiver for electric waves. The third one is to transmit electric waves by satellites in order to decrease the covered blocking extent resulted from buildings (as Table 27 shows).

For this building, the mitigation measure against blocking electric waves is to install a common signal receiving facility for TV in the building and provide it to the affected residents nearby for free.

Table F-27 : Preventive Measures against Blocking Electric Waves of the Building

Measures Of Target Building	Measures of Direction, Arrangement Type & Height	Change of Direction/Location of Target Building
		Change of Arrangement Type
		Change of Height
	Measures of Pattern/ Shape on the Surface Of Outer Wall	Use of Convex-Concave Surface of Wall
		Use of Arch-shaped Surface of Wall
		Use of Tilt Structure of Wall Surface
	Measures of Material For the Surface Of Outer Wall	Change of Material for the Surface of Wall
		Use of Electric Wave Absorber on the Surface Of Wall
Measures Of Signal Receiver	Measures of Installation Of Common Antenna Equipment	Install shared signal receiving equipment for TV in the building.
		Addition of Multi-function CATV
	Measures of Application Of High Performance Antenna	Application of Multi-reflecting Antenna
		Application of variable & direction-indicative antenna
	Installation of Shadow Removal Device	
	Moving or Adjustment of Location of Signal Receiving Antenna	
Other Measure	Improvement Measure of Satellite Transmittal	

Data source: P. 161, Wu Woo Yi, 1992.

APPENDIX G: ASSESSING ENVIRONMENTAL OF FORMOSA BUILDING

The Formosa Building is located at the intersection of Jian Shin Road and Taichung Kan Road, which used to be a wholesale fishmarket, and is now a metropolitan hub. This new commercial centre is well situated, as Taichung Kan Road is an artery road affording good connections both with other parts of this and other cities. The building plan was to build 32 floors aboveground with six floors below. It will be a multi-functional edifice combining offices with recreation and resort hotels. With the increase in the Taiwanese economy Taichung City has become the dominant city in central Taiwan

The EIA review for the Formosa Building was applied for in 1992, which was passed allowing construction to commence in 1993. It was completed and operational by 1998. Underground, the sixth up to the third floor is used for parking. The section of the building from second floor underground through to the tenth floor aboveground is office space whilst the 11th to 15th floors are restaurants. The 16th to 26th floors is office space again with the upper floors (27th to 32nd) is hotel accommodation. The building has a total floor area of 118,437m^2 and is 117.25m in height.

G.1 PROPOSAL DETAILS

G.1.1 An Analysis of the Building Location

Analysis of building site location

The site is located at the intersection of Taichung Kan and Jian Shin Roads in western Taichung. To the southwest of the building is the 50m wide Taichung Kan Road with Jian Shin Road (20m wide) at the northwestern edge. To the northeast and southeast are 10m and 8m wide roads respectively (Figure 10-1, chapter 10).

The area of the construction site was 6,891m^2. It was situated on 80m away from Taichung Kan Road.

This area is the pivotal point for road transportation in Taichung as Jian Shin Road is important in connecting areas in the north and southwest. This area has become an important commercial and recreational area with features such as the Science Museum being only 200m away, the tranquil Ging-Kuo Park Avenue, together with a large number of office buildings, hotels and large-scale shopping malls.

The building site was the sole auction and fish distribution centre for Taichung City. All the buildings were one-floor awnings or shacks. Nevertheless, with urbanisation this area developed from suburban region in the 1980s to the present day booming commercial centre of Taichung. As the fish market could not keep up with the demands of urbanisation, the area was redeveloped as a commercial access region meeting urban planning goals.

The status quo of urban development in this region

This commercial area, together with business and administration centres, the municipal government and the city council, is situated in western Taichung. In 1998 there were 110,000 people living in this area accounting for 12 % of the population of Taichung City. The population density was 19,248 people km^{-2} (second highest in Taichung) with 3.29 people per household (second lowest in Taichung). Population growth was higher prior to 1975 at an annual rate of over 4%. In the subsequent twenty years, the annual growth rate steadied at 1.25% (1978 to 1998) with negative growth rates in 1990 and 1991; an indication of a decrease in the urban function of this area.

Of the 619ha in this region of Taichung City, 344ha (56%) has been built upon. 141ha (22.6%) is agricultural whilst 134ha (21.6%) is used for transportation and water utilisation purposes. The remaining area has been used for embankments etc. This is all evidence pointing towards the highly urbanised nature of the region with numerous businesses and busy commercial activities. Twenty one percent of all stores and shops in Taichung City are located at this area.

Industrially, this area encompasses 5.65% of primary, 31.99% secondary and 62.36% tertiary industry. The proportion of tertiary industry is second only to that of central Taichung indicating that the development of the service industry in the west is promising. In recent years, in the west, buildings for business purposes, restaurants and supermarkets have been built sequentially contributing to the current busier, bustling trading activities.

The status quo of the traffic environment around the building site

(A) Road Network: The urban development of Taichung City encircles the train station extending in a fan shape to the northwest with the north-south railway line as the boundary. In observing this urban development, the construction of roads and facilities can be divided into three categories: (a) the central downtown area is in front of the train station and is radially connected with the outskirts (b) the central downtown area connects with the City's Ring Road in an arch method (c) the downtown road layout is as a grid.

The road system immediate to the building site is described as follows:

(a) Taichung Kan Road: It is a 50m wide artery road connecting to exterior roads and routes. It is the main route between downtown Taichung to Taichung Harbour and the Industrial Park. It has six lanes.

(b) Hsi Tun Road: It is 20m wide and connects with outer roads. It is the main link between the downtown region with the west, and has four lanes.

(c) Jian Shin Road: This four laned road is part of the inner circular road. It is 20m wide and conjoins northern, western and southern areas.

(d) In Tsai Road: This is also 20m wide, has four lanes, and is part of the inner circular road. It links northern and western areas.

The completion of the building will have a tremendous impact on ability of the roads adjacent to the site to cope with associated changes in traffic characteristics, loads and volume. An analysis of traffic characteristics is usually split into an assessment of the ability of roads and intersections to cope with

demand.

The Ministry Transportation and Communications categorise the level of service into six groups (Chapter 7, Table 7-21). With respect to traffic congestion, Class A has the highest level of service, and Class F the lowest. Individual traffic features of each road are listed in Table G-1. This indicates that the level of service (LOS) on Taichung Kan Road is not good. This is due to illegal parking on the inside lane so needlessly slowing traffic and reducing the service level to either Class E (unendurable delay), or F (traffic congestion). The outside (fast) lanes of Taichung Kan Road also do not score well due to approach delay.

However, the traffic on San Chon Road flows smoothly and has a Class A (free traffic flow) level of service. In general, other roads in the area do not have excellent levels of service usually ranging between Class C (acceptable delay) and Class D (endurable delay).

(B) Level of Intersection Service: The level of intersection service is based on the average time delay per car (Chapter 9, Table 9-21). The level of intersection service is shown in Table G-2. Generally the level of intersection service in the Building's immediate vicinity are graded either Class D or E. However the intersection on Taichung Kan Road has a Class F level of service indicating traffic jams and obstructed traffic flow. As a higher proportion of traffic turns left turn at the Taichung Kan Road/Chon Ming Road and Taichung Kan Road/Jian Shin Road intersections, the straight through lanes are always occupied so increasing delay times at the intersection resulting in a Class F level of service during the afternoon rush hour. In general, there is a significantly greater volume of traffic during the afternoon rush hour than in the mornings. This is due to Taichung Kan Road being a major artery with traffic volumes reaching a maximum during the rush hours with tremendous numbers of vehicles coming in and out of the city. The level of intersection service is usually particularly low.

(C) Mass Transportation System: As the construction site is located on a major road, the mass transportation system is already well developed providing a convenient and fast service. There are twelve public bus routes run by two downtown-orientated bus companies, Taichung Bus Company and Ren You Bus Company, with an average of 85 pick-ups per hour. In addition, long-distance bus stops are located near the site with companies such as the Taiwan Bus Company and Ju Ye Bus Company providing convenient and rapid transportation for the area.

(D) Parking: The neighbourhood provides both roadside and off-road parking facilities. Roads around the construction site permitting roadside parking include Taichung Kan Road, Chong Ming Road, Jian Shin Road, San Chon Road, Hwa Mei Street and Hwa Mei West Street. The parking demand and supply is shown in Table G-3. Taichung Kan Road faces the most serious parking problems as the rate of demand exceeds supply by 4.27 (ie. there is only one space to every four cars). Chong Ming Road also has problems with a rate of 1.81. Nevertheless, Jian Shin Road with a demand and supply rate of 0.79 is best able to meet parking demands. The Da Guang San is an off-road car park, located 500m from the construction site. This has a demand and supply rate of 0.28 indicating an abundant number of parking spaces but is used less due to the distance between it and the Formosa Building.

To summarise, the supply of roadside parking is significantly insufficient with an average demand and supply rate of 1.65. However, that of off-road parking is only 0.28 indicating that the general public tends to focus on convenience and lack the concept of parking fees.

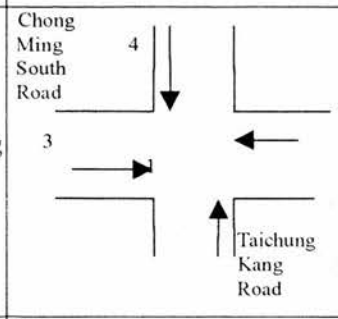
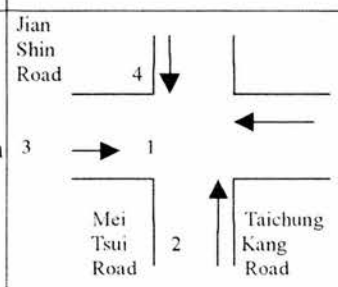
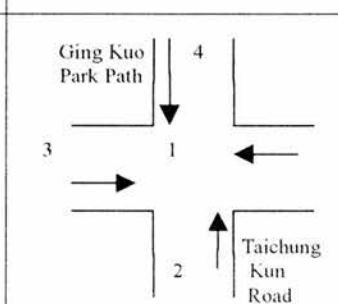
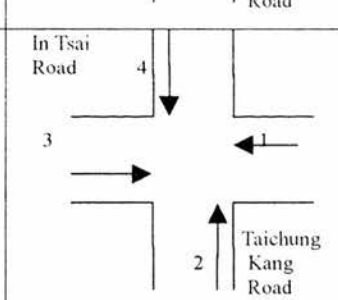
Table G-1 : Level of Service during Rush Hour

Road Name	Section	Morning Rush Hour				Afternoon Rush Hour			
		East → West		West → East		East → West		West → East	
		South → North		North → South		South → North		North → South	
		Rate of Travel	Level of Service	Rate of Travel	Level of Service	Rate of Travel	Level of Service	Rate of Travel	Level of Service
Taichung Kang Road	Chong Ming Rd. - park path (fast lane)	15.71	F	21.69	E	17.5	E	10.5	F
	Chong Ming Rd. - park path (slow lane)	14.71	F	18.69	E	16.71	F	8.9	F
Jian Shin Road	Taichung Kang Rd. – San Chon Rd.	22.51	C	24.55	C	30.51	B	24.55	C
In Tsai Road	Taichung Kang Rd. – San Chon Rd.	17.24	D	31.14	B	14.24	E	16.14	D
Chong Ming Road	Taichung Kang Rd. – San Chon Rd.	26.48	D	31.87	C	22.48	E	24.87	E
San Chon Road	Taichung Kang Rd. – San Chon Rd.	43.48	A	47.51	A	43.42	A	46.84	A

Note: Unit for Rate of Travel, km hr^{-1}

Data source: Yo-Che Company, 1997, pp. 6-46

Table G-2 : Level of Intersection Service

Name of Intersection	Sketch of Intersection	Time	Assessment Item	Approach Section Number 1	2	3	4	Intersection As a Whole	Remarks
Taichung Kang Rd. / Chong Ming South Rd.		Rush Hour A.M.	Average Delay (sec/veh)	64.6	68.2	88.5	52.1	62.1	Signalized Intersection
			Level of Service	E	E	F	D	E	Signalized Intersection
		Rush Hour P.M.	Average Delay (sec/veh)	86.2	88.5	98.3	72.1	82.1	Signalized Intersection
			Level of Service	F	E	F	E	F	Signalized Intersection
Taichung Kang Rd. / Jian Shin Rd.		Rush Hour A.M.	Average Delay (sec/veh)	71.8	50.2	73.9	58.2	68.7	Signalized Intersection
			Level of Service	E	D	E	D	E	Signalized Intersection
		Rush Hour P.M.	Average Delay (sec/veh)	92.5	64.2	95.5	62.3	83.3	Signalized Intersection
			Level of Service	F	E	F	E	F	Signalized Intersection
Taichung Kang Rd. / Ging Kuo park path		Rush Hour A.M.	Average Delay (sec/veh)	50.2	28.2	42.9	26.2	43.8	Signalized Intersection
			Level of Service	D	B	C	B	C	Signalized Intersection
		Rush Hour P.M.	Average Delay (sec/veh)	61.9	31.5	55.5	30.3	55.3	Signalized Intersection
			Level of Service	E	C	D	C	D	Signalized Intersection
Taichung Kang Rd. / In Tsai Rd.		Rush Hour A.M.	Average Delay (sec/veh)	55.6	65.3	51.9	63.5	56.8	Signalized Intersection
			Level of Service	D	E	D	E	D	Signalized Intersection
		Rush Hour P.M.	Average Delay (sec/veh)	76.3	76.2	96.6	78.3	85.0	Signalized Intersection
			Level of Service	E	E	F	E	F	Signalized Intersection

Data source: You-Che Company, 1997, pp. 6-52

Table G-3 : Parking Status in the Formosa Building Neighbourhood

Parking Method	Section or Car Park	Parking Space [Supply (S)]	Actual Parking Number [Demand (D)]	Demand and Supply (D/S) rate
Roadside Parking	Taichung Kan Road	48	205	4.27
	Chong Ming Road	31	56	1.81
	Park path	184	304	1.65
	Jian Shin Road	122	96	0.79
	San Chon Road	52	61	1.17
	Hwa Mei Street (Taichung Kan Rd. – San Chon Rd.)	18	29	1.60
	Hwa Mei West Street (Taichung Kan Rd. – San Chon Rd.)	34	60	1.76
	Total	489	811	1.65
Off-Road Car Parking	Da Kua San Multi-Storied Car Park	1,500	423	0.28
Grand Total		1,989	1,234	0.62

Data source: Kua-San Company, 1993, pp. 3-1-30; Yo-Che Company, 1997, pp. 6-55

G.1.2 Building Project

Principle of building allocation and the design concept

As previously stated, the building site is in the west of Taichung City and was once a fishmarket but is now an international hotel with additional office and entertainment function. Taking regional environmental characteristics into consideration, a strip of open space (7m wide) must be reserved on the western side of the building (along Jian Shin Road). A 22m long pavement is necessary and a 10m wide strip of open space must be provided from the borderline of the building site on each side.

In the design of the building a step back individual floor must be adopted to substantially reduce volume caused tremendous pressure. As for the mobile line plan, the entrance/exit of vehicles from the site will be from the 10m wide stretch of road to the north so avoiding placing extra traffic pressure on Taichung Kan Road and Jian Shin Road, and to maintain the integrity of the open space reserved along Taichung Kan and Jian Shin Roads.

The design concept for this building is 'compound environments' which is a breakthrough from the traditional monotype operation method for hotels. This concept advocates a multi-variety of services

combining hotel facilities with recreation and business functions needed to meet the complicated demands of a diverse industrial and commercial society. Consequently, the following goals for the design concept must be accomplished (Chung-Kan Company, 1993, pp. 2-12).

(a) Provision of open space: As this building project follows legislation for a high-rise building plan, part of the grounds must be reserved for open space to maintain space quality in the regional environment. The public at no cost can use reserved open space.

(b) Maintenance of urban landscape: There are a high number of new high-rise buildings on Taichung Kan Road resulting in a more diverse sky line than in other areas. With some buildings reaching heights of 110m and more, the design of the shape of a particular building, and the way it will interact with the current skyline, is important in creating an image for the city so enriching the urban landscape.

Table G-4 : Development Project for the Formosa Building

Floor Number	Number of Floors	Use	Area of single floor (m^2)	Total area (m^2)	Remarks
32	1	Hotel	1,446.93	1,446.93	28 guest rooms and one presidential suite
28-31	4	Hotel	1,446.93	5,787.72	31 guest rooms per floor
27	1	Hotel	1,463.13	1,463.13	28 guest rooms
26	1	Office	1,959.04	1,959.04	44
17-25	9	Office	2,149.53	19,345.77	50 units per floor
16	1	Office	2,073.52	2,073.52	44 units
15	1	Restaurant of Hotel	2,919.38	2,919.38	
12-14	3	Restaurant of Hotel	3,572.17	10,716.51	
11	1	Restaurant of Hotel	3,715.32	3,715.32	
10	1	Office	3,715.32	3,715.32	
5,7,9	3	Office	3,444.01	10,332.03	
4,6,8	3	Office	3,395.07	10,185.21	
3	1	Office	3,444.01	3,444.01	
2	1	Office	3,228.71	3,228.71	
1	1	Office	3,206.04	3,206.04	
B1	1	Office	5,608.20	5,608.20	
B2	1	Office	5,499.79	5,499.79	
B3	1	Parking	5,484.76	5,484.76	101 cars;139 motorbikes
B4	1	Parking	5,484.76	5,484.76	125 cars; 251 motorbikes
B5	1	Parking	5,469.69	5,469.69	125 cars; 240 motorbikes
B6	1	Parking	5,469.69	5,469.69	255 cars

Data source: Chung-Kun Company, 1993, Table 4-3-1

Plan of traffic mobile line

The plan for the traffic mobile line can be split into external and internal mobile lines. The former consists of a vehicle and a pedestrian mobile line. The principle is based on the separation of people and vehicles so that one does not interrupt the flow of the other. The entrance and exit for vehicles is, therefore, on the 10m wide stretch of road to the north of the site. This both reduces the traffic impact upon Jian Shin and Taichung Kan Roads, and also prevents the strips of open space along these roads from obstruction. The pedestrian mobile line, the public usually uses Taichung Kan Road and Jian Shin Road as approaches to the building, the 10m and 7m open spaces are, therefore, reserved and developed for pedestrian use.

Although the internal mobile line encompasses the environment of the building site, the external traffic mobile line and space applications must be taken into account. Consequently, the entrance/exit to and from large-unit offices (the lower floors) and the vertical mobile line are established on the right-hand side of the 50m wide Taichung Kan Road. However access to small-unit offices (the higher floors) and the vertical mobile line are set up on the side of the 20m wide Jian Shin Road. This set-up allows the evacuation of crowds during peak hours with the separation of the entrances and exits of the large- and small-unit offices allowing for better management. To avoid interference between hotel residents and office employees, a special mobile lift for the hotel has been installed on the ground floor near the Jian Shin Road entrance. The lift only stops at the parking levels and ground floor before going directly to the reception on the 12th floor and further floors of the hotel.

The plan for the service mobile line includes an entrance/exit being located in the basement car parks with a vertical mobile line allocated to both sides of the corridor. There are also goods lifts, an emergency lift and a special fire staircase. In essence, the vertical mobile lines separate the large-unit offices and the hotel on the lower floors from the small-unit offices on the higher floors; to the east and

north respectively.

Structural system project

As Taiwan is situated in an earthquake zone, and is frequently affected by typhoons in summer, the structure of the building has to carry static and active loads vertically, and withstand winds, earthquakes and other external forces. The structure of the Formosa Building is described as follows:

(a) **number of floors:** six below-ground, 32 above

(b) **building height:** basement storey heights vary from 2.7m to 4.4m. The height of the ground floor is 5m, the 2nd through to the 9th are 4m, the 10th floor is 5m, the 11th through to the 15th are 3.m and the 16th through to the 32nd floor are 3.15m. The total height of the building is, therefore, 117.25m, with an excavation depth of 23.35m below the basement.

(c) **building dimensions:** 68m wide and 63m long in the T-shape plane of the higher floors, and a 65m square plane on the lower floors.

(d) **structural system:** in general, there are three major structural systems for high-rise buildings. These are steel structure (SS), RC and SRC. In the basement, the 6th up to the 2nd floor are RC constructed whilst the 1st floor has an SRC structure. The ground floor is also an SRC structure, and all floors above the 2nd are all SC built. The column mainframe and shear wall comprises the main structure underground whereas dimensional flexible structure is used aboveground.

(e) **foundations:** RC floating foundation

(f) **outer wall:** curtain wall

(g) **basement excavation:** support from inside is used in excavation with the soil blocking wall applied manually (Chung-Kan Company, 1993, pp. 2-13).

Landscape plan

The plane of the building is virtually square and is situated at the centre of the building site. A 22m long pavement runs along Jian Shin Road with a 7m width set aside as open space. A 10m stretch of open space occurs along Taichung Kan Road, which is both available to the public for free and reduces the

sense of enclosure. In addition, artistic work such as carvings or sculpture, and other aspects of landscape design can be used in the open space. Furthermore, the pavement is intentionally built to allow the setting up of tables and chairs with flower platforms for rest and entertainment purposes. The integral planned use of indigenous plants and saplings is in compliance with urban characteristics and local climate, and creates a pleasant and comfortable landscape.

As this edifice is located on a main road in Taichung City it will have high visual impact so the landscape design should combine modernism with tradition ie. as well having a modern look, the detailed dimensional design must also relate to traditional Chinese architectural style.

Fire prevention plan

The main output of the fire prevention plan for this building is the installation of a fire control centre and an automatic monitoring system (or building automation). It includes fire prevention (FA), safety guard (SA), passenger control (PA), and equipment management automation (MA) for energy, etc. In addition to the efficient operation, a safe, comfortable, economic, and high quality environment for working and living must also be achieved. As a result a separate treatment system of 'control distribution and monitor concentration' is used. The central control station is established on the 1st floor and controllers are found on every floor. Its structure is shown in Table G-5 (Chung-Kan Company, 1993, pp. 7-4-7-12). The monitoring system in the fire prevention plan caters for the management of safety maintenance. This includes fire-fighting, fire alarm, and safety alarm systems.

Fire-fighting and fire alarm systems include:

- water tank for fire-fighting - monitor low water level
- fire-fighting pump - monitor operation and power safety alarm for the pump
- sprinkler system - monitor water on/off, and position of shut-off valve
- fire-fighting pipe - monitor the position of shut-off valve

Safety alarm systems consist of:

- intercom system - monitor low water level and emergency call
- cable TV monitoring system - selection of control panel and data video recorder

The basic role of the fire-fighting equipment is to take precautions, to announce, and to evacuate the building rapidly and safely as soon as a fire has been detected. The fire-fighting equipment comprises indoor fire hydrants, stand pipe system, automatic sprinkler system, automatic foam system, extinguisher system, automatic fire-fighting system, portable extinguisher, fire-fighting pool, and escape facilities.

The design for fire evacuation is as following:

(a) There are two emergency lifts inside the building that travel from the ground floor directly to the top for assistance.

(b) Fire staircases are allocated in dispersal for multi-direction evacuation.

(c) Emergency lighting indicating direction for evacuation direction and emergency exit lights must be installed.

(d) Each floor has a reserved evacuation area for personnel serving as an escape location to prevent chaos.

(e) A spot for evacuation and escape is established on the 23rd and 32nd floors to await aid and supplies.

(f) The fire control centre is installed on the ground floor and performs the task of hazard control and surveillance using the monitoring system set up in the building.

Fire alarm and fire-fighting equipment are listed in Table G-6.

Table G-5 : The Central Control System of the Formosa Building

Management of Power Supply	(A) Power System	Power distribution equipment
		Emergency generating equipment
		Capacity limit
		Power plant
Management of Energy Environment	(B)Air-conditioning System	Air-conditioning & heater equipment
		Ventilation equipment
		Main engine of air-conditioning equipment
		Environment control equipment
	(C) Hygiene Facilities	Equipment of water supply/exhaust
		Hot-water supply equipment
		Health equipment
		Public hazard control equipment
Management of Safety Maintenance	(D) Fire-fighting & Fire Alarm System	Automatic fire alarm equipment
		Fire extinguishing equipment
		Smoke control/exhaust equipment
		Emergency P.A. equipment
		Evacuation guidance equipment
		Emergency call equipment
	(E) Safety Alarm System	Patrol equipment against theft/burglary
		Visit limit control equipment
General Management	(F) Traffic Facilities	Escalator equipment
		Elevator/lift equipment
		Parking lot equipment
	(G) Management Service	Indoor telephone equipment
		Form interpretation equipment
		Form draft equipment

Data source: Chung-Kun Company, 1993, pp. 7-5

Table G-6 : Plan of Fire Alarm and Fire-fighting Equipment

Appliance	**Car Park**	**Office**	**Office**	**Hotel Restaurant**	**Roof**
Fire Alarm System	*	*	*	*	
Emergency P.A. System	*	*	*	*	
Emergency Exit Signs	*	*	*	*	
Emergency Power Supply	*	*	*	*	
Exit Lighting	*	*	*	*	
Stand Pipe System	*	*	*	*	*
Automatic Sprinkler System		*	*	*	
Automatic Foam System	*				
Halon Extinguishing System	*	*			
Smoke Control System		*		*	

Data source: Chung-Kun Company, 1993, pp. 7-12

G.2 PREDICTION OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE FORMOSA BUILDING

G.2.1 Physical Environment

G.2.1.1 Terrain and Geology

(a) **terrain and topography:** The building site covers 6,891m^2 with most of the adjacent already developed. As the location is flat the terrain changed during the construction stage. Although the original fishmarket was removed its replacement with a high-rise building will not make a large impact on the terrain and topography as the land was already built on. The skyline varies after construction of the high-rise; some aspects of the site will be restored to serve as open space. This single 117.25m tall high-rise building has a stepped back retreating shape that fits in with neighbouring finished buildings. Positive impacts include the landscaping and redevelopment of an urban site.

(b) **waste soils:** The planned excavation area of this high-rise building is about 6,413m^2 with an excavation depth of 23.35m and an estimated earthwork volume of 150,000m^3. If the coefficient of loose soils is 1.2, then the total earthwork volume will be 180,000m^3. Aside from any earth used for hard landscaping and as fill, the surplus material will be treated as waste soils. To recycle the used earthwork, a sand processing method will be used to produce usable construction materials. As for non-recyclable waste soils, they will be shipped for burial at the soil dump yard.

(c) **settlement and expansion of soils:** When a large-scale foundation is built, a large amount of soil will be excavated and the soil under the base surface will expand. This is especially true for compressible geology. There are two kinds of expansions, water absorbing and elastic. The former only occurs on clay whilst the latter can happen to any kind of soil. At this site there are gravel and pebble soils so its major expansion is elastic. Expansion as a result of excavation may affect buildings and public facilities adjacent to the construction area evidenced as the cracks in houses and breaking pipes. Therefore, the degree of expansion together with the impact on other structures

should be scrutinised at the beginning of the project. The following formula can be applied:

$$\Delta i = \frac{qB}{E}(1 - \mu^2)$$

q = loading weight

B = width of the base

μ = Poisson's ratio

E = elasticity of soils

Expansion figures for the centre of the excavation surface and a corner are 14cm and 7cm respectively (Chung-Kan Company, 1993, pp. 4-5). Land at the corners of the construction site are reserved for open space and a road wider than 10m serves as a buffer zone so reducing the dilatability to a minimum with no significant impact to surrounding buildings, piping or infrastructure.

Furthermore settlement will occur with increasing weight during the construction stage as pressure is produced on the soils. If the sinking range is too great, nearby public facilities and buildings will be put in jeopardy. However, at this particular site, as the gravel and pebbles have a greater porosity and permeability there is limited settlement range. The formula is as follows:

$$\Delta H = \frac{\Delta \sigma v}{Es}(1-2\mu\,\Delta\sigma v) \quad \Delta \sigma v = \frac{29\,P\,X^3}{\Pi\,(X^2+Z^2)^2} \quad \Delta \sigma v = \frac{29\,E^2X}{\Pi\,(X^2+Z^2)^2}$$

ΔH : settlement amount

H : thickness of soils

μ : Poisson's ratio

P : loading weight

X, Z : horizontal & vertical distance from the point loading weight

Through calculation the maximum settlement range of the 32 floors is 5 to 7cm (Chung-Kan, 1993, pp. 4-6). As some empty land is reserved as open space, this settlement will have little impact to surrounding buildings.

G.2.1.2 Hydrology and Water Quality

(a) **hydrological balance:** The level of underground water must be reduced to below the level of excavation in the construction stage. As a result, sectional water withdrawal inside and around the construction site was carried out performed, which changed the underground ecology. Nevertheless, as water withdrawal during the construction stage is only temporary, there will not be any long-lasting effects on underground ecology. The volume of water needed during the construction stage for workers can be calculated when the number of construction labourers is known. In general, the daily water requirement for a worker living on-site is 120 litres; otherwise a worker only needs about 30 litres. There are about 200 construction workers on-site daily, with 50 living there. Therefore, the required water volume will be 10.5CMD. The water will be supplied as tap water rather than from underground water sources so no significant impact will be imposed on the hydrological balance. During the operational stage no underground water will be withdrawn so not affecting the hydrological balance although the daily volume of water required will be 1,993CMD.

(b) **water quality:** The soft loose soils from excavation, together with the dust and mud from the construction vehicles could result in water pollution. A daily average of 10.5CMD of polluted water is produced by construction workers that can contaminate the nearby water sources. However, as construction is temporary there should be no long-term effects. During the operational stage about 1,993CMD of polluted water is produced each day; equivalent to 0.023CMS. This is first treated at the sewage disposal plant before discharge to meet effluent standards. However, river water quality will be affected.

(c) **water drainage:** As this construction site was once a fish distribution centre, its surface was paved

with concrete, thus the flow of rainfall after construction will not increase significantly. Using the rationalised formula, Q = CIA/360 [where the coefficient of run-off (C) is 1.0, the area of water catchment (A) is 6,891 m^2, the maximum rainstorm volume (rainfall intensity) (I) is 343mm hr^{-1} based on an averaged frequency over 25 years] we can calculate that run-off flow (Q) will be 0.66CMS. However, as rain sewers are installed around the construction site, the increasing volume of water drainage can be accommodated.

G.2.1.3 Air quality

(a) **construction stage:** As large-scale excavation is required during earthwork engineering, suspended particulates will be produced. In order to reduce the impact caused by excavation pollutants on the environment, the principle of small-area excavation will be adopted. It is estimated over a period of 18 months, 545 working days will be required to excavate an area of 6,413 m^2. Using emission factors from the EPA, the emission factor of TSP can be found (Table G-7) ie. there will be 1.05g of particulates produced per second at the building site during the excavation stage. The average volume of dust falling per km^2 in Taichung in 1995 was 15.7tonnes km^{-2} $month^{-1}$[1] (15.7g m^{-2} $month^{-1}$). Together with background and prediction values, the volume of dustfall around the site during the excavation stage is about 16.69tonnes km^{-2} $month^{-1}$. Although the affected area is limited to the immediate neighbourhood, there is a significant negative impact on air quality that needs mitigation. As 1.02g sec^{-1} of particulates is produced during the operation stage (0.88tonnes m^{-2} $month^{-1}$) which affects local air quality, mitigation measures should be proposed.

(b) **transportation:** Trucks transporting construction materials greatly influence the air quality. Waste air from diesel truck exhausts contain air pollutants (SO_2, NO_2, CO and PM_{10}) affecting air quality. Sources of construction materials (including concrete, steels, and steeled materials) are widespread meaning varied transportation routes are necessary. Nevertheless, as all transportation vehicles enter the construction site via Taichung Kan Road, and as most of the land along Taichung Kan

[1]Taichung City Government, *Statistic of Taichung City* (Taipei, 1995), p.258

Road is already used for industrial and business purposes, environmental sensitivity is lower. A separate period and area method for site excavation will be implemented for air pollutants produced by transportation vehicles during the construction stage (including waste air and dust). The total earthwork volume was previously stated to be 180,000m^3 achieved in 545 days. The average soil shipping volume is 330m^3 day^{-1}. For an 8m^3 truck, 84 trips will be required each day (ie. 42 round trips). In addition, most transportation vehicles are heavy-duty diesel trucks (HDDT) travelling on the 20m wide road. Estimated emissions can be calculated once the emission factor and number of round trips are known (Table G-8) shows. Through the application of a formula which uses the local weather conditions and a simulation of the rate of diffusion of each pollutant, the analysis of results is as follows[2]:

TSP volume of emissions:

$$Q = (Q + Q_2)V$$

Q_1 = air emission per car (calculated as 0.99g km^{-1} according to Table G-8)

Q_2 = other resources (including dust content on surface of vehicle and dust fallout volume on road) such as:

$$Q_2 = (3 \times 10^{-6})SLW$$

where:

S = dust content on surface of vehicle (%), counted as 5%

L = dust content on road (lb/mile), counted as 150lb/mile

W = weight of the vehicle (tonne), counted as 20tonnes

$Q_2 = (3 \times 10^{-6}) \times 5 \times 150 \times 20 = 0.45$ lb/mile – vehicle

= 12.8g km^{-1} – vehicle

V = daily trip (about 84 trips per day) where daily working hours are 8

$Q = (0.98 + 12.8) \times 84/8 \times (1/3600) \times 10^3 = 40.2\ \mu g\ m^{-1}\ sec^{-1}$

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[2]Yu-Chu Company, *Environmental Assessment of High-rise Building* (Taipei, 1997), pp.7-15

Emission of other air pollutants

Q = emission factor x number of daily vehicles

Emission factors are listed in Table G-8. Assuming speeds of 40 km hr^{-1}, the emission of SOx is 12.39ug m^{-1} sec^{-1}, Nox 39.37ug m^{-1} sec^{-1}, and CO is 16.04ug m^{-1} sec^{-1}. According to the diffusion model, the concentration of pollutants is (Chung-Kun Company, 1993, pp.4-26):

$$C = \frac{2Q}{(2\Pi)^{1/2} \cdot \mu \cdot \sigma_z \cdot \sin\theta} \cdot \exp\left[-1/2\left(\frac{H}{\sigma_z}\right)^2\right]$$

C : concentration of pollutant (g m^{-3})

Q : intensity of pollutant (g km^{-1} sec^{1})

μ : wind speed (m sec^{-1}), wind speed in this area is 1.4m sec^{-1}

θ : angle between wind direction and polluting source (calculated as the most unfavourable angle, which is 90°)

σ_z : the diffusion coefficient in the vertical direction (estimated results in Table G-9, which reveal that the impacts are not significant).

The increase in the concentration of air pollutants during the operation phase is shown in Table G-11. According to this table, if the distance from the side of the road is more than 20m, the increasing volume of TSP will be less than 9.59ug m^{-3}, SO_2 will be 1.22 ppb, NO_2 50.56 ppb and CO 0.77 ppm. After addition to background concentrations, the air quality standard will still be met. Nevertheless, air quality will deteriorate slightly.

Table G-7 : Dust Emission from the Formosa Building during Construction

Stage			Emission Factor	Construction Duration (Days)	Construction Area (m^2)	Total emissions (kg)	Emission rate of TSP ($g\ m^{-2}\ s^{-1}$)
Excavation Stage	Excavation Procedures		0.1206kg m^{-3}	545	6,413	18,090	1.7972×10^{-4}
	Naked Surface of Construction Site		4.257×10^{-4} kg m^{-2} day^{-1}	545	2,600	603	4.9271×10^{-6}
Construction Stage	Building Procedure	Full period	0.424 kg m^{-2} $month^{-1}$	625	6,250	55,186.95	1.6358×10^{-4}
		Naked Surface of Construction Site	4.257×10^{-4} kg m^{-2} day-1	625	1,567	416.90	1.6423×10^{-6}
	Disposal of Waste Soils and Construction Materials		4.257×10^{-4} kg m^{-2} day-1	625	670	178.67	1.6423×10^{-6}

Notes:

1. Daily working hours are eight
2. Emission factors are in compliance with standards published by EPA, June 1996

Table G-8 : Emission Factors for Air Pollutants from Transportation Trucks

Units : g km^{-1}

Speed (km hr^{-1})	Polluted Particulates	SO_x	NO_x	CO
10	0.99	4.25	19.00	23.0
15	0.99	4.25	17.25	17.1
20	0.99	4.25	15.50	11.2
30	0.99	4.25	14.00	7.5
40	0.99	4.25	13.50	5.5
50	0.99	4.25	13.50	4.0
60	0.99	4.25	14.20	3.2
70	0.99	4.25	15.50	3.0

Data source: EPA, 1993, pp. 3-136-158

Table G-9 : Estimated Air Pollutant Concentrations from Transportation Vehicles during the Construction Stage

	Air Pollution Produced by Construction Vehicles	Air Quality Standard
SO_x	0.06 ppb	0.10 ppm (daily average)
NO_x	0.70 ppb	0.25 (average of 1 hr)
CO	1.40 ppb	9.00 ppm (average of 8 hrs)
Suspended Particles	0.76 ppb	250.00 ug m^{-3} (for 24 hours)

Note: The distance from the side of the road is 20m.

Data source: Chung-Kun Company, 1993, pp. 4-27

Table G-10 : Emission Factor for Air Pollutants from Cars

Speed of Car (km hr^{-1})	Polluted Particulates	SO_x	NO_x	CO
10	0.2197	0.116	1.76	132.77
15	0.2138	0.116	1.76	84.16
20	0.2114	0.116	1.82	60.64
30	0.2089	0.116	1.94	39.44
40	0.2075	0.116	2.07	29.39

Date source: Taiwan Sugar Company, 1997, pp. 7-10

Table G-11 : Concentration of Air Pollutants on Roads Adjacent to the Construction Site during the Operation Phase

Name of Road	Section of Road	Increasing Flow at Peak Hour	TSP (μ g m^{-3})	SO_2 (ppb)	NO_2 (ppb)	CO (ppm)
Taichung Kang Road	Chong Ming Rd. - park path	322	9.59	1.22	16.23	0.77
Jian Shin Road	Taichung Kan Rd. - San Chon Rd.	143	3.08	0.39	16.23	0.26
Chong Ming Road	Taichung Kan Rd. - San Chon Rd.	55	1.19	0.15	6.28	0.14
San Chon Road	Jian Shin Rd. - park path	42	0.91	0.12	4.80	0.10
Background Air Quality			150.11	16	33	0.84
Standard Air Quality			250	250	250	35

Data source: Chung-Kun Company, 1993, pp. 4-30

G.2.1.4 Micro-Climatic Effects

A number of factors relating to high-rise buildings (such as the large areas of land occupied, the huge, wide dimensions, proximity to hard pavements) will all play a part in the micro-climatic impact on the neighbourhood. In addition, extensively paved roads, dense buildings, waste, polluted air, dust, and car exhaust fumes contribute to the special urban micro-climate phenomena. Further influential elements to the local micro-climate include surface building materials as well as the types and allocation of the

buildings. These are described below[3]:

(a) impact of surface materials: Artificial building materials, roads and paved grounds, etc. affects the neighbourhood micro-climate by changes in radiation and heat. Therefore, the choice of surface materials must be taken into account as to the impact it may impose. Primary factors include surface temperature changes and the reflective value of the material.

Although some heat energy is reflected, most will affect the surface temperature through transmission, convection and radiation processes. The degree of temperature change will depend on the specific heat, radiation and absorption rates of the material. As well as insolation, exterior temperatures and the wind will affect surface temperatures of the building material. If the surface building material, or pavement, has a high specific heat or large volume, its interior will absorb a lot of the transmitted heat which will be gradually exuded when the exterior temperature lowers (such as at night). The overall effect in this case is, therefore, trivial.

The reflective value (the hue and saturation) of the surface material is also of importance. Different reflection surfaces will influence the heat performance and optical characteristics of the material. For example, material with a white surface will reflect energy as light is reflected, however a black surface will not. Therefore, the degree to which the colour of the surface material reflects and absorbs energy will directly affect changes in the external temperature.

The surface material on the lower floors has a high specific heat and large volume to reduce external temperature impacts; stone or metal curtain walls. On the higher floors, curtain walls with low reflective qualities were used; tiles, metal and glass curtain walls. Materials with a high reflective value are not used to reduce changes in the exterior temperature (Chung-Kun Company 1993, pp.4-13).

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[3]Chung-Kun Company , Environmental Impact Assessment Report of So-Go Building, Taipei, 1993, pp. 4-13~4-24

(b) local wind effects: Wind flows from areas of high to low pressure. The greater the pressure gradient, the higher the wind speed. Wind speed at ground level is slower due to friction and obstruction by various obstacles. The relationship between the ground wind speeds and height is:

$$\frac{V}{V_o} = \left(\frac{h}{h_o}\right)^{\alpha}$$

h, h_o = height above ground

V, V_o = velocity at respective height

α = friction coefficient on the ground's surface (urban: $\alpha = 0.36$; suburb: $\alpha = 0.25$; open space: $\alpha = 0.15$)[4]

From the formula, velocity multiplies parabolically; the closer to the ground, the lower the velocity. Wind speeds onto the building increases with height. The Formosa Building has 32 floors and is 117.25m tall, the wind speeds and the pressure produced on the higher floors not only threatens the safety of the structure, but also influences the intensity of the curtain walls. However, the outer walls of this building are curved with an inner retraction mechanism in the higher positions that diminish wind field impacts.

The RWDI has to carry out wind tunnel teststo evaluate effects of various wind velocities on the structure, as well as its comfort[5].

'Comfort' is based on a range of all different kinds of activities carried out by pedestrians. The result of the wind tunnel test is a percentage of time for different velocity ranges at each test point, which is then ranked as a level of comfort. Wind velocity ranges can be classified into five groups in compliance with

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[4]Coefficient α in Taiwan suggested by Mr. Yi Chao Tsai. Refer to Wu, 1993, pp. 4-17~4-23

[5]For wind tunnel test results refer to Chung-Kun Company, 1993, pp. 4-1~4-23

the principle of the comfort of pedestrians. The velocity range for a comfortable sitting environment is 0-17km hr^{-1}, standing environment is 0-25km hr^{-1}, and walking environment is 0-32km hr^{-1}. If the range at a certain test point is not suitable for sitting, standing and walking, it is termed the range of discomfort, which is 32-95km hr^{-1}. Danger levels are those when the range exceeds 95km hr^{-1}.

Tables G-12 and G-13 show the results from the combination of wind tunnel test data with seasonal monsoons. The tables indicate the potential percentage of time in each velocity range. A comfortable zone is when wind velocity is between 0-32km hr^{-1} for over 80% of the time, outside of this it is an uncomfortable zone for pedestrians. If the velocity surpasses 95km hr^{-1} for more than 0.1 % of time it is a dangerous zone (Chung-Kun Company 1993, pp. 4-18).

Figure 10-4 (Chapter 10) describes the localised wind environment at each test point:

A. **wind environment on the roof (test point 1):** The average frequency during the summer monsoon season at this test point is 89% (0-17km hr^{-1}) satisfying the requirement for a comfortable sitting environment. The average frequency during the winter monsoon is also 89% (0-25km hr^{-1}) satisfying conditions for a comfortable standing environment. Thus, test point 1 fulfils the basic demands for a comfortable wind environment. However, if a comfortable sitting environment is required during the winter monsoon, a wind net with a 40% clearance rate must be installed to reduce wind velocity.

B. **wind environment on the balcony restaurant (test points 2 and 3):** Comfort demands for a sitting environment is met during both the summer and winter monsoon seasons.

C. **wind environment around the swimming pool (test points 4 to 8):** The wind velocity in this area is quite low fulfilling the requirements for a comfortable sitting environment.

D. **wind environment on Jian Shin Road (test points 9 to 18):** Comfort demands for a standing environment during winter and summer monsoon seasons are met. However, eight test points fail to meet sitting comfort requirements in the winter monsoon season, and five points fail in the summer.

From Figure G-4 the wind environment at the entrance of the hotel facing onto Jian Shin Road satisfies the demands. However, when a southerly wind blows the velocity at the southwestern corner of the hotel (test points 13, 14, and 15) significantly increases, changes direction and dives downward. Although, according to Taichung weather data, the frequency of this wind pattern is not high (just eight days per year) tall evergreen trees have been planted to decrease wind velocity in this area.

E. wind environment on Taichung Kan Road (test points 19 through 25): This area also reaches standards for a comfortable standing environment. In summer, except for the southeastern side of the building (test point 24), comfortable sitting requirements are also met. In winter five places fail to fulfil demands for sitting comfort. The main gate of the hotel (test point 21) reaches requirements for sitting comfort, vital for a main entrance/exit.

F. square-style open space on the east side (test points 26 and 28): This area meets comfort demands for sitting in summer although it only reaches walking comfort in winter. As the wind velocity in this area is high during the winter monsoon season, tall evergreen trees must be planted on the northern edge. The main reason for this greater velocity is due to the creation of a narrow wind passage for northerlies or northwesterlies between the Formosa Building and houses to the northeast.

G. car park entrances and north side of hotel (test points 29 and 30): The wind environment in the car park (test point 29) satisfies the demand for comfort standing in summer, but only walking comfort in winter. Trees need to be planted. The entrance on the north face of the hotel fulfils sitting comfort demands in both the summer and winter seasons.

H. wind environment outside the construction site (test point 27): Areas to the east of the construction site do not meet sitting comfort demands either in summer or winter due to northwesterly winds. Further mitigation measures (eg. multi-storied pot plants and tall evergreen trees) are necessary to reduce wind velocity and impacts in the neighbourhood.

From the above the wind environment at the construction site is appropriate. After modification to the

wind environment outwith the site, the integral goal can be achieved. Values for comfort demands at test points in winter and summer seasons are listed in Table G-14.

Table G-12 : Monsoon Environment in Summer Season

Range of Wind Velocity (km hr^{-1})

	Sitting 0-17	**Standing 0-25**	**Walking 0-32**	**Discomfort 32-95**	**Dangerous >95**	
Minimum Frequency	80%	80%	80%		0.1%	
Test Point	Actual Appearance Frequency					Comfort Satisfied
1	89	98	99	1	0.01	Sitting
2	96	99	100	0	0.00	Sitting
3	96	99	100	0	0.00	Sitting
4	95	99	100	0	0.00	Sitting
5	95	99	100	0	0.00	Sitting
6	94	99	100	0	0.00	Sitting
7	No Test Value					
8	90	98	98	0	0.01	Sitting
9	85	97	97	1	0.01	Sitting
10	83	95	95	2	0.01	Sitting
11	79	94	94	2	0.01	Standing
12	89	97	97	1	0.01	Sitting
13	73	90	90	4	0.03	Standing
14	86	96	96	2	0.01	Sitting
15	79	94	94	2	0.02	Standing
16	82	96	96	1	0.01	Sitting
17	79	94	94	2	0.02	Standing
18	76	92	93	3	0.02	Standing
19	92	98	98	1	0.01	Sitting
20	82	95	95	1	0.01	Sitting
21	94	99	99	0	0.00	Sitting
22	88	98	98	1	0.01	Sitting
23	82	95	95	2	0.02	Sitting
24	79	94	94	2	0.01	Standing
25	80	94	94	2	0.01	Sitting
26	80	92	92	3	0.01	Sitting
27	74	89	89	5	0.03	Standing
28	82	94	94	2	0.02	Sitting
29	78	92	92	3	0.03	Standing
30	95	99	99	0	0.00	Sitting
31	86	97	97	1	0.01	Sitting

Data source: Chung-Kun Company, 1993, pp. 4-22

Table G-13 : Monsoon Environment in Winter Season

Range of Wind Velocity (km hr^{-1})

	Sitting 0-17	**Standing 0-25**	**Walking 0-32**	**Discomfort 32-95**	**Dangerous >95**	
Minimum Frequency	80%	80%	80%		0.1%	
Test Point	Actual Appearance Frequency					Comfort Satisfied
1	73	89	96	4	0.00	Standing
2	84	96	99	1	0.00	Sitting
3	85	97	99	1	0.00	Sitting
4	89	98	100	0	0.00	Sitting
5	92	99	100	0	0.00	Sitting
6	86	97	100	0	0.00	Sitting
7	No Test Value					
8	83	96	99	1	0.00	Sitting
9	80	95	99	1	0.00	Sitting
10	79	94	99	1	0.00	Standing
11	74	91	98	2	0.00	Standing
12	93	99	100	0	0.00	Sitting
13	74	92	98	2	0.00	Standing
14	79	94	99	1	0.00	Standing
15	66	85	94	6	0.00	Standing
16	75	92	98	2	0.00	Standing
17	66	84	93	7	0.00	Standing
18	64	83	92	8	0.00	Standing
19	95	99	100	0	0.00	Sitting
20	71	89	97	3	0.00	Standing
21	86	97	100	0	0.00	Sitting
22	77	93	98	2	0.00	Standing
23	64	82	92	8	0.00	Standing
24	68	86	95	5	0.00	Standing
25	69	87	95	5	0.00	Standing
26	70	87	95	5	0.00	Standing
27	60	78	88	12	0.00	Walking
28	62	79	89	11	0.00	Walking
29	59	76	87	13	0.00	Walking
30	87	98	100	0	0.00	Sitting
31	74	8890	97	3	0.00	Standing

Data source: Chung-Kun Company, 1993, p. 4-22

Table G-14 : Standard Point for Each Comfortable Wind Environment

Season	**Sitting**	**Standing**	**Walking**	**Discomfort**	**Dangerous**
Summer	22	8	0	0	0
Winter	11	15	3	0	0

Data source: Chung-Kun Company, 1993, pp. 4-24

Table G-15 : Maximum Noise Levels for Construction Procedures

Unit : dB(A)

Construction Item		Major Construction Appliance	Estimated level of Noise	Level at 30m distance	Level at 60m distance	Level at 120m distance	Level at 240m distance
Arrangement Procedure		Excavator Bulldozer	75-87	69-81	63-75	57-69	51-63
Excavating Process	Soil Blocking Column	Diesel Engine Pile Engine/ Pile Driver	97-107	93-101	87-95	81-89	75-83
	Excavating Engineering of Basement	Bulldozer Excavator	82-91	76-85	70-78	64-73	58-67
Concrete Process	Soil Blocking Column	Pump for Concrete; Air Compressor	86-92	80-86	74-80	68-74	62-68
	Floors at each Storey	Pump for Concrete; Air Compressor	86-92	80-86	74-80	68-74	68-74

Data source: Taiwan Sugar Company, 1997, pp. 7-14~7-15

G.2.1.5 Noise Impact

The types of noise impact from this building can be split into the construction and operation stages.

(a) construction phase

Most noise produced by construction has a time limit, and is temporary. The human ear cannot detect changes in noise intensity below 3dB(A), so in assessing noise impact if the increased noise level is between 0 and 5dB(A), no mitigation measures are required. However, if the range is between 5 and 10dB(A) moderate impact results so mitigation measures must be considered. When the increased volume is over 10dB(A) mitigation measures, or an alternative, should be taken as it is a major adverse impact.

Noise from construction engineering include surface clearance processes, soil blocking engineering, earthworks, foundation piling, and concrete engineering. Their applications, types of appliances and estimated noise values are listed in Table G-15. There is a distance of 30m between the construction site and established buildings to the west and north. Noise levels measured during the day are 66.6dB(A).

An increased noise level of over above 10 dB(A) generally comes from concrete and soil blocking engineering. To reduce noise impact, concrete engineering should be carried out as far from residential areas as possible (or certainly at least 60m). Sound-proofing walls should be installed around construction works to reduce the noise impact.

(b) noise impact from transporting vehicles: Construction hours were from 8am to 5pm, lunch from 12-1pm; an eight hour working day. During the excavation stage 84 trucks arrived at the site daily (11 trucks per hour). Together with vehicles used to ship construction materials there could be up to 20 vehicles hourly. This will reduce to 10 vehicles per hour once excavation has been completed. Ten and 20 vehicles were taken to estimate level of noise using the formula of estimation in compliance with the Noise Control Manual established by EPB in 1987 (Chung-Kun Company 1993, pp. 4-29).

$$L' = 10 \log (1/3600)L[3600-(NxT)x10^{log/10} + NxT \times 10^{Lc/10}]$$

L' = Leq level of hourly operation during construction stage

N = average interval per hour for construction vehicle

T = delay time on sensitive roads for transporting vehicle (8 seconds assumed)

Leq = noise level of the background

Lc = volume of transporting vehicle 1 metre from the road (75 dB(A) at 40 km hr^{-1} assumed)

3600 = a fixed measured value of noise volume per hour

The results are listed in Table G-16. It shows that the maximum increase in noise for transporting vehicles is 3.04 dB(A) at Chong Ming primary school, whilst all other areas are below 2 dB(A). The noise caused by construction vehicles has not made a significant impact upon the area as a whole (Table G-16).

(b) operation stage

After development is complete, the major noise source comes from various treatment facilities and vehicles coming and going. Potential noise sources related to treatment facilities include the operation of ventilation equipment and air-conditioning. The operation rooms will therefore be installed either indoors or on the open balcony with sound-proof boarding to reduce any noise impact.

Noise from vehicles during the operation stage can be estimated using the aforementioned formula. As the number of attracted vehicles are 568PCU, and as the background noise from Taichung Kan Road is around 75dB(A), increases in noise level will be limited to 3dB(A); minor impact.

Table G-16 : Increasing Noise Level from Construction Vehicles

Time	Section	Measured Level (Leq)	10 cars hr^{-1}		20 cars hr^{-1}	
			Estimated level	Increasing Level	Estimated Level	Increasing level
0800-0900	Taichung Kan Rd.	75.41	75.59	0.18	75.76	0.35
	Chong Ming Elementary School	70.60	71.30	0.70	71.89	1.29
0900-1000	Taichung Kan Rd.	76.21	68.89	1.38	76.48	0.27
	Chong Ming Elementary School	68.61	69.68	1.07	70.56	1.95
1000-1100	Taichung Kan Rd.	76.41	76.53	0.12	76.65	0.24
	Chong Ming Elementary School	68.80	69.85	1.05	70.67	1.87
1100-1200	Taichung Kan Rd.	76.41	76.53	0.12	76.66	0.25
	Chong Ming Elementary School	68.52	69.62	1.10	70.51	1.99
1300-1400	Taichung Kan Rd.	78.21	78.26	0.05	78.31	0.10
	Chong Ming Elementary School	67.22	68.68	1.46	69.78	2.56
1400-1500	Taichung Kan Rd.	76.30	76.43	0.13	76.55	0.25
	Chong Ming Elementary School	66.21	67.98	1.77	69.25	3.04
1500-1600	Taichung Kan Rd.	75.81	75.96	0.15	76.11	0.30
	Chong Ming Elementary School	69.10	70.00	0.90	70.81	1.71
1600-1700	Taichung Kan Rd.	74.31	74.55	0.24	74.79	0.49
	Chong Ming Elementary School	68.41	69.55	1.14	70.42	2.01

Data source: Chung Kun Company, 1993, pp. 4-29

G.2.1.6 Impact of Vibration

(a) construction stage

The source of vibration mainly comes from construction machinery and traffic. There are two primary sources of vibration: mechanical appliances such as bulldozers and compressors; traffic especially from heavy vehicles transporting construction materials or waste earthworks. The theory used to estimate vibration is the same as for noise. A pile driver (Hammer using diesel oil) has a basic level of noise vibration, from 5m and 10m, of 82dB and 80dB respectively (Chapter 7, Table 7-11). As the geology of Taichung is gravel and pebbles, the doubled attenuation volume is about 3dB. As a result the vibration level of the residential area 30m away is 74dB, detectable only by shallow sleepers (Table 7-12). Therefore, a pile driver should not be operated during the lunchbreak. The most common excavation bulldozer has a noise vibration level from 30m of 65 dB, a minor impact. All other common construction appliances have a vibration level of 60dB (eg. trucks) from a distance of 15m (ie. the outer edge of the construction site). Taking the distance of 15m as the vibration source, vibration attenuation values for multiple machines operating at the same place simultaneously are listed in Table G-17. Five machines operating together create an estimated vibration level of 67dB; 'slight' vibration.

The movement of transporting vehicles also causes vibration. Table 7-11 indicates that the vibration level of a transportation truck from distances of 10m and 20m is 56dB and 53dB respectively; 'senseless' vibration.

In Japan the maximum level for vibration control during the day is 65dB (Zone 1) or 70dB (Zone 2). At night the levels are 60dB (Zone 1) or 65dB (Zone 2). However, there are currently no regulations for vibration control in Taiwan. However, according to the Japanese standards, the vibration impact during the construction stage is not significant.

(b) operation stage

Aside from minimal vibration caused by attracted vehicles, there is no vibration impact from special machinery during the operation stage.

Table G-17 : Attenuation Vibration Values Caused by Multiple Machines Operating Simultaneously

Distance (m)	5 Machines	10 Machines	20 Machines	30 Machines
15	67.0	70.0	73.0	74.8
100	50.5	53.5	56.5	58.3
125	48.6	51.6	54.6	56.4
325	40.3	43.3	46.3	48.1
400	38.5	41.5	44.5	46.3
540	35.9	38.9	41.9	43.7
700	33.6	36.6	39.6	41.4
1,100	29.7	32.7	35.7	37.5
2,100	24.1	27.1	30.1	31.9

The volume of noise from each machine should be 60dB(A), a distance of 15m is taken as the vibration source to estimate attenuation.

Data source: Chung-Kun Company,1993, pp. 4-32, Table 4-1-11.

G.2.1.7 Waste and Waste Soils

waste: During the construction phase, there are about 200 construction workers with 50 actually living at the site. The daily volume of rubbish is low at about 150kg (150 x 0.5 + 1.5 x 50). Daily waste produced during the operation phase is about 0.01kg per person in the car parking area, 0.3kg per person in the offices, 0.1kg per dining person in the restaurant, and 1.5kg per person in the hotel. The volume of rubbish produced during the operation stage is estimated as:

- Car parks (B6F-B3F) 629 x 2 x 0.01 = 1.3kg day^{-1} (2 people per parking space)
- Large-unit offices (B2F-10F) 45,219.31m^2 x 0.6 x 0.2 person m^{-2} x 0.3kg $person^{-1}$ = 1,627.8kg day^{-1}
- Small-unit offices (538 in total) 3 people x 538 x 0.3kg $person^{-1}$ = 484.2kg day^{-1}
- restaurants (11F-15F) 17,351.21m^2 x 0.6 x 1person m^{-2} x 0.1kg $person^{-1}$ = 1,041kg day^{-1}
- hotels (178 in total) 178 x 2 people x 1.5 kg $person^{-1}$ = 534kg day^{-1}

Thus, the daily volume of rubbish is 3.7 tonnes.

waste soils: The amount of waste soils produced during construction is 180,000m^3. Foundation works take about 545 days. Therefore, the daily volume of earthworks is about 330m^3. Aside for any earth used in landscaping open spaces, all surplus soil is shipped to a gravel processing plant and utilised as concrete aggregate. Any non-recyclable earthwork will be transported to the soil landfill site in Nan Tun.

G.2.1.8 Insolation and Overshadowing

The shadow formed by the building over the immediate vicinity needs to be included in the EIA process. Insolation is the major heat source at the surface of the ground and ultraviolet light can sterilise. Proper insolation can save energy and help maintain a level of environmental hygiene.

A high-rise will shade nearby buildings and residential areas blocking sunlight. The assessment of the impact of insolation is in compliance with the concept of 'shadow with an outer frame'. The shadow area can be found by overlapping the shadows of the outer frames on the building caused by insolation. According to Taiwanese regulations, the shadow caused by a high-rise building cannot block the insolation of another building or the ground for more than nine hours at the winter solstice.

As shown in Figure G-5, the shadow at the winter solstice is the longest as the sun is at its lowest angle and faces north. Therefore, buildings and land to the north (northwest or northeast) of the building site must meet the insolation and light requirements. According to the analysis of the shadow, the Formosa Building meets these requirements.

Table G-18 : Analysis of Insolation at the Winter Solstice

Time	Angle of The Sun	Angle of the Height of the Sun	Projected Length of Insolation (m)
07:00, (17:00)	SE (SW) 62°33'	3°05'	2175.76
08:00, (16:00)	SE (SW) 55°16'	14°49'	443.06
09:00, (15:00)	SE (SW) 45°54'	25°24'	246.82
10:00, (14:00)	SE (SW) 33°41'	34°12'	175.84
11:00, (13:00)	SE (SW) 18°07'	40°13'	172.45
12:00	SE (SW) 0°	42°24'	128.35

Note: The height of the building is 117.25 metres.

G.2.1.9 Environmental Impact of Blocking Electrical Waves

The obstruction of electrical waves by high-rise buildings can be caused either by blocking or reflecting obstacles. These, in turn, are affected by the physical presence of the building, allocation direction, height, and materials of the outer walls. A theoretical prediction of the blocking of electrical waves can be calculated using the height and width of the building, the height of the transmission tower, the frequency, projection station and distance to the target building.

In this instance, the area blocking electrical waves (on the east side of the building) has a length of 327.5m and a width of 83.08m (Figure 10-6, chapter 10).

As the blocking area is large, mitigation measures must be taken. One measure would be to ensure the outer wall is an arch shape. Surface materials on lower floors should have a low reflection rate (eg. stone) which will reduce the reflecting obstacle of electrical waves. A further mitigation measure could be to improve the reception of the signal. A community antenna television (CATV) should be installed and provided free to residents in blocking areas.

G.2.2 Ecological Environment and Energy Application

G.2.2.1 Fauna Ecological Environment

The site, and adjoining area, is urbanised. The site was once a fishmarket so the land had previously been developed on. The area as a whole is not a good habitat for fauna as residential areas are very dense, population levels are very high. Mammals and reptiles are never seen although there is a limited insects and bird population in the park avenue 200m away. This is, however, far enough away from the site that their habitat will not be disturbed. Nevertheless, birds that use the trees lining the pavements

will be influenced by the noise and dust generated by the construction. Therefore, preventative measures against pollution are needed.

After completion of the building indigenous plants will be cultivated in the open spaces together with the restoration of the trees on the pavements providing a habitat for insects and birds. Generally speaking, the development of this building has not had a significant impact on the faunal environment.

G.2.2.2 Flora Ecological Environment

Indigenous plants and grassland on the site prior to construction site should be removed and replanted elsewhere. For example, a Banyan was moved to a local school. Transplantation is unlikely to apply to bushes under 1m in height, and common species. Photosynthesis by the trees lining the pavement around the site will be affected by dust, so endangering growth. To reinforce preventative measures against pollution, these trees must be protected.

During the operation stage, pot plants need to be cultivated in the open spaces to improve the landscape value of the building as well as providing a sound floral environment.

G.2.2.3 Energy and Water Use

Energy consumption during the operation stage includes electrical power, water requirements, and gas.

Of the power needed, 60% is met by electricity generated from a fossil-fuel power station in Taiwan. However, emissions from the power station are a major source of air pollution eg. of the 445,460tonnes of SO_x produced annually, 226,466tonnes is from the power station (50.9%). The power station also produces 21.5% of the annual volume of NO_x emissions. Consequently, the demand for more power indirectly adds to air pollution.

Power usage in the building can be classified into three categories; public electricity, power for offices,

and power for small-unit offices and restaurants. In addition to the auxiliary generators, the main source of electricity is from the Taiwan Power Company. An evaluation of the power demands is listed in Table G-19. Using Table G-19 the capacity of the equipment in the building is 13,320KVA, the contract capacity for public electricity is 550KW, the offices is 3,000KW, small-unit offices and restaurants is 2,600KW, and the integral power requirement is 6,150KW. Two 1,000KW generators are to be installed for temporary use (Chung-Kun Company 1993, pp. 2-19).

The daily water requirement of the upper floors of the building are assessed separately from that for the lower floors (Chung-Kun Company 1993, pp. 4-34):

(a) B6F to 10F

Car parking (B6F to B3F): 629 x 2 people x 3 l/person. Day = 3,774 l/D

Offices (B2F to 10F): 45,219.31m^2 x 0.6 x 0.2 person/m^2 x 120 l/D = 651,120 l/D

Daily water amount = 654,894 l/D

Water supply for air-conditioning: 11 l/RT x x0.025 x 2400RT x 60 x 10 = 396000 l/D

Daily total water volume = 654,894 l/D x 1.3 + 396,000 l/D = 1,247,363 l/D

= 1,247 tonnes/D

Therefore, the total daily volume of water needed from B6F to 10F is 1,247 tonnes. A 200 tonne water reservoir has been installed on B6F, which raises water to the 85m^3 reservoir on the 14F. This supplies water to the lower floors by gravity. The water supply for air-conditioning and fire-fighting purposes is from a 42 tonne reservoir installed on B6F.

(b) 11F through 32F

Small-unit offices (16F to 26F): 538 x 3 people x 120 l/D = 193,680 l/D

Common hotel facilities (11F to 15F): 17,351.21 x 0.6 x 1 person/m^2 x 30 l/D

= 312,318 l/D

Hotel: 178 x 2 people/1 room x 300 l/D = 106,800 l/D

Daily water amount = 612,798 l/D

Water supply for air-conditioning: 11 L/RT x 0.025 x 2,000RT x 60 x 10

= 330,000l/D

Total daily water volume = 1,126,637 l/D = 1,127 tonnes/day

A water reservoir of 250 tonnes is installed on B4F that first raises water to a $85m^3$ reservoir on 13F, then to a $100m^3$ water sink on the roof. This supplies water to 11F through to 32F.

From the above, the total daily water requirement of the building is 2,374 tonnes. Day to day living consumes 1,648 tonnes whilst air-conditioning requires 726 tonnes (Chung-Kun Company 1993, pp. 4-34).

Most of the restaurants are supplied with natural gas (NG). The floor area of the restaurants is $17,351.21m^2$ with tables to accommodate 6,590 diners. 16,475 meals can be served daily. As a result, the required consumption of NG is $1,110m^3\ day^{-1}$ (ie. 600Kcal $meal^{-1}$ x 16,475 meals / 8,900Kcal m^{-3} = $1,110m^3\ day^{-1}$) (Chung-Kun Company 1993, pp. 2-24)

Table G-19 : Plan for Power Requirements

Floor	Power Supply Specifications	Total No.	Application	Application Range	Capacity of Equipment	Capacity of Contract
B6F - B3F	3_3W 22.8KV	1	Car Park Control Rooms	Each Floor	Lights: 330 KVA Power:1060 KVA	550 KW
B2F - 10F	3_3W 22.8KV	1	Offices	Each Floor	Lights:1780 KVA Power:4590 KVA	3000 KW
11F - 32F	3_3W 22.8KV	1	Restaurants Hotels Suites with Offices	Each Floor	Lights:1460 KVA Power:4100 KVA	2600 KW
Total		3			Lights:3570 KVA Power:9750 KVA	6150 KW

Data source: Chung-Kun Company, 1993, pp. 2-19, Tables 2, 2-2

G.2.3 Landscape and Recreation

(a) **construction phase**

As there are no special landscapes or scenic spots near the construction site, there will be no significant impacts. However, construction materials, the piling of waste soils, temporary housing on the construction site, as well as the site itself, will cause a number of impacts, such as:

- Construction materials and miscellaneous facilities present a disharmonic view against the surrounding urban landscape. This may cause a sense of discomfort to passengers travelling on Taichung Kan Road and Jian Shin Road.
- Volatile solvents applied during construction can destroy plants and their habitat.
- Excavated earthwork temporarily stockpiled at the site will affect the urban landscape. Non-decorated materials on the surface of the structural high-rise frame will impact on the landscape of Taichung Kan Road.

(b) operation phase

There may be a potential impacts on the nearby park avenue and Science Museum that are 200me from the construction site. These impacts could be:

- The development of a high-rise building may form a disharmonic view against the low buildings around it.
- A sense of pressure will be imposed on the residents living on the north side of the high-rise building as there is only a 10m wide buffer zone.
- The use of stone materials on the lower surface, and glass and metal curtain walls on the higher floors, is very difference when compared with original buildings in the locality.

G.2.4 Traffic Impact

G.2.4.1 Impact of Traffic During Construction

(a) **construction workers:** The impact of the building site on traffic is mainly from the extra volume generated by transportation vehicles. In general, most construction appliances are stored on the construction site reducing any impact. However, 150 construction workers have to commute daily to and from the site, which will affect the traffic flow in the immediate vicinity of the site. Fifty percent of the vehicles are cars, and that the rest are motorbikes (potentially 47 cars, 58 motorbikes[6]), the traffic volume derived by the commuting workers in the construction phase will be 64PCU each day.

(b) **transportation vehicles:** The transportation of materials, equipment and earthworks will put pressure on the traffic. From Table G-20 42 trucks were needed daily to transport excavated earthwork. About 15 trucks were used to transport concrete, steel, module boards, materials for power and water installation, and equipment during construction stage. This equates to 48PCU of traffic volume.

(c) **traffic impact during construction phase:** From Table G-20 there will be 198PCU increase in the traffic volume during the excavating phase. Aside for the arrival and leaving of construction workers during peak hours, any movement of earthwork should be temporarily stockpiled on the site for transportation during non-rush hour times. There will be 162PCU of traffic volume daily because of the construction phase. Trucks transporting materials should, therefore, avoid travel during rush hour so reducing the impact.

(d) **impact of occupation or shutting of lanes by construction vehicles:** Construction appliances and vehicles which occupy any area of the road, or even shut the road, obstructs vehicular flow and downgrades the service level of the road. The main routes to the site (Taichung Kan and Jian Shin Roads) are also two major routes in Taichung City. Their traffic is always busy so any disruption should be avoided. Temporary covered pavements should be built to ensure pedestrian and passenger safety. Transportation vehicles should operate outwith rush hour.

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[6] The loading rate for cars is 1.6 people and 1.3 people for motorbikes. Thus, 75 /1.6 = 47 & 75 / 1.3

G.2.4.1 Prediction of Traffic Volume During the Occupancy stage

As the Formosa Building is a large-scale office and hotel complex, a high volume of associated traffic is forecast. The prediction model, and results, is described below.

(a) **trip type:** Hotels include guestrooms and other necessary common facilities (eg. lobby, recreational facilities, restaurants, and coffee shops) for guest use. Larger offices are on floors B2F to 10F, and small-unit offices are from 16F to 26F. The rate of trips during rush hour was listed in Table 7-15. Due to the scale of this development project it is predicted that 1,765 trips will be made in the rush hour (Table G-21). Eighty percent of the trips are made by office personnel. This can be explained as there are more office employees than hotel guests (lower floor area per office employee than for residents), and offices keep business hours so travel coincides with the rush hour.

(b) **model split:** Trips during the rush hour to the site originate in many different places, use different transport methods and routes. Transport generally consists of public transport (ie. bus, MRT, and taxi) or private transport (ie. private cars, motorbikes, bikes, and walking). The distribution rates for different types of transport is shown in Table G-22 with the numbers of people transported by each in Table G-23. The loading ratio of the MRT system with the bus is 4:6[7]. Table 7-18 (Chapter 7) lists the loading ratios for various transport options. Based on this, trips using each mode of transport used to predict the traffic volume in rush hour (Table G-24) (Chung-Kun Company 1993, pp. 4-46).

= 58.

[7]On average, less than 1% of the trips to offices and hotels is by public transport in Taichung. The Formosa Building is located near the MRT system, and is serviced by 12 bus routes, therefore the rate of

Table G-20 : Prediction of Transportation Attracted during Construction phase of Formosa Building

Construction Item	Content	Quantity	Daily Quantity	Car Trips	P. C. U.
Earthwork Excavation Engineering	Transportation of surplus soils	180000m^3	330m^2	42(x2)	134
	Construction workers	150 people/day	150 people/day	47 (58)	64
	Total				198
Construction Engineering	Concrete	48455m^3	65	15(x2)	
	Steel	8722 tonnes	12		
	Module Board	266502m^2	355		
	Materials for Painting, Plumbing	66834m^3	89		48
	Total				
	Construction worker	150 people/day	150 people/day	47 (58)	64
	Grand Total				162

Notes:

1. ( ) refers to the number of motorbikes.
2. Except for cars belonging to construction workers, the vehicle unit is trucks.

Table G-21: Statistics of Trips to the Formosa Building

Application	Floor Area (m^2)	Rate of trips during peak hours (people/100 m^2)	Trips during peak hours (people)
Offices	68597.6	2.01	1379
Hotels	26049.0	1.48	386
Grand Total			1765

Data source: Chung-Kun Company, 1993, pp. 4-34, Table 4-3-3

Table G-22 : Rate of Model Split for the Formosa Building

Application	Mass Transportation	Taxi	Private Car	Motorbike	Other
Office	30.00	2.7	33.04	34.14	0.12
Hotel	20.00	8.53	44.54	0.44	26.49

Data source: Chung-Kun Company, 1993, pp. 4-45, Table 4-3-5

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public transport use needs to be amended. Chung-Kun Company, 1993 pp. 4-45

Table G-23 : Distribution of Types of Transport to the Formosa Building

Unit: people

Application	Hour	Mass Transportation	Bus	Taxi	Private Car	Motorbike	Other
Office	Peak Hour	166	248	37	456	471	2
Hotel		31	46	33	172	2	102
Total		197	294	70	628	473	104

Data source: Chung-Kun Company, 1993, pp. 4-46, Table 4-3-6

Table G-24 : Prediction of Traffic Volume during Rush Hour

Application	Hour	Bus	Taxi	Private Car	Motorbike	P. C. U.
Office	Rush Hour am	11	23	285	362	435
Hotel		2	21	108	2	133
Total		13	44	393	364	
P. C. U.		21	44	393	110	568

Data source: Chung-Kun Company, 1993, pp. 4-47, Table 4-3-8

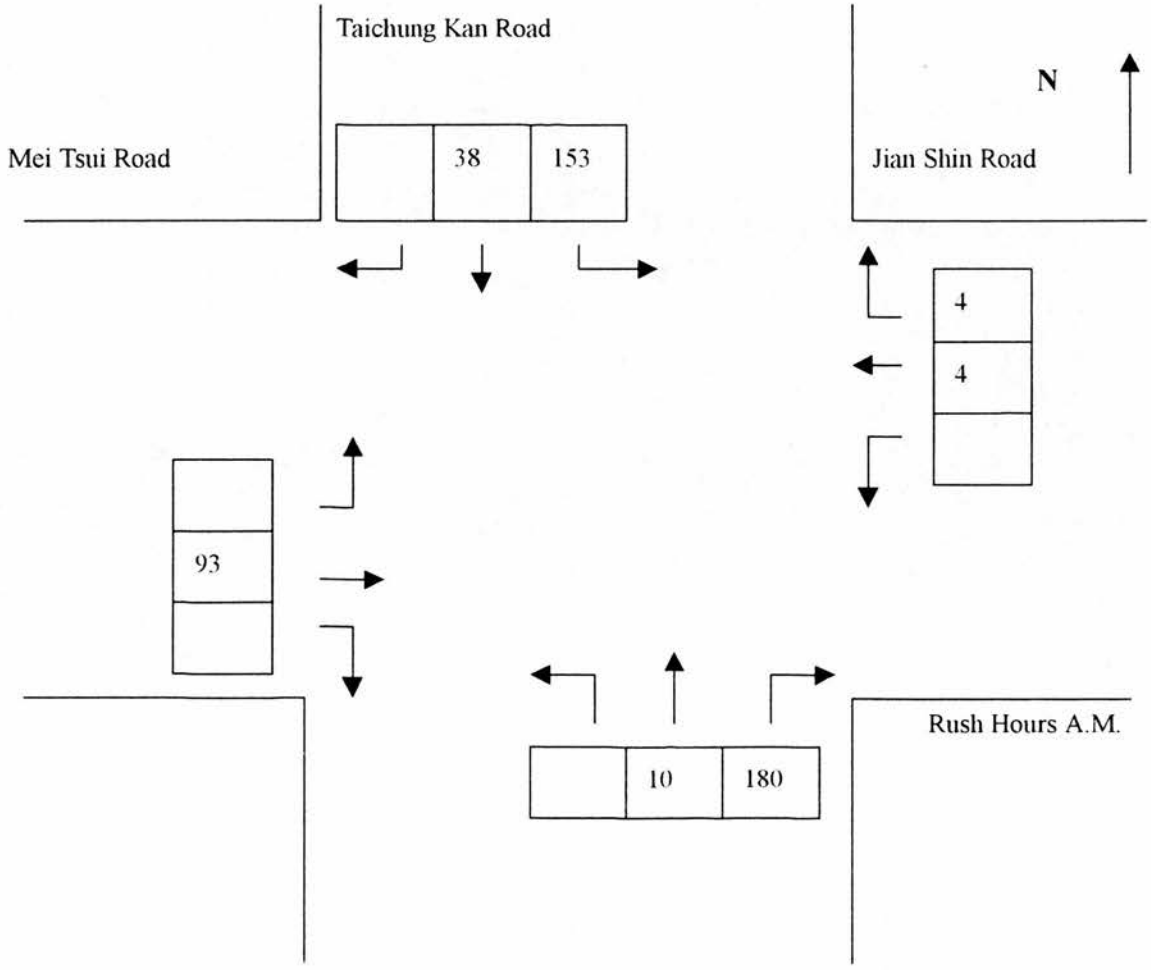
G.2.4.3 Traffic Impact during the Occupancy Stage

From Table G-24, the traffic volume associated with the Formosa Building is 568PCU during peak hours distributed throughout the neighbouring road network.

(a) **traffic assignment:** Traffic to the site comes from four directions. To determine the traffic volume assignment it is taken that 35% of taxis and 35% private cars travel along Taichung Kan Road in an east-west direction and 15% of each along Jian Shin Road. A 25% proportion of motorbikes travel in all four directions. West-bound motorbikes and private cars have to enter the car parks through a 10m wide road before they can get onto Taichung Kan Road and Jian Shin Road. The traffic volume as a result of the construction site during rush hour is shown in Figure G-8.

(b) **assessment of the level of service (LOS):** After the changes in traffic volume have been assigned, the actual increase in volume on each road is not very great. As a result, the level of service on Taichung Kan Road is maintained at Class F, and that on Jian Shin Road stays a Class C. As for the intersection service level, the level of service east-west on Taichung Kan Road and Jian Shin Road

maintains its pre-development Class F status. The south-north bound level of service remains Class E.



Data source: Chung-Kun Company, 1993, pp. 4-51

FIG. G-8 : Assigned Traffic Flow from the Formosa Building.

Prediction of the impact for parking

Parking is currently inadequate (Table G-3). The prediction of parking demand for the building is based on requirement rates during peak hours (Table 7-24). Hotels require 0.51 parking spaces per $100m^2$ per hour, and offices need 0.62. Using this model, 425 spaces must be provided for the offices, and 133 for the hotels: totalling 558 parking spaces during the rush hour (Chung-Kun Company, 1993, pp. 4-48).

Underground, the 3rd to the 6th floors are car parks offering 629 spaces for cars and 630 for motorbikes. The entrance to the car parks is situated at the north side of the building. It faces the 10m wide road, and is 60m from Jian Shin Road to the west, which allows for queuing to the car parks without interfering with traffic flow on Jian Shin Road.

Impact assessment of pedestrian traffic

On completion of the development, the original 5m pavement along Taichung Kan Road is reinstated together with a 10m wide stretch of open space set aside for pedestrians. On Jian Shin Road, in addition to the original 2.5m pavement, more than 4m of open space is reserved giving pedestrians at least 6.5m walking space.

According to the estimation of trips to the site during peak hours, there will be 1,765 people in the building (Table G-21). There are 1,379 people/trip for the offices, and 386 people/trip for hotels; a rate of 30 people/trip per minute. If all trips are along the Jian Shin Road and the 4m pavement, then the volume of pedestrians will be 7.5 people/second. metre. According to the assessment principle (Table G-25), the level of pavement service is Class A, which shows the traffic condition of pedestrians is good. If the trips were all along Taichung Kan Road and the 10m open space, the volume of pedestrians would also be 7.5 people/second. metre, whose level of service is also a Class A (Chung-Kun 1993, pp.4-56).

If trips during the rush hour are kept on the reinstated pavements (with an area about 1100m^2), then an area of 0.61m^2 is available to each pedestrian during the peak hours. According to Table G-25 this would be a Class E level of service meaning there is enough space for people to assemble in case an emergency in the building.

Table G-25 : Levels of Service of Transportation Facility for Passengers

Level of service	Area	Areas occupied by pedestrians (m^2/people)	Traffic flow (people /second, metre)	Remarks
A	Business District	$\geqq \infty$ 3.13	$\leqq$22	Walking rates can be chosen freely. No conflict will occur while passing others. Direction can be changed at will.
	Commuting Area	$\geqq$ 3.13	$\leqq$23	
B	Business District	2.08 – 3.12	23 – 31	Walking rates can be chosen freely. There is slight conflict while passing other people and interruption may occur.
	Commuting Area	2.08 – 3.12	24 – 33	
C	Business District	1.28 – 2.07	30 – 48	Walking rates are limited. There is a high degree of conflict while passing others and interruption may occur.
	Commuting Area	1.28 – 2.07	34 – 49	
D	Business District	0.85 – 1.27	49 – 59	Normal rates are limited. It is not possible to pass others and difficult to change direction.
	Commuting Area	0.85 – 1.27	50 – 66	
E	Business District	0.48 – 0.84	60 – 72	Walking pace is limited. Difficult to pass others and conflict unavoidable.
	Commuting Area	0.48 – 0.84	67 – 80	
F	Business District	<0.48	>72	Walking pace cannot be decided at will, cannot pass others, or move in adverse direction.
	Commuting Area	<0.48	>80	

Data source: Chung-Kun Company, 1993, pp. 4-57

G.2.5 Social & Economic Impacts

G.2.5.1 Land Use Type

(a) use of site: This site was classified as a suburb prior to 1970. Neighbouring land is mainly put over to agriculture with a minor portion used for industrial purposes. The population to the west of the construction site was 71,726 in 1970. The development of the city and the expansion of the business district has resulted in a population increase to 113,049 by 1990; a growth rate of 57% in 20 years. Business is also increasing with the number of shops growing from 623 in 1970 to 4,890 by 1990. The land use of the neighbourhood has changed from a fishmarket to a residential district with increased urban development.

(b) use of surrounding lands: To the northeast of the site is the Science Museum and park avenue.

These are important recreational places in Taiwan with over two million visitors annually. Therefore, this district of Taichung, as well as being a booming business centre, is also an area of scenic beauty.

To the south of the building site is the So-Go Department Store, to the east offices and business buildings with shops and stores to the west. In general, aside from the residential district to the north, the Formosa Building is compatible with other office and business buildings in the vicinity.

G.2.5.2 Social Environment

(a) population: The population in this area has steadily grown (except in 1990 and 1991) as previously mentioned. This trend can be split into two phases: high growth period before 1975, annual growth rates over 4%; slower growth period, growth rate between 1-2%. This indicates that urban development in this district has stabilised.

The gender rate among 109797 people in 1995 was 97.20%. There were slightly more females than males. Household populations have dropped from 4.12 people in 1989 to 3.29 people (1999) indicating an increase in the number of small families. Population density is 19,248 people km^{-2}; the third most dense area in Taichung City.

In this area the emigration rate is higher than immigration[8]. To reverse this trend, schemes to increase job creation through business activities are major issues in redeveloping this district.

Daily, there are about 200 construction workers coming and going from the site during the construction phase. Fifty live at the site, which is only 0.05% of the population in the district so does not influence population structure.

It is estimated that 650 job opportunities will be created during the operation phase of the building

[8]Immigration population was 15,106, and emigration was 17,161 people in 1995.

(Table G-26). It is estimated that 60 employees and their families will move into this district. This may amount to 200 people or 0.2% of the district's population, ie. not a significant impact on the populations structure.

Large numbers of people will be attracted to the Formosa Building during the operation phase with restaurants, hotels and offices being the focus. This could result in 20,000 visitors and employees daily (Chung-Kun Company 1993, pp. 4-34). The estimation model is explained below.

- general offices (B2F to 10F): 45,219.31m^2 x 60% x 0.2 people m^{-2} = 5,426 people
- small-unit offices (16F to 26F): 538 rooms x 3 people = 1,614 people
- restaurant population (11F to 15F): 17,351.21m^2 x 60% x 1 person m^{-2} = 10,410 people
- hotel population: 178 rooms x 2 people = 356 people

Table G-26: Prediction of Employees in the building

Application	Area (m^2)	Attracting rate of employee (people/m^2. day)	Number of employees (people/day)
Office	68,597.6	0.007	480
Hotel	26,049.0	0.006	156
Total			636

Note: The attracting rate for employees is based on Taiwan Sugar Company,1997, pp. G-1

From the above, there will be a significant impact on the district population structure on completion of the building. The biggest impact will be the daytime gathering crowds as 20,000 people is about 18% of the population in the west. Further incentives and a concentration of economy will encourage the development of surrounding land, which will result in further population and density increases.

(b) public facilities: The sewerage and drainage facility is of the utmost importance. A sewerage facility has not yet been installed in the area so, daily, 1,300 tonnes of waste water have to be treated and drained at the self-made waste water treatment plant. The effluent volume is 0.015 $m^3 sec^{-1}$, which is compatible with the carrying capacity of the drainage and river system.

At a recreational level, there are an insufficient number of playgrounds and parks, which will be even more inadequate once the building is fully operational. Education facilities will be able to cope as the increase in the permanent population will only be 200.

(c) public service: As this area is the booming business centre of Taichung City, with the municipal government and city council, public services are well developed eg. the post office headquarters, 242 hospitals (ranked 2nd only to ones in the north), the Cultural Centre, and the Provincial Museum of Arts.

Fire-fighting: the height of this high-rise building is beyond the fire-fighting limit so automatic fire-fighting equipment and facilities are installed throughout the building.

G.2.5.3 Economic Environment

(a) job creation: There were 200 construction job opportunities during the construction phase and 636 vacancies during operation stage (Table G-26), which will help reduce unemployment in Taichung. The shift of the working population to tertiary industry also affects the structure of industry in this area. The employment population in the service industry in this western district has increased from 67.5% to 69.5% with 2% provided by this building.

(b) economic activities: The completion of this high-rise building will promote economic activity in this district, especially in the tertiary industry. The requirements for construction materials and equipment during the construction phase can help in the development of related industries. Since the construction industry has been termed the 'locomotive industry', integral economy will be motivated and developed positively. Local stores and shops will also benefit from the daily presence of construction workers.

The local government can impose tax revenues on the building once completed. It is estimated that

£50,000 land tax, £240, 000 pounds house tax and £5 million worth of income tax will be collected by the government.

(c) land ownership: The fish company previously owned this building site. The ownership is now split and held by all owners of the building proposal, which may cause problems when a unanimous agreement for re-building or redevelopment is needed in the future.

(d) land prices: Currently, land prices in this district are expensive at £10,000 m^{-2}. As business activities get busier, land prices will increase further.

(e) living standards: As the business and administration centre of Taichung City higher incomes are expected. A daily influx of 20,000 people will cause an impact on the local lifestyle with the old communities to the north being particularly affected.

G.2.5.4 Social Relationship

The analysis of the impact on social relationships can be divided into three: social system; social psychology; and security hazard.

The construction of the high-rise does not impose a significant impact on the original social structure. The majority of local residents agreed to rebuild the fishmarket into a high-rise building although concerns were expressed at the public briefing about the impact of increased parking on their day to day. They were also concerned about changes in quality to their living environment from large shopping crowds and noise. Nevertheless, when compared with impacts from the fishmarket, most residents still accepted the offer[9].

Disaster prevention is a major social issue. The most common catastrophes in the metropolis include

[9]Local residents often complained about early morning operations and the stinking smell of the

fire, earthquakes and wind disasters. As fire is difficult to control and could easily spread to nearby residents, this is taken into consideration at the planning stage. Consequently, open spaces are reserved on the western and northern aspects of the building to serve as buffers against fire spread. In earthquakes, falling materials and debris may affect the safety of neighbouring buildings. An insufficient space between this building and those adjacent to it would result in collision and destruction. In general, a space greater than $(H/2)^{1/2}$ is a basic requirement. A space of over 5m is reserved for this purpose to the west and north of the building. Wind disasters generally occur during typhoon season. The position of this building may change or increase the intensity of typhoons damaging neighbouring houses. Wind tunnel tests are carried out to assess the impact of the wind field. Results show that wind disasters will not occur because of this high-rise building.

G.3 MITIGATION MEASURES AND ALTERNATIVES

G.3.1 Mitigation Measures

Micro-climate

(a) control of heat environment: The micro-climate of the site changes due to changes in heat capacity. Therefore, surface materials on the lower floors should be of low reflective quality with a high specific heat rate. Aside from areas of greenery, and water landscaping, climbing vines should be arranged and planted to reduce the site temperature through evaporation.

(b) wind hazard: Southerly and northerly winds usually occur in this area. In order to avoid forming a vertical angle between the building and the wind, which might enforce windflow separation at the corners, the location of the building must be arranged and adjusted to form a slanting angle with wind direction. From wind tunnel tests, wind disturbance will be greatest at the northwestern and northern sides of the building. Adopted mitigation measures are:

A. installation of a canopy or screen against the wind on the northwestern side to diminish the

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fishmarket. They were happy to have this site used for commercial purposes.

wind impact on pedestrians to prevent whirlwinds and descending air flows

B. facility layer on the medium and higher floors of the building can be used for ventilation so reducing wind hazard impact

C. the building is a column style design that can limit the power of the descending wind produced at the higher floors onto the roofs of lower buildings and pedestrians

D. according to the wind tunnel test, wind velocity in winter at the north end of the site is strong. This might affect sitting and standing activities of neighbouring buildings. Consequently, evergreen trees should be planted to reduce velocity and wind hazard.

Disturbance of electrical waves

To resolve reception difficulties due to the blocking of electrical waves, community antenna television (CATV) and band increasing facilities will be installed and incorporated into the shared audio-video antenna system

Noise nuisance

To prevent large levels of noise during the construction phase, a manual soil blocking column support will be applied to the base excavation instead of steel pile or steel track piling. This should ensure noise levels do not increase more than 5dB(A). A 3m high fence around the construction site will also reduce noise levels to below 65dB(A).

Land use

The specific use of this site as a hotel and office complex is very different to its former use as a fishmarket. The land will be subjected to three types of impact: insufficient open spaces; traffic congestion problems; and chaos of land use orders. The following mitigation measures will be implemented.

(a) Open space will be reserved for use by people inside the building as well as local residents to

compensate for the lack of public parks in the area

(b) Parking spaces must be reserved inside the building to prevent roadside parking and obstruction of traffic flow. Entrance and exit to the car parks will not be directly connected to Taichung Kan Road so preventing disturbance and obstruction of traffic flow by queuing traffic or by changes in direction.

(c) All activities are designed to be held inside the building to prevent any impact on the surrounding land. In addition, the management of the open space will prevent the gathering of temporary vendors.

G.3.2 Alternatives

Development goal alternatives

This alternative is to change the design of the development project and to alter its uses if necessary.

(a) office building: An advantage of this alternative is increased economic activity and job opportunities. However, this use is not beneficial to recreational development in central Taiwan. The traffic volume would also exceed the predicted volume of the original project so imposing greater impact on the local environment. Furthermore, there is an abundance of similar office buildings in the district that might not attract investors.

(b) residential building: The advantage of this alternative is less pollution during the operational stage than the original project. Nevertheless, the construction of a residential building in a booming business centre on the busy Taichung Kan Road does not fit in with the city development and will lead to crowding and pressure on insufficient public facilities.

Intensity alternative (decreasing building coverage ratio)

Advantages of this alternative are the reduction in the size of the excavation area and construction period. This could reduce the range of environmental impacts. A decreased floor area will reduce the

number of trips made to the site so alleviating impacts during the operation stage. However, as land costs are fixed, the cost per unit area will be raised lessening the competitive capacity of the industry.

Architecture style alternative (low-level building)

Under the principle of maintaining the total floor area the Formosa Building could be redesigned as a 20 floor building. The advantage of this alternative is a smoother skyline. However, the building coverage over the ground's surface will increase by about 400m^2, which will enlarge the excavation surface and diminish the amount of open space.

No-action alternative

The no-action alternative means that no construction on the site will be carried out. Its purpose is to predict changes and the impact of the development proposal in the application area.

The primary goal of this building project is to provide quality recreation and entertainment, both for foreign tourists and the general public. It is estimated that the total room requirements for the hotels will be 1,850 in 2001. Nevertheless, international hotels like the Plaza Hotel, Howard Hotel, Evergreen Hotel and International Hotel can only provide 1,469 rooms; 381 rooms short of the target[10]. Therefore, this building can accommodate the shortcomings of these international hotels.

If the project had not been given the go-ahead, the original use of the land as a fishmarket would be incompatible to the services and requirements of the rest of the neighbourhood. The local residents have already experienced foul odours, noise, and a heavy traffic volume in the mornings. The application to change the land use to hotel and office buildings will meet the demands of urban development in this area.

Engineering alternative

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[10]If we calculate the lodging rate of international hotels as 70%, then 2,643 rooms will be required in

This alternative is a change in the construction method, including an alternation of the foundation type used, a change in the structure, and a change in the construction timetable. Any changes in engineering, however, do not reduce significantly impact on the environment.

2001 (Chung-Kun Company, 1993, pp. 2-4).