

Innovation in the Water Industry: Challenges and Opportunities from the Water Engineering Perspective

Professor Andrea I. Schäfer¹

Introduction

In order to address the apparent lack of innovation in the UK water industry one ought to define this term in the context at hand. A definition that appears relevant to the process of water provision is;

'Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace.' (Balgreh et al. (2009))

What does this mean in a context where there is no market place due to very little scope for competition? In essence a very multi-layered and integrated innovation covering novel approaches to policy, cost model, regulation, public participation, and technology that brings the UK to the forefront of the global water industry. To assume an innovation leadership role a number of stages will be required, namely;

- ◆ Definition of the key challenges facing the sector in terms of its duties
- ◆ Understanding of the current state-of-the-art – i.e. the baseline across a range of specified indicators across the range of activities that are undertaken
- ◆ Knowledge of best practise in other countries to drive innovation
- ◆ Clarity on roles and responsibilities of different stakeholders in driving innovation

How can wholesome water be provided to the public at reasonable cost in the most appropriate, efficient and sustainable way? Answering this question is likely to require a paradigm shift in the way water is currently provided and requires a fresh look at the true value of water and customer expectations.

Much of innovation is about the uptake of research, beyond the development that industry generally does reasonably well. The perceived need is to innovate – the actual issue being how to move from acquisition of knowledge to doing something significantly better? This requires in the first instance knowledge of the clear benefits of such innovation to society as a whole.

Key Issues facing the Water Industry

Why change what works? Population growth, climate change and increasing pressures such as micropollutants are challenging water security and costs. Countries that are facing more immediate pressures (e.g. Australia, Israel, California, Singapore) have experienced a boost in water innovations in recent years and have assumed a leadership role.

- ◆ Health (water quality) vs environment (ecosystems/carbon emissions)
- ◆ Emerging contaminants (Water Framework Directive Priority Substances)
- ◆ Increasing energy requirements
- ◆ Water pressure (scarcity vs flooding) and environmental/climate change
- ◆ Regulation of costs and reward/penalty for investments
- ◆ Need for 'innovation' generation and implementation to stimulate water industry and supply chain and secure a competitive place at the forefront of global efforts

UKWIR has produced a roadmap to 2030 identifying issues and needs in the sector. This document ought to be reviewed by the experts in sector and updated on a regular basis including both the needs of the water industry nationally and globally – and going through an open process of

¹ Chair of Environmental Engineering, School of Engineering, Institute for Infrastructure and Environment, The University of Edinburgh, William Rankine Building, The King's Buildings, Edinburgh EH9 3JL, UK Tel +44(0) 131 650 7209 - Fax +44(0) 131 650 6781, Andrea.Schaefer@ed.ac.uk

consultation with stakeholders. Such workshops – if drawing from the full breath of the knowledge base - present an excellent opportunity for the water sector and universities working together to establish relationships that can shape the research direction.

Recommendation 1: Establish an avenue of focused communication of water sector needs in terms of R&D, fundamental research, policy, supply chain. This role has already been assumed by UKWIR in part and hence it would make sense for UKWIR to at least engage in this role and ensure good coordination with Recommendation 3.

Processes to identify the Gaps: Research Needs

'If I had an hour to solve a problem and my life depended on the solution, I would spend the first 55 minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes.'

(Albert Einstein, 1879 – 1955, Physicist & Nobel Laureate)

The UKWIR Roadmap identifies needs and direction. A very important follow-on from this roadmap is the identification of focused research questions. This effort is often cut short resulting in somewhat random activity in a particular area that was identified as a priority. This can be unduly influenced by the self-interest of particular stakeholders (academics in particular have a reputation to influence research direction towards their interests) in particular if only a small number of stakeholders participates in activities (e.g. Environmental KTN, 2008). In consequence a mechanism that facilitates broad participation in solving focused problems and encourages collaboration is required.

Recommendation 2: Based on the needs identified in the UKWIR Roadmap a process of 'problem focused think tanks', workshops to identify appropriate research questions in the context of the goals of innovation should take place. This process should be driven by an independent body (research councils could be ideal provided that a truly independent approach can be demonstrated) and be open to experts (see Recommendation 3) and stakeholders.

Water Sector Research Capacity

Historically, the UK water sector has held a strong position in the global water sector. Through a significant reduction in investment in water related research this has declined drastically in recent years. This is affecting not only the performance of the sector, it is threatening the loss of research capability. For the UK to be internationally competitive (or even leading) has significant positive impacts on the economic performance of the water sector, related consultancy firms, supply chain, spin offs and SMEs and inevitably research institutions and academia – and hence job creation and security in the sector. In consequence, it is important for the UK to know what expertise is available in the sector and maximise the opportunities through;

- ◆ visibility and showcasing of the broad knowledge base in the sector
- ◆ a strategic review of expertise with potential application to the water sector to identify UK strengths (e.g. the UK has a very strong material science knowledge base that traditionally has no link to water research)
- ◆ generate a water research platform where water research results can be disseminated (research publications are not always readily accessible to industry)
- ◆ monitor the funding provided for water research in the UK and impacts of such funding (research councils now request impact statements)

Recommendation 3: Generate a database of broad water expertise in the country by identifying all individuals in research institutions and universities with a well defined description of their relevant expertise. This role could be assumed by DEFRA which is carrying out similar exercises in other sectors unless another mechanism is deemed more suitable.

Processes to identify Innovation

'We can't solve problems by using the same kind of thinking we used when we created them.'

(Albert Einstein, 1879 – 1955, Physicist & Nobel Laureate)

It is important to note that it is very difficult to see issues from 'within'. This is where reports such as the one by the Council for Science and Technology, that criticises the low research and development investment in the sector and encourages a step change, are very important (CST, 2009). Arguably such findings require a more solid evidence base - such as a quantifiable measure for innovation - that appears to be unavailable at present. In consequence criticisms are seen to be based on anecdotal evidence or perceptions. A closed sector will be unlikely to be able to objectively identify and effectively address issues. Efforts are naturally hampered by a reluctance to openly admit shortcomings, in particular in a resource constraint environment where competition over resources may distort the identification of genuine need and where economic regulators (and shareholders) do not adequately reward efforts to innovate. Yet, admitting shortfalls and taking responsibility for change will inevitably precede such a step change and contribute to a thriving sector. A climate that rewards innovation and a transparent and measurable indicator to quantify innovation is required.

Recommendation 4: Establish a measure for innovation and what industry (and as a result society as a whole) will gain from responding to challenges (inevitably taking into account the difference facets of innovation such as service delivery, financing, technology, monitoring) and an independent body to assess progress. Such a role could be taken on by OFWAT and/or the water company reporters – or individual leaders in the water industry eager to trail blaze and setting an example of leadership.

Mechanisms to facilitate/fund Innovation

With properly identified research questions from 'problem focused think tanks' the identification of the best teams to address these problems can be narrowed. While a healthy degree of competition between researchers should be maintained, the current level of competition partially created by a lack of an adequate level of resources and a questionable process of funding allocation is disabling. It is in everyone's interest to work together to create a reasonable pot of resources to enable addressing both applied and fundamental problem based research questions that operate to address grand challenges beyond requiring specific outcomes for a specific project at a specific cost. A good example may be the Living with Environmental Change (LWEC) initiative if indeed an evidence base for policy development can result from research. This will require a working together by all stakeholders to contribute to this pot through, for example,

- ◆ Consumer levy for 'green water' or 'water security' (see OFGEM mechanisms)
- ◆ Research Council involvement in ring fencing of funding for relevant water research to deliver on water policy – in line with an agreed vision & strategy for the sector as well as encouraging transparent funding allocation based on impact and excellence
- ◆ Creation of a TSB innovation platform – and coherent lobbying from the sector to support such initiatives
- ◆ Joint initiatives to secure EU funding (e.g. WssTP Task Force for the European Water Platform)
- ◆ Participation in EU activities through dedicated UK funding (e.g. EUREKA that facilitates innovation import and hence competition at least at the level of the supply chain)
- ◆ Financial commitment from water companies by providing leadership and taking ownership in resolving local and global water problems
- ◆ Uptake of funding schemes available to all sectors (e.g. KTN, Carbon Trust, etc) and provision of assistance to prepare high quality bids

- ◆ Coordinate efforts in an inclusive manner to avoid duplication and inefficiency within the UK and globally (uptake of research findings from the international knowledge base)
- ◆ Collaboration between Royal Academy of Engineering, Water companies and Universities to create a suite of 'Chairs for Water Innovation'

Recommendation 5: Establish a mechanism to generate a research & innovation fund for the water industry to address research needs and stimulates innovation. Most likely suitable mechanisms can be adapted from the electricity regulator (OFGEM) and policy makers ought to facilitate this process.

While it is important to compete for funds, the preparation of bids for funding costs time and money, in particular for EU schemes. Funding allocated to the sector from research councils is disproportionately low compared to other sectors. Two main reasons may contribute to this fact; 1) the sector is not helping each other by giving sufficiently positive assessments (this can be driven by excessive competition) and 2) proposals cannot compete in quality with other sectors (e.g. some physical sciences). Fostering a culture of working together will be essential to overcome 1) while writing high quality proposals (2)) can be supported by Recommendation 2 and provision of training and facilitate collaboration. Industry has an important role to play in this area through

- ◆ Pump priming: generation of preliminary 'proof of principle' results that then can attract significant research projects
- ◆ Resource leveraging: in kind contributions of expertise, facilities, services and materials – as well as some cash can help significantly with funding success
- ◆ Pooling: national facilities for water analysis, for example, will provide a broad accessibility of analytical instruments (to researchers), a degree of quality control and avoid widespread duplication of infrastructure efforts

Recommendation 6: Establish a one stop resource site listing all funding opportunities for the sector and offering training opportunities for grant writing (e.g. workshops for junior researchers, mentoring schemes and sessions with funding agencies). UKWIR in collaboration with Research Councils may be able to offer such support?

Bridging the Gaps: from Academia to Industry and Policy Experts

While innovation should be a consequence of self-motivated best practise in the water sector rather than responsive to government imposed 'targets', policy can help with facilitating innovation, in particular by ensuring that regulation does not provide disincentives to innovation. Policy makers do not necessarily know how to tell what innovation in the water sector means. While recommendation 4 can assist in quantifying innovation, bridging the gap between the state-of-the-art and policy is required. A number of activities can facilitate this process.

- ◆ Expansion of the DEFRA-EPSC policy fellowship scheme to a larger number of fellows to facilitate interaction between academia and government agencies. The DFID Senior Research Fellow Scheme warrants investigation for adaptation
- ◆ Create a similar schemes for industry placements (for academics and policy makers)
- ◆ Facilitate information accessibility through MEng/MSc student placements in government agencies to provide focused synopses on particular topics to allow informed policy decisions. Such placements should originate from a diverse source and be linked to relevant experts for academic supervision (see Recommendation 3)
- ◆ Stronger integration of MEng/MSc projects in industry through placements and industry supervision of well defined joint projects
- ◆ Defining the Policy driven knowledge needs and contribute those to Recommendation 2 and 5

- ◆ Bring policy and industry to the classroom: invitation of policy makers and industry representatives to the classroom to give guest lectures

Recommendation 7: Establish mechanisms to bridge the gap and open communication between academia, the water industry and policy makers to smooth the way to innovation – DEFRA may be in a strong position to drive such an initiative forward from the policy perspective while industry-academia partnerships should be based on relevant expertise.

Incentives for Innovation

Innovation requires effort, risk and investment. Successful innovation hence should be celebrated and rewarded to foster creativity in the knowledge base. Such rewards can be financial or reputational. Some ideas on how those could look like are;

- ◆ Provide rewards and incentives for water companies, SMEs and supply chain for ambitious long term vision and innovation strategy development
- ◆ Create the UK innovation prize with categories for research & industry that attracts research ideas from around the world for potential industry uptake (e.g. Water Globe inspired by the Energy Globe awards: <http://www.energyglobe.com/en/award/>)
- ◆ Create an innovation entrepreneurship activity (e.g. 'Waterdragon's Den' inspired by the 'BBC Dragon's Den' or 'Britan's got Water Talent' inspired by 'Britan's got Talent')
- ◆ Inspire young people: create competitions for school children to raise public awareness of water challenges / value of water (e.g. activities at Science Festival or the Royal Society of Chemistry Parliamentary Initiatives for Schools)
- ◆ University open days for the water industry (this will need to be matched with attendance of such events by water industry representatives)
- ◆ UKWIR water industry fora to showcase new technology developments

Recommendation 8: Establish inspiring and challenging ways to reward innovation through financial incentives (OFWAT), and reputational challenges. Some of those activities need to be funded and some Venture Capital Partners are probably a good start.

Case Study Water Treatment Technologies: The Advanced Water Recycling Demonstration Plant

While a number of water technology test centres exist across the world that should be looked at for possible implementation in the UK to create opportunities to;

- ◆ Fast track mechanisms for new technology (pre)approval and uptake
- ◆ Level testing platform for new technologies for spin offs and SMEs lacking such infrastructure (access to water/wastewater and discharge as well as analytical facilities)
- ◆ Mechanisms to turn technology failures to case studies for learning and ultimately success
- ◆ Showcasing of state-of-the-art water and wastewater treatment technologies and emerging technologies and technology transfer
- ◆ Addressing global challenges and providing access to first class experiential learning for future leaders: engineering graduates and researchers

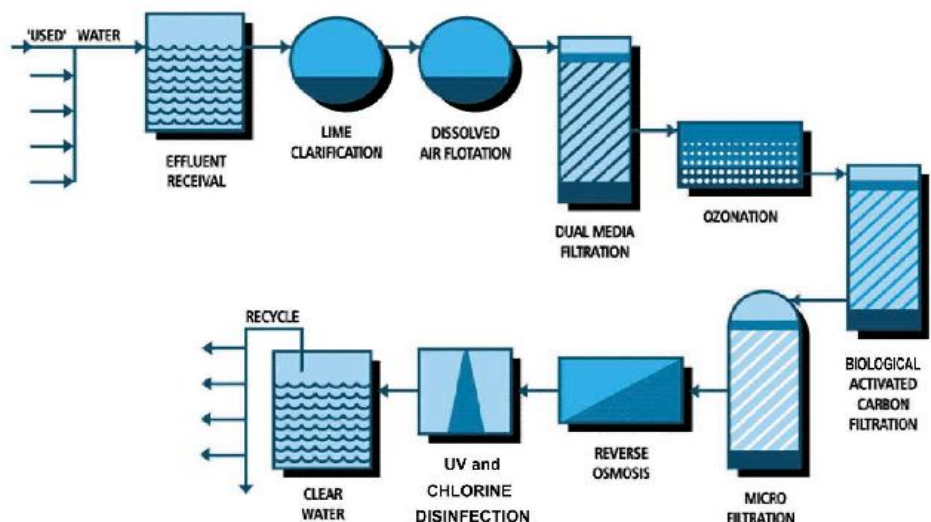
The Advanced Water Recycling Demonstration Plant (AWDRP) in Brisbane, Australia was chosen here as a case study of what can be achieved through a focused government-industry-academia partnership.

The AWRDP was constructed by the Queensland Government as part of the Queensland Water Recycling Strategy (QWRS) 'to provide a framework to encourage the adoption of sustainable water recycling to better manage water resources, and to support economic growth while protecting the environment and safeguarding public health' (Gibson and Apostolidis, 2001). Part of this strategy was technology demonstration, demonstrate technical feasibility of water recycling, engage in a public demonstration of treatment technology and to respond to concerns of a vocal

'toilet to tap' media campaign against water recycling. The plant was a temporary demonstration facility set up amidst public playing fields (high visibility) and accessible for researchers to carry out focused research projects. The plant was operated by the Queensland Government and could be leveraged to secure research funding. A photo of the site including the fish ponds fed with recycled and tap water is shown in Figure 1A while the eight treatment modules are depicted in Figure 1B. The modules could be operated in parallel or series as required for particular research projects.



Figure 1 Advanced Water Recycling Demonstration Plant (A) Site photo and (B) technology modules



As an example of the type of research conducted, a team of researchers (Khan *et al.* (2004 & 2005)) have carried out a research project on the removal of hormones and pharmaceuticals by the AWRDP funded through an Australian Research Council – Industry grant (SPIRT, now ARC Linkage Scheme). The project has attracted significant industry as well as international interest and visibility. Ultimately this led to unprecedented financial support of the Department of Education Science and Training (DEST) for the participation of Australia in the FP6 project AQUAREC through OZ-AQUAREC. Research findings from this particular project have inspired a decade of fundamental, yet industrially relevant research work on micropollutant sorption to materials used in water treatment.

Although a great demonstration of win-win results of a government-industry-academia cooperation, this particular project came to an unfortunate ending when the temporary demonstration period was over and the technology ended up in a scrap yard with no new host and home: a more beneficial arrangement (although maybe not possible in this particular case) could have been to set this facility up in a more permanent location to reap the benefits over a longer

period and capitalise more fully on the public demonstration capacity through regular school visits and training through student placements.

There is no reason why such a test site could not be established and hosted by a UK water company, providing infrastructure (in this case access to treated effluent, site management, some very basic field laboratory space and an operator) to host pilot units of innovators. Competition for technology performance, energy and water efficiency, long term operation for system maintenance protocols, access to research to remove particular pollutants that could potentially be spiked into the water are only a small selection of possibilities that such a facility might create. A cutting edge collaborative approach and a courageous leader in the water industry can design an opportunity to recreate an era of dynamic water technology innovation and fruitful partnerships in the UK.

'Happy are they that can hear their detractors and put them to mending.'

(William Shakespeare, 1564-1616, *Much ado about nothing*)

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