Diffusion of Engineering Innovation in the Wastewater Engineering Departments of the Water and Sewerage Companies Regulated by Ofwat In Amp6

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Abstract

The water industry in the UK is facing the twin environmental challenges of climate change and population growth. Within a broad array of potential innovations, engineering innovations provide new technology enabling the successful delivery of water and wastewater services in a changing environment.

This paper aims to investigate and evaluate the diffusion of engineering innovation (DoEI) in the wastewater engineering departments of the water and sewerage companies (WaSCs) regulated by Ofwat during AMP6.

The literature review presents the main concepts of the diffusion of innovation developed by Everett Rogers and theories on the effects of institutional interventions on the diffusion of innovations. Building on this theoretical foundation, the study focuses on the empirical aspects of DoEI in WaSCs and examines the extent to which the efforts made by WaSCs and Ofwat policies have contributed to the implementation of engineering innovations. Evidence is gathered from the three main groups working in the wastewater engineering departments of WaSCs: technicians, engineers and engineering line managers.

Keywords: diffusion of innovation, engineering innovation, regulation

Introduction

In recent years, industry authorities have recognised the need to embed innovation into the DNA of the water and sewerage companies (WaSCs) in order to tackle environmental issues and meet customers' expectations (Ofwat, 2017; WWT, 2018).

This is even more pressing in light of the AMP7 ambitions around efficiency, performance and customer service that were set following the 2019 price review. The fact is that the water sector, unlike other free-market enterprises, is not subject to competitive forces. Arrow (1962 cited in Reksulak et al., 2008) argues that organisational inertia, supported by the lack of competitive pressures, would lessen large firms' incentives to innovate. A similar view is presented by Parente and Prescott (1999) who convince that monopoly powers impedes economic progress and leads to economic inefficiencies. Ofwat, the regulator, aims to redress this through economic regulation to protect customers from monopoly power and drive better services. But how exactly are engineering innovations being diffused in WaSCs, and what could be done to encourage better take-up of new approaches?

Objectives

To answer these questions, I took an engineering perspective and explored the diffusion of engineering innovation (DoEI) in the wastewater engineering departments of WaSCs regulated by Ofwat in AMP6.

The main objectives of the research were:
1. To evaluate DoEI in the wastewater engineering departments of WaSCs.
2. To evaluate Ofwat's PR14 policies on engineering innovations in WaSCs and identify deficiencies and gaps.
3. To develop recommendations to improve DoEI in WaSCs by addressing issues within WaSCs and improving Ofwat's policies.

Methodology

This was a mixed-methods study based on a deductive approach and building on the diffusion of innovation concepts originally developed by Everett Rogers. Data was gathered from the three main groups working in the operational and project-based departments of WaSCs: technicians, engineers and engineering line managers. The research participants were 34 respondents to online questionnaires carried out in April and May 2019. All worked in the wastewater engineering divisions of 10 different WaSCs in England and Wales during AMP6 (Figure 1). I also scrutinised Ofwat policies.

Literature review

Diffusion of innovation

Rogers (2003, p.5) defines diffusion as 'the process by which an innovation is communicated through certain channels over time among the members of a social system' (Figure 2). Rogers' framework (2003) contains four elements of the diffusion of innovation: (1) innovation – an idea, practice or object that is perceived as new; (2) communication channels – the means by which messages pass between individuals; (3) time – comprising three factors: (a) innovation-decision process, (b) innovativeness: the relative time within which an innovation is adopted by an individual or group and (c) innovation's rate of adoption; and (4) social system – a set of interrelated units engaged in joint problem-solving to accomplish a common goal.

The innovation-decision process

The innovation-decision process (Figure 3) consists of a series of choices and actions through which an individual evaluates a new idea and decides whether to incorporate it into ongoing practice (Rogers, 2003). Namely, the individual learns of an innovation's existence and function (knowledge), forms an attitude towards it and chooses to adopt or reject it (decision). If they decide to adopt, implementation follows. Confirmation involves integrating the innovation into routines, recognising its benefits and promoting it to others (Rogers, 2003). Throughout this process, the individual must deal with the uncertainty and ambiguity inherent in choosing a new alternative to an extant idea (Rogers, 2003).

Fig 1: Percentage of Questionnaire Respondents with their Employment Positions

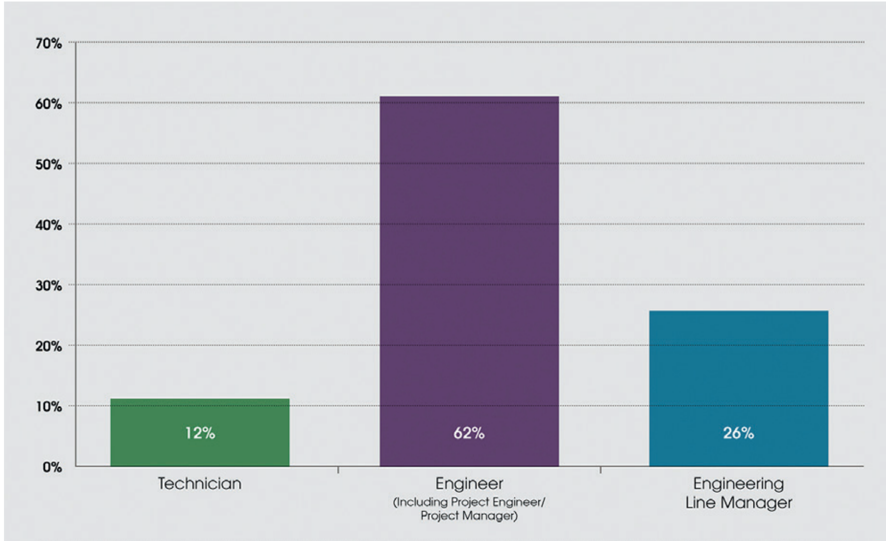


Fig 2: Diffusion of Innovation (Rogers, 2003)

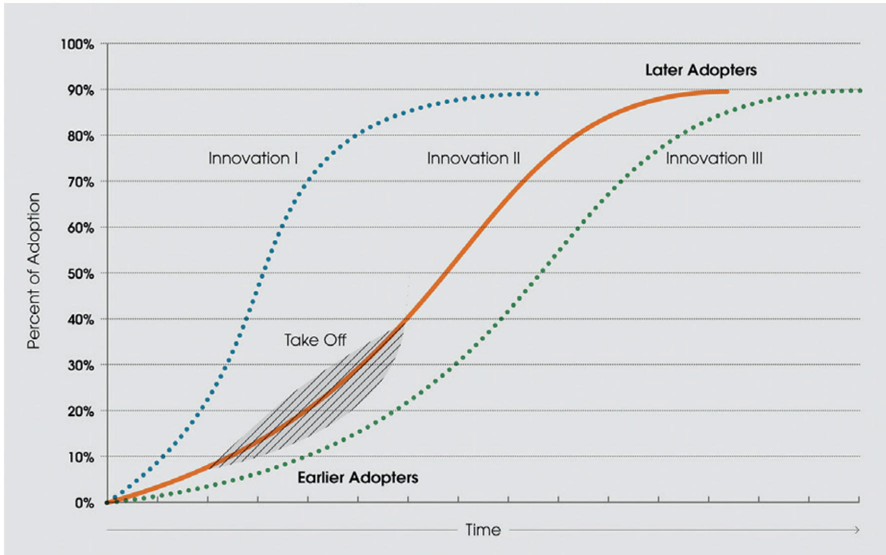
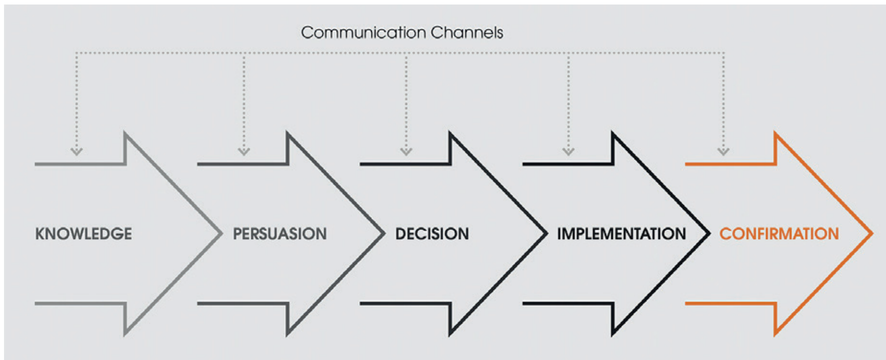


Fig 3: Innovation-Decision Process (Rogers, 2003)



The innovation process within an organisation

Organisational variables influence innovation behaviour beyond the aggregate effect of the organisation's individual members (Rogers, 2003). Rogers' framework of the innovation process in an organisation presents a valuable perspective that is relevant to larger enterprises such as WaSCs. The process comprises information-gathering, conceptualising and planning for adoption, leading to the decision to adopt and on to implementation. There are five stages in the process (Figure 4):

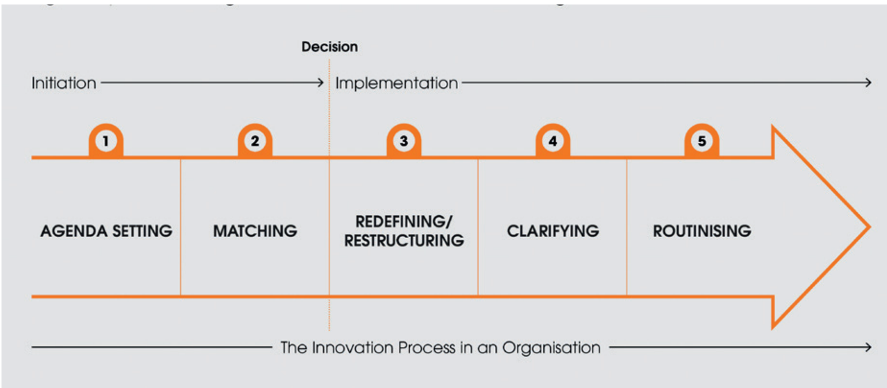
1. **Agenda-setting** is when a general organisational problem is defined. One or more organisational members identify an important problem, and then identify an innovation as one means of coping with it.
2. **Matching** is when the members attempt to determine whether the innovation will solve the problem.
3. **Redefining/restructuring** is when the innovation is modified to fit the organisation; conversely, the structure of the organisation may also be changed to accommodate the innovation.
4. **Clarifying** occurs as the innovation is put into more widespread use within the organisation. As individuals ask typical questions such as 'How does it work?', 'What does it do?' and 'Will this affect me?' they help to socially construct the meaning of the innovation.
5. **Routinising** occurs when the innovation has become incorporated into the regular activities of the organisation and has lost its separate identity (Rogers, 2003).

Regulation

Regulation is an intentional measure or intervention that seeks to change the behaviour of individuals or groups (Freiberg, 2010, cited in Hodge and McCallum, 2017). For example, regulators such as Ofwat demand ongoing improvements in the quality and efficiency of services from WaSCs and water-only companies (WOCs) (Tanner et al., 2018).

Maria (2005, cited in Spiller et al., 2015) argues that direct regulation that defines and enforces specific standards is successful in promoting technical change by setting performance targets and creating a 'performance gap'. Porter and van der Linde (1995) dispute that 'light touch' regulation can be dealt with end of pipe solutions without innovation. They convince that stricter ruling may result in more radical changes: innovations. Porter and Van Der Linde (1995, p.98) further argue that 'properly designed environmental standards can trigger innovation that may partially or more than fully offset the cost of complying with them'. This statement is well recognised as the Porter Hypothesis (PH).

Fig 4: The Five Stages of the Innovation Process in an Organisation

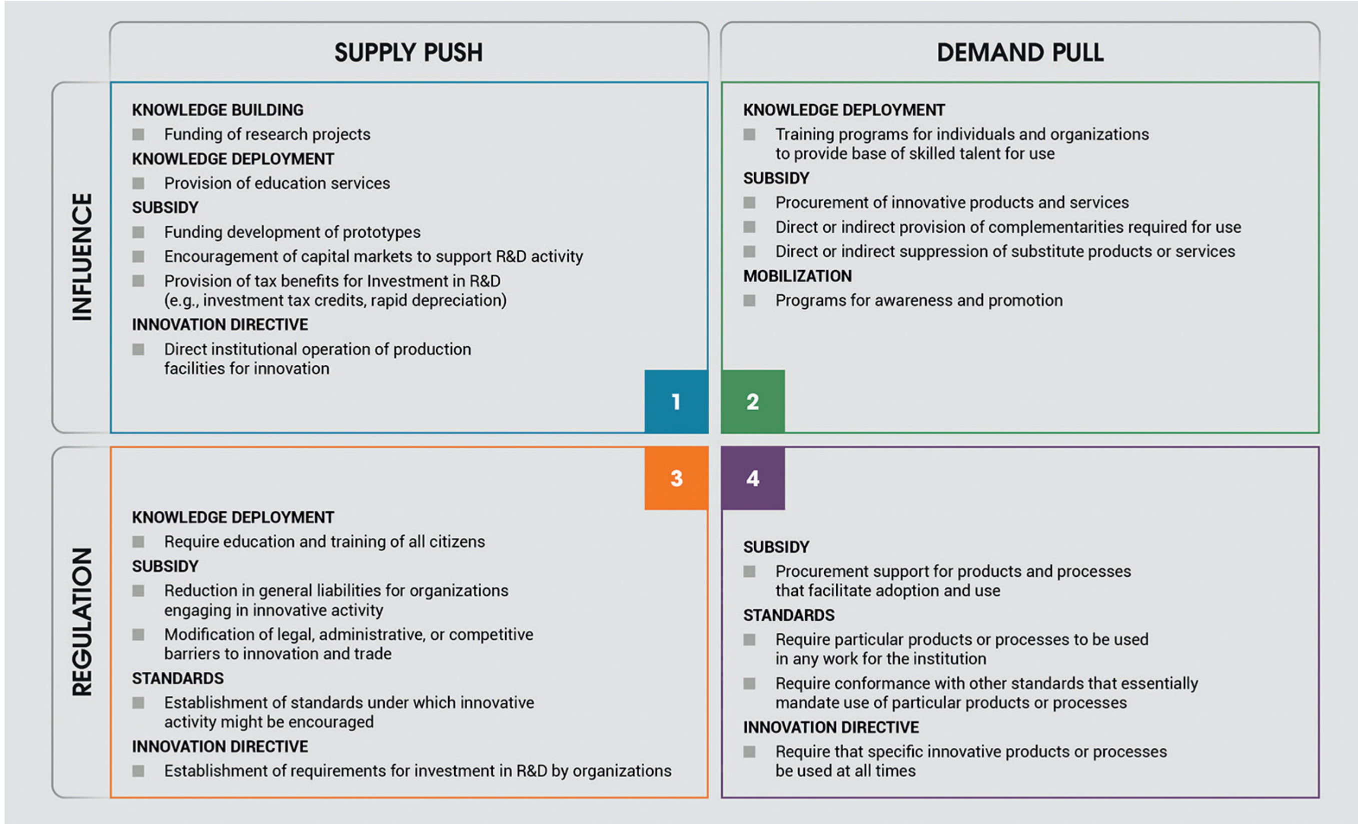


According to King et al. (1994), a supply-push force for innovation comes from the production of the innovative product or process itself, while a demand-pull force arises from the willingness of potential users to use the innovation. Within institutional interventions, King et al. (1994) distinguish influence and regulation. An institution exerts influence by exercising persuasive control over the practices, rules and belief systems of those under its sway (Kimberly, 1979). Conversely, regulation is direct or indirect intervention to modify the behaviour of those under the institution's influence, with the specific objective of modifying that behaviour through sanction or other affirmative means (King et al., 1994).

King et al. (1994) postulate five interventions to improve the innovation process in the regulated Information Technology industry (Figure 5), which could also be considered for the regulated UK water sector:

1. **Knowledge-building.** Intervention to promote knowledge-building is essential to the sustained production of innovation, but not absolutely required for successful diffusion in use.
2. **Subsidising** innovation, including institutional activities designed to produce specific innovative outcomes.
3. **Mobilising** decentralised actors and organisations to think in a particular way about innovation. The main institutional instruments for this are promotional and awareness campaigns, advertising to support the use of the innovation, staging of major events and establishing social traditions. Mobilisation is a subtle force.
4. **Standard-setting**, which aims to constrain the options of decentralised actors and organisations in line with larger social or institutional objectives. Standards are also established to promote the use of innovations after they have been developed.
5. **Innovation directive:** a command to produce or use innovations, or to engage in some activity that will specifically facilitate their production and use. Top-down directives for stimulating innovation and diffusion can be powerful interventions in special circumstances such as crises.

Fig 5: Dimensions of Institutional Interventions (King et al., 1994)



Results, discussion and recommendations

This section presents the key findings of the evaluation of communication channels, the innovation-decision process, social system, the innovation process in an organisation and Ofwat's PR14 policies.

Communication channels

Seventy per cent of respondents indicated that they prefer face-to-face communication over digital means to discuss engineering innovations. Most choose to discuss engineering innovations with members of their team – usually those based in the same location. The implication here is that specific knowledge of engineering innovations stays within the team, and there is limited inflow of new information. These communication channels are homophilous, limiting the spread of innovation to those already connected in a close-knit network (Rogers, 2003). To spread innovation more widely, communication channels need to become more heterophilous and engage a more diverse range of employees. The promotion of cross-department communication on engineering innovations, including the use of online forums or inter-departmental meetings, might help in this.

The innovation-decision process

The evaluation of the engineering innovations knowledge in WaSCs revealed prominent findings in relation to both the innovation-decision process and the innovation process in an organisation. Rogers (2003) claims that if people lack sufficient 'how-to' knowledge of an innovation before it is trialled and adopted, it is likely to be rejected and discontinued. Hence, such knowledge also plays an important role at the decision and implementation stages. Nearly half of the responding technicians and engineers believed that they were only aware of the existing engineering innovations specific to their jobs, rather than understanding how to use those innovations. Therefore, WaSCs need to cultivate the appropriate technical expertise among their employees and supply chains, to enable engineering innovations to be considered and implemented.

Turning to the persuasion stage, over two-thirds of respondents said they often persuaded their counterparts to try engineering innovations. Further, 75% of technicians, 52% of engineers and 44% of managers perceived that the innovations they advocated were successfully adopted, suggesting an encouraging outcome of the decision and implementation stages. Overall, technical workers are keen to promote exploration of engineering innovation for their projects and could help to implement new solutions once an adoption decision is made.

Evaluation of the confirmation stage brought out interesting observations and conclusions regarding recognising the benefits of implemented innovations and rewarding personnel for their innovative behaviours. These are discussed below under social system.

Social system

Over 60% of participants indicated that they were always or frequently encouraged to deliver engineering innovations. However, 89% of engineering managers, 63% of engineers and 25% of technicians admitted that they did not hear enough from colleagues who are passionate about engineering innovations and advocate new ideas. This suggests that the engineering workforce needs more exposure to cosmopolitan and influential 'opinion leaders' who can take the lead in spreading new ideas (Rogers, 2003).

Sixty-two per cent of respondents indicated that they were often encouraged to develop innovative engineering ideas at work, and 79% acknowledged that their companies supported them in initiating and implementing engineering innovations.

However, respondents also indicated that the benefits of the implemented innovations were mainly recognised by the people who were involved in the project; only around one-quarter said that management appreciated the benefits too. Also, over 55% of respondents felt that they were only sometimes or rarely rewarded for their innovative behaviour in the workplace. Cultivating the motivation to seek innovations is a complex issue involving many variables. However, technical personnel need positive messaging from senior management, as well as the industry at large, to support their effort to drive and implement engineering innovations. This will help to resolve the cognitive dissonance caused by the mixed messages of, on the one hand, urgent calls for innovation, and on the other, a lack of appreciation and recognition for those who actually pursue it. Encouraging innovative behaviour in a consistent manner can help to turn it into a habit. WaSCs should improve workplace norms so that innovative behaviour is recognised and rewarded more often, and the implementation of engineering innovations 'ripples out' beyond the original project environment.

The innovation process in an organisation

Agenda

Each WaSC sets its agenda when it defines a problem that calls for innovation. The agenda is then communicated to the employees to raise awareness and activate innovative behaviours to address the problems defined. The research shows that only a minority of respondents recognise that climate change and population growth make engineering innovations essential. Most indicated cost reduction as the main driver for pursuing engineering innovation in their companies. However, it is questionable whether a financial driver can stimulate innovation effectively. Can innovation be properly initiated and implemented when its true origins and causes are neither recognised nor appreciated within engineering departments? WaSCs might subsequently need to revise their approach on how their corporate agendas are communicated throughout the organisation's structure to stimulate innovative behaviours.

Matching and redefining

Respondents generally rated their matching ability highly: 91% felt they were able to pinpoint engineering innovations that would improve wastewater systems. In an equally encouraging finding, the competency of redefining new solutions to meet WaSCs' needs were perceived as adequate by 85% of the respondents.

Clarifying and routinising

Most respondents indicated that innovations became routines once implemented, although 32% stated that they did not. We did not explore the reasons for this. It could be that a given innovation solved a unique site-specific issue and could not be applied more widely. However, we can also speculate that the failure to routinise could be due to hasty implementation, unwanted side-effects or simple misunderstandings. Implementing too quickly is one of the issues that typically constrains the embedding process (Rogers, 2003). Therefore, WaSCs need to ensure stable arrangements for the process of embedding engineering innovations into their organisational structures.

Regulations

The findings suggest that Ofwat PR14 policies do not concern either engineering innovations or the process of diffusion of innovation in water companies. However, innovation is considered in the policies. Namely, Ofwat focuses on creating strong incentives for companies to submit high-quality business plans (Ofwat, 2013a). Secondly, regarding the assessment of such plans, Ofwat (2013a, pp. 13–14) introduced a risk-based review containing tests aimed at distinguishing between genuine innovation that missed the mark and poor business planning. The tests look at four key areas: 1) outcomes, 2) cost, 3) risk and reward and 4) affordability and financeability. Of these four, the test that seemed most likely to stimulate engineering innovation in WaSCs was outcomes. This test was associated with incentivising the companies for better performance in delivering water and wastewater services through the introduction of an Outcomes Delivery Incentives (ODI) mechanism for rewarding a certain performance, e.g. reduction of sewer flooding. This aligns with the objective outlined by Maria (2005, cited in Spiller et al., 2012) about setting performance standards to drive innovations. However, the ODI policy also included a cap on the incentive value, determined by customers' willingness to pay (WTP).

Considering the framework of institutional intervention outlined by King et al. (1994), PR14 seems to involve institutional control over the monopolies: influence, which aims to stimulate the companies' behaviour towards innovations. It is therefore quite likely that given the lack of organic competition between the water companies, the incentives, ambitious performance targets and efficiency challenges set by Ofwat could drive some innovations, including engineering innovations. However, it remains unclear how the policies could distinguish between performance gains originating from true engineering innovation, and those associated with higher efficiency. Moreover, since the policies do not cover mobilisation for the diffusion of innovation – i.e., DoEI – there is no clear expectation that WaSCs should demonstrate robust DoEI. At least, there is a risk that an investment driven by an engineering innovation to provide a step-change in performance will be rejected if its cost is above WTP.

It could be argued that the UK water sector is driven by demand-pull forces – namely, the willingness to use innovations to tackle the challenges facing the industry. For demand-pull forces, an intervention must define and link together demand, potential sources of supply and innovative action, while mobilising users to acquire the innovations produced (King et al., 1994). Therefore, if more innovations are to be instigated and implemented in the water sector, the regulator should consider moving from influence-type policies towards more direct interventions. One possibility is an innovation directive that encourages WaSCs to demonstrate how they are transforming themselves to improve the diffusion of innovation – which, in turn, would have a positive impact on DoEI. This approach could also be supported by the mobilisation of the sector through promotional and awareness campaigns about the importance of innovation diffusion. The policies could also potentially provide mechanisms to:

- Incentivise knowledge deployment in WaSCs to train individuals and teams, to create a base of appropriately skilled talent to support the innovation process.
- Subsidise a significant step change in performance attributable to the use of engineering innovations, to mitigate the negative effects of the WTP mechanism on engineering innovation expenditure.

Conclusions and outlook

This study has shown that the diffusion of innovation is an important mechanism that can enable better introduction and implementation of engineering innovations in organisations such as WaSCs. It also points to the importance of the causal relationship between the institutional controls exerted by Ofwat and DoEI in addressing environmental challenges. The results indicate that there are some deficiencies in some WaSCs' organisational systems and culture that can constrain DoEI. In the main, deficiencies relate to the development of the technical expertise among the engineering personnel, the communication of the corporate agendas throughout the organisation's structure, the homophilous communication channels and, promoting and rewarding innovative behaviours and attainments. Further, PR14 has played an influential role in driving innovations, although only a few of its interventions served to improve the innovation diffusion process.

The research highlights the following key recommendations which would benefit DoEI in WaSCs:

- improving engineering innovation knowledge among the WaSCs' engineering personnel
- evolving the communication channels to become more heterophilous
- taking a more systematic approach to promoting and rewarding achievements in engineering innovation

In relation to the controls over driving innovation in the industry, Ofwat might consider moving from an indirect, influential approach towards a more direct, regulatory approach.

Like all studies, this research has its limitations. First, while I considered most elements of the innovation diffusion process, I did not investigate innovativeness and innovations' rate of adoption in wastewater departments. Secondly, some bias might have arisen due to the size and qualitative attributes of the sample: 34 respondents, 44% of whom are employees of the same Water Utility. For these reasons, the findings and recommendations presented are indicative; future research might investigate DoEI further for the benefit of the industry and customers.

Linking the research with recent events, it is encouraging to observe Ofwat's more direct approach towards stimulating innovation in the industry: the introduction of the £200m innovation fund for driving innovation during AMP7. Ofwat policies have recently driven the creation of the Water 2050 Innovation Strategy by the WaSCs, which would hopefully help embedding innovation at their core.

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