Innovation in the water industry in England and Wales

FINAL REPORT

Cave Review of competition and innovation in water markets

Prepared by

London Economics

February 2009

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Dwr Cymru Cyfyngedig (Welsh Water)	WSH
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Three Valleys Water Plc	TVN

Executive Summary

In October 2008, the Cave Review engaged London Economics to undertake a study on innovation in the water industry in England and Wales. The study informs the Review of Competition and Innovation in Water Markets.

The objectives of the study are:

- Benchmark innovation amongst the water companies.
- Provide a comparison of innovation in the water sector in England and Wales to other countries.
- Identify the key barriers of innovation within the industry.
- Provide recommendations to address the barriers to innovation in the water sector.

During January and February 2009, London Economics undertook innovation interviews using structured questionnaires with the 22 regulated water and sewerage companies in England and Wales. Six contractor firms supplying to the companies were also interviewed.

London Economics also interviewed stakeholders including Defra and Ofwat, and comparator regulators such as Ofgem, and the water organisations in Scotland, including the Water Industry Commission and Business Stream Scotland. The interviews focused on how innovation can be promoted in regulated industries.

Approach to measuring innovation

In order to measure and benchmark innovation in the water industry first it is necessary to define what innovation is. The definition of innovation used in this study is the following:

> *"The creation, development and implementation of a new product, technology, service, tariff design or process of production with the aim of improving efficiency, effectiveness or competitive advantage. It includes new ways of acquiring or deploying inputs, such as financial resources. The change may be incremental or fundamental."*

It should be noted that the definition includes the following:

- It deals with both products and processes;
- It refers to the creation, development, implementation of a new product/process developed either in-house or by other companies and sectors;

- All products and processes have to be new or novel; and,
- The aim has to be improving efficiency, effectiveness or increasing competitive advantage.

Innovation can be measured in terms of both inputs and outputs. Innovation inputs consist of all the resources dedicated to promote innovation. It includes all scientific, technological, organisational, financial and commercial steps that lead to, or are intended to lead to, the development of innovations. Outputs include consumer value and efficiency measures such as market growth, cost reduction, profits, revenues and better quality for consumers.

Innovation inputs

From the survey of water and sewerage companies the following is observed:

- All companies are aware of the importance of innovation and have a special focus on it. Interestingly, 5 companies mentioned that they consider themselves as second adopters of innovations in the sense that they aim at being aware of new methods in the industry and to adopt innovations once others have tried them out (this was not explicitly mentioned by the 17 other companies).

- There seems to be a positive environment towards innovation within the industry. All companies have processes for encouraging employees to generate new ideas that could be developed into useful innovations. Companies have different processes for evaluating such ideas employed by the companies.

- Not surprisingly, water and sewerage companies identify efficiency performance targets as an important driver of innovation. All companies state that Ofwat's comparative performance measures create an environment that encourages searching for innovative solutions to increase efficiency.

- Water and sewerage companies acknowledge the importance of innovation in contractor firms. With this aim, contracts between water and sewerage companies and contractor firms are usually designed to include reward and penalty incentives to encourage better ways of doing things either through lower costs and/or new solutions.

- We have identified a group of seven companies (which we call the "Top 7") which are best equipped in terms of resources dedicated to innovation inputs. This has been measured in terms of R&D expenditures, internal resources used for R&D purposes, number of contracts with external institutions and ratio of R&D expenditure to the company's turnover. The findings are the following:

a. "Top 7" companies spent over £1 million each in R&D in 2008, while the group of remaining companies (which we call the "Rest") are spending less than £0.5 million.

b. All "Top 7" companies have an R&D department (with the only exception of WSX where all R&D activities are outsourced). Companies in the "Rest" group do not have a specific department (exceptions are: TVN, which reported to have an R&D division, and WSH, where individual teams have innovation as a remit).

c. Companies in "Top 7" usually have a number of contracts with external institutions to develop innovative projects. A few of the companies in "Rest" have permanent links with universities and research centres, but most of them (especially small companies) typically do not collaborate on a permanent basis with external institutions.

d. The relative effort of each company in R&D (ratio of R&D expenditure to the company's turnover) in "Top 7" companies is around 0.35%, while the "Rest" of the companies spend on average less than half of that percentage (with major exceptions of CAM, FLK, and TVN).

Innovation outputs

- Of particular interest of any innovation policy is the impact of innovation activities. However, it is recognised that measuring the outcomes of such activities is usually a difficult task. Nevertheless, the outputs of innovation activities typically include customer value and efficiency measures, such as cost reduction, profits, revenues and better quality for consumers.[1] The collection of complete and accurate estimates of output measures has been difficult and most of the time only qualitative judgements have been obtained.

The results of our research are the following:

- In general, innovation had a bigger impact on measures which refer to customer service (rather than for the indicators on drinking water quality and environmental water outputs).

- Furthermore, companies providing water and sewerage services reported some effect of innovation which may reflect a greater impact of innovation on wastewater.

[1] OECD, 2005, "Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition".

- Some companies reported a number of other innovations related to different concepts (reduction in Opex and Capex; customer service; leakage; environmental measures or water quality).

Benchmarking water and sewerage companies

Using information on R&D expenditure and the ratio of R&D expenditure to the company's turnover we provide the rankings of the water and sewerage companies for the year 2007-08 in Table 1. It is interesting to note that six companies (TMS, YKY, SVT, WSX, ANH and NES) are both at the high end in terms of total expenditure (more than £1.8 million) and all spend more than 0.2% of their total turnover on R&D.

Table 1: Water companies R&D expenditure rankings (total expenditure and as % of turnover)

Company	R&D (000)	Rank	R&D (%)	Rank
TMS	5080	1	0.34	5
YKY	4400	2	0.55	2
SVT	4300	3	0.34	6
WSX	2600	4	0.66	1
ANH	2083	5	0.21	9
NES	1800	6	0.29	8
NWT	1000	7	0.07	16
TVN	650	8	0.29	7
WSH	500	9	0.08	15
SWT	420	10	0.10	11
SRN	130	11	0.02	19
MSE	105	12	0.06	17
CAM	85	13	0.41	4
BRL	80	14	0.09	14
FLK	75	15	0.42	3
SES	52	16	0.10	12
BWH	50	17	0.11	10
PRT	30	18	0.09	13
THD	6	19	0.04	18
CDW	.	.	.	.
DVW	.	.	.	.
SST	.	.	.	.

Note: "."denotes where the company was unable to provide a figure for R&D expenditure.

To provide a picture of the resources that different companies are dedicating to innovation, the different innovation measures are summarised in Table 2.

For each company, a ✓ indicates that they are meeting a minimum level for the innovation measure.[2] For example, a ✓ within the "renewable resources" measure means the company reported that innovation has had an impact on this output.[3] Similarly, a ✓ within the input measure "R&D internally" indicates that the company does undertake innovation activities within the business.[4]

As it can be seen in the table, most of the ✓'s are concentrated on the rows corresponding to the "Top 7" companies (top section of the table). This indicates that these companies are undertaking a broad range of activities (e.g. internally, externally, investing in renewable resources) to effectively promote innovation.

It is difficult to tell exactly what all this effort is yielding in terms of output. This is because many companies were not able to identify the impact of innovation on the output measures, or to provide an aggregate estimate of the benefits generated by R&D activities.

[2] We identify those companies fulfilling a minimum criterion for innovation. The threshold for defining each of the criteria was chosen using our own judgement to separate each of the variables' dimensions into two groups containing observations of similar characteristics.

[3] For details on the qualitative information provided by the companies for this measure refer to Annex 2, Table 19.

[4] Chapter 5, Table 5 provides the companies' responses to this measure.

Table 2: Innovation Summary Table.
Companies sorted by R&D expenditure (in decreasing order)

	Company	Inputs									Outputs				
		R&D Expenditure > £1m	% R&D > 0.2	R&D Dept	FTE R&D > 10	R&D Internally	R&D Externally	R&D Evaluation process	Contracts with universities	Value of contracts more than £100k	Service and Performance (DG measures)	Drinking Quality	Environmental Outputs	Renewable Resources	Other relevant measures
Top 7	TMS	✓	✓	✓	✓	✓	✓	✓	✓	.	✓	.	✓	✓	.
	YKY	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
	SVT	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
	WSX	✓	✓	.	.	.	✓	✓	✓	✓	.	.	.	✓	✓
	ANH	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	NES	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	.
	NWT	✓	.	✓	.	✓	✓	✓	✓	✓	✓	✓	✓	.	✓
Rest	TVN	.	✓	✓	.	✓	.	✓	✓	✓	✓	.	--	.	✓
	WSH	.	.	.	.	✓	✓	✓	.	.	.	.	✓	✓	.
	SWT	.	.	.	.	✓	✓	✓	.	.	.	✓	✓	✓	✓
	SRN	.	.	.	.	✓	.	.	.	.	✓	.	✓	✓	.
	MSE	.	.	.	.	✓	.	.	.	.	.	.	--	.	✓
	CAM	.	✓	.	.	✓	✓	.	.	.	✓	.	--	.	.
	BRL	.	.	.	.	.	✓	✓	.	✓	✓	.	--	.	✓
	FLK	.	✓	.	.	.	✓	.	.	.	.	✓	--	.	.
	SES	.	.	.	.	.	✓	.	.	.	.	.	--	.	✓
	BWH	.	.	.	.	.	✓	✓	.	.	.	.	--	.	✓
	PRT	.	.	.	.	.	✓	✓	.	.	.	.	--	✓	✓
	THD	.	.	.	.	.	✓	✓	.	.	.	.	--	.	✓
	CDW	.	.	.	.	.	✓	.	.	.	.	.	--	.	.
	DVW	.	.	.	.	✓	.	.	.	.	.	.	--	✓	✓
	SST	.	.	.	.	.	✓	.	.	.	.	✓	--	.	.

Note: ✓ Indicates the condition is fulfilled; "." Indicates no evidence the condition has been fulfilled; -- The measure does not apply to the company.

In summary:

- Companies are well aware of the benefits of innovation and have implemented processes to generate innovative ideas and facilitate their diffusion throughout the company.

- This is because water and sewerage companies believe that innovation plays an important role in helping them meet efficiency performance targets, reducing costs and improving the quality of the service.

- In terms of innovation infrastructure, we found that it is basically companies in the "Top 7" group that are the ones that are best equipped in terms of resources dedicated to primary research and development.

- It has been hard to quantify the effects of innovation on outputs. This is because of the inherent nature of innovation (and in some cases the difficulty to clearly separate between investments that are not innovation and those that are) and because companies do not keep, in general, records on the impact of the different innovations.

International comparisons

We also undertook an international comparison of innovation in the water and sewerage industry in England and Wales with the water and sewerage industry in other "similar" countries, which are the G7 countries plus Australia and Spain.[5] We first sought information from the OECD on total R&D expenditure, R&D intensity and the share of R&D in the water industry as compared to R&D expenditure in all other industries. Unfortunately, the OECD data is not disaggregated to individual industry level. Instead data could only be sourced for the electricity, gas and water supply sector as a whole. The OECD data shows that overall R&D has been declining in almost all the G7 countries except Australia, and this is the case both for the absolute measure of R&D expenditure, and for the measures of R&D intensity during the period 2000 to 2004 (which is the period for which data is available). The UK has experienced considerable decline in these measures, for the electricity, gas and water supply sector, as compared to the other countries. The analysis of the OECD data is presented in Chapter 3.

The only country we were able to source data for the water sector alone was Australia.[6] The Australian Bureau of Statistics reports R&D intensity in the water and waste water industry. Therefore we compare R&D intensity in Australia to R&D intensity from our survey of water companies in England and Wales in 2008. R&D intensity in Australia is 0.33% while in England and Wales it is 0.25%.

The only other data that is available for international comparisons is the number of patents filed in water and waste water treatment and in water collection. This data was provided by the OECD to the Cave team and then

[5] Australia is included because of the scarcity of water resources on the continent and because Australia has pursued a number of new approaches to managing water quality and quantity. Examples of these Australian approaches are provided in section 8. Spain has been included because of its water scarcity issues.

[6] We contacted the Office of National Statistics in the UK and spoke to their R&D data unit. The ONS was not able supply data for the water industry separate from other utilities due to confidentiality constraints and the possibility individual water companies could be identified.

passed to London Economics. We have considered the data for the G7countries and Australia. From this data set, the number of patents filed is greater in water and waste water treatment as compared to water collection. Great Britain appears to have had the larger decline in the number of patents filed in water and waste water treatment as compared to the other countries. For water collection there were four patents filed in the Great Britain.

Competition and innovation

Retail competition should encourage better ways of doing things by incumbent companies due to the threat of new entrants, and or consumer switching. The design of the market-like incentives for upstream competition should, however, be considered carefully to avoid gaming of the market-like system.

Scarcity pricing for water (to consumers) may also want to be considered. Scarcity pricing can take into account, across time and location, the change in the opportunity cost of current water consumption and the cost of augmenting future water supply. Scarcity pricing can signal to consumers the true cost of their consumption and can provide information, to new entrants and market incumbents, about the willingness of consumers to pay higher prices for water (during periods of low supply), and therefore the expected benefits of investments in new (potentially higher cost) water supplies. As such the price of water can change depending on the cost of depletion.[7] This means that as storage levels fall, during dry periods, the price of water will increase to reflect the (opportunity) cost of consuming today as compared to in the future. Conversely during wetter periods, the price of water will fall.[8]

An important consideration is that competition alone will not encourage improved environmental and natural resource outcomes. This is because under competition companies will seek to minimise costs such that private marginal costs are equal to private marginal benefit (the reward/price the company receives for the good (water and sewerage)). But, with environmental externalities, the social marginal cost (the true cost) is greater than the private cost of supply. Therefore, companies under competitive conditions do not internalise the negative externalities. It is therefore necessary to introduce well designed environmental regulation. Regulations that price the external impacts of abstraction and discharge, could be considered.[9]

[7] Depletion is the cost associated with consuming the water now such that it cannot be consumed in the future.

[8] Further discussion on scarcity pricing is provided in Chapter 7.

[9] Examples of such regulations are provided in Chapter 8.

Barriers to innovation and recommendations

The regulatory barriers to innovation as identified in our survey of water and sewerage companies, and our recommendations for mitigating these barriers are the following:

- Regulatory co-ordination leading to a *common agency* problem: The common agency problem is one where multiple regulators (called principals in the literature) with different objectives (economic, environmental and safety) might counter each others' incentive scheme by encouraging effort in those activities that matter to the individual principal while the agents (the companies) underperform on other tasks. This may result in confusion and regulatory uncertainty.

  There is evidence of this happening in England and Wales from the responses to our survey of the water and sewerage companies.

  Therefore, England and Wales should consider the trade-offs between regulatory objectives: It is not possible to improve economic efficiency and environmental impacts and drinking water quality all at the same time. Mitigating environmental impacts will most likely require an increase in costs to companies. Therefore regulators need to explicitly recognise these trade-offs and build them into the reward and penalty structure.

  This can be done by;

  Improving co-ordination across regulators, such as contingent monitoring and reward where companies are only rewarded for outperformance in the economic objectives if they have also met their standards for environmental impacts and drinking water quality. Likewise, companies are not penalised for failing to meet their economic performance if they have over performed in their environmental targets.

  Using the new environmental policies – further discussed in the point below - which create tradable property rights/licences for environmental impacts such as abstraction and discharge can reduce the co-ordination problem, because the property rights define the rights and responsibilities, and the trade determines the price for abstraction and emissions.[10] In this instance the regulator need only make the rules for the market, such as the definition of the property

[10] It is not necessary to trade to gain benefits. The licences can be held in perpetuity and the flexibility in how much of the licence can be exercised and when it can be exercised will introduce benefits, but without trade the licence may not be held by the highest value user.

right and how, where and when they can be traded. This reduces the number of regulatory co-ordinations.

- Risk and in-flexible incentives which lead to historical solutions by the companies: Some flexibility particularly flexible incentives for environmental and natural resource outcomes - such as temporal targets, or accounting for non-standard impacts across geography – could facilitate innovation in these areas.

  Therefore, consider investigating more flexible approaches to environmental and natural resource regulation. Looking to examples particularly in Australia could help develop such incentives in England and Wales. Using innovative policy to integrate the external impacts of water use into the economic decisions made by water companies, can efficiently account for these external impacts. Further, it can reduce the co-ordination problem across regulators.

  In order to use these new policies it is necessary to model the catchments and (often) monitor them in real time to account for changes in flow. This has been done in the Murray River and the Hunter River in Australia, further the Australian "e-water" co-operative investment scheme (discussed in the next point below) is investing in these tools to support integrated water management.

  England and Wales should look to see how science is supporting policy design for environmental outcomes in other countries, and consider how they can be used here.

- Return on investment: How to manage the dampening of incentives due to the 5 year economic profit period should be investigated.[11] The solution here is far from clear, but most likely should not include the economic regulator picking projects that are breakthrough innovations.

  England and Wales should consider the role of co-operative research. In many cases the innovation public good is at the industry level (not cross-industry level), and at society's level, and therefore co-operative research should be funded by the water sector and government (carbon emissions is one exception as it is cross-industry and society).

  The use of innovative incentives such as Ofwat's menu regulation should be trialled. A consideration of the costs of increased information burdens to support detailed out performance incentives

[11] Economic profit is when resources earn more than their opportunity cost. In competitive markets these economic profits last until competitors catch-up or new entrants enter the market. In the long-run profit returns to normal economic profit.

relative to the benefits of increased detail should, however, be considered further.

- While not a barrier, the use of new tools for designing and ex-ante testing of incentives and targets could drive innovation – both within the companies and in regulatory and incentive design. The methods are often called policy roadtesting and are used in other countries to pre-test policy before it is piloted in the field. Using roadtesting could increase the policy toolbox available to regulators, and can help regulators select between different incentive designs.

  Therefore the use of policy road testing to pre-test new incentive designs before they are piloted in the field should be considered. England and Wales could observe how new methods for road testing, such as economic experiments, have been used abroad to design environmental policy, and how it is used in other industries in Europe such as consumer protection.

  The barriers and recommendations are presented in Chapter 8.

Conclusions

The survey of water and sewerage companies in England and Wales shows that the water and sewerage companies are very aware of the need for new ideas and innovations, and are putting in place internal processes to facilitate such.

There are seven companies that are best equipped to promote innovation in terms of their resources dedicated to innovate, is not a problem as they are private companies with shareholders (except WSH which is not for profit), and therefore they will invest whether it be in "innovation" or other forms of investment to ensure productivity is maximised within the company and costs are minimised.

The regulators therefore need to ensure that the natural monopoly features of the industry are managed such that companies cannot monopoly price to consumers (i.e. price above marginal cost). Where competition is feasible, it should promote the improved economic outcomes due to the "threat" of new entrants and due to the potential for consumer switching. In the case of upstream competition, because it is necessary for the regulator to create market-like incentives, how such incentives are designed is important to mitigate the chance of companies gaming the system. Competition on its own will not, however, promote improved environmental outcomes and therefore well designed environmental regulation needs to be employed to internalise, within the companies' private decision making, the cost of negative environmental externalities.

Examples of new environmental policies and the supporting science to design and use such schemes, particularly in Australia, should be considered and learnings transferred where appropriate to the water and sewerage sector in the England and Wales.

1 Introduction

The project objectives, methods of achieving these objectives and the structure of the report are presented in this chapter.

1.1 Project objectives

The objectives for the project are the following:

1. Benchmark innovation amongst the water companies.
2. Provide a comparison of innovation in the water and sewerage industry in England and Wales to other countries.
3. Identify the key barriers of innovation within the industry.
4. Provide recommendations to address the barriers to innovation in the water sector.

In order to achieve these objectives London Economics has undertaken the following activities:

1. Review the different definitions of innovation used in previous studies when measuring innovation. And, agree, with the Cave Review team, the definition of innovation to be used in this study.
2. Provide case study examples of innovation in the water sector internationally.
3. Undertake innovation questionnaires with water and sewerage companies, and contractors, in England and Wales, in order to obtain quantitative information for the benchmarking exercise.
4. Interview stakeholders, both within the water sector, and in comparator industries, to complement the information collected from the water companies.
5. Seek information on innovation in water and sewerage industries internationally.

1.2 Structure of the report

The report is structured as follows:

- Chapter 2 presents the review of innovation definitions from the international literature and the definition used for the purpose of this study.
- Chapter 3 presents the international comparisons of innovation measures.
- Chapter 4 presents our methodological approach and the main features of the innovation questionnaire.
- Chapter 5 reports the findings from the innovation survey and compares innovation across the 22 regulated water and sewerage companies.
- Chapter 6 reports the observations from the contractor survey.
- Chapter 7 provides a discussion of competition and innovation.
- Chapter 8 presents the main barriers to innovation as identified in our discussions with water and sewerage companies, and recommendations for mitigating these barriers.

2 Definition of innovation

This chapter presents a review of innovation definitions used in previous studies, and provides the definition of innovation for the purpose of this project.

2.1 Review of innovation definitions from the international literature

We have reviewed different definitions used in previous studies for measuring innovation.

The OECD defines an innovation as the *implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.* The definition includes products, processes and methods developed for the first time and those that have been adopted from other firms or organisations.

The Department for Business Enterprise and Regulatory Reform (BERR) defines innovation as *the successful exploitation of new ideas – incorporating new technologies, design and best practice, the key business process that enables businesses to compete effectively in the global environment.*

The Economist Intelligence Unit defines innovation as *the application of knowledge in a novel way, primarily for economic benefit.*

The Melbourne Institute defines innovation as *the development of new and better products and services, and of lower cost production methods*. In "Innovation Index of Australian Industry" (see IBM – Melbourne Institute, 2008[12]) the definition includes innovations *which are both new-to-the-world (such as patents) and those which may be simply new-to-the-firm (such as trade marks)*. The definition also includes all innovative activities, not just the few that achieve success[13].

NESTA (Adams, Neely, Yaghi and Bessant, 2008) defines innovation as the *change associated with the creation and adoption of ideas that are new-to-world, new-to-nation/region, new-to-industry or new-to-firm.*

[12] http://www.melbourneinstitute.com/publications/innovation/IBM_MI_Innovation_Index.pdf.

[13] This is done by including data on R&D expenditure and employment since it embodies elements of both successful and unsuccessful innovation (not all R&D projects end up in marketable products and services or new processes).

The MORI Innovation Survey (2005) defines innovation as *the successful exploitation of new ideas, whether it results in new products and services or new business processes, [which] can give companies the competitive edge they are seeking.*

In the UK innovation survey[14], innovation is defined as *new or significantly improved products (goods or services) and/or the processes used to produce or supply them, that the business has introduced, regardless of their origin. These may be just new to the business or new to the market. Investments for future innovation and changes that the business has introduced at a strategic level (in organisation and practices) are also covered.*

Hence, despite the fact that innovation is relatively easy to conceptualise and is commonly used in our daily language, we see that there are several variants of its meaning.

All definitions have in common the features of the Economic Intelligence Unit definition, i.e. they are related to ideas or knowledge, they are new, and they have a purpose (economic benefit). It is interesting to note that the definitions differ in the results of the innovation. Hence, the department for BERR or MORI survey define innovation as the *successful* exploitation of ideas, whereas other definitions are less restrictive and allow for failed products or processes to be included in the definition of innovation.

For the purpose of our research, we believe that innovative firms are those that undertook innovation activities during the period under review, regardless of their commercial success, as many innovations fail or are not completed. In this regard, we subscribe to the definition provided by the OECD (2008) which allows firm's innovation activities to be of three kinds: successful (though not necessarily commercially successful); ongoing (or work in progress that has not yet resulted in the implementation of an innovation); and abandoned before the implementation of an innovation[15].

It is important to capture all three kinds of innovation, as defined by the OECD, because innovation is an activity for which benefits are not always known. The fact that an innovation was abandoned or was not a commercial success does not mean innovation is not occurring in the firm. Failure to capture all kinds of innovation activity will lead to an underestimation of innovation effort.

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[14] http://www.berr.gov.uk/dius/innovation/innovation-statistics/cis/UKIS%202006%20Questionnaire/page44937.html.

[15] It should be noted we include in our definition of innovation three stages: research and invention; development (piloting, trial, …) and commercialisation. This distinction is important as in some contexts the three stages are separated into invention (first and second stage), and innovation (third stage).

2.2 Definition of innovation for the purpose of this study

The definition provided in the Cave review is useful as it addresses the important aspects to be measured in regard to innovation and is in line with what has been proposed in the literature. The Cave review defines innovation as:

> *the creation, development and implementation of a new product, technology, service, tariff design or process of production with the aim of improving efficiency, effectiveness or competitive advantage. It includes new ways of acquiring or deploying inputs, such as financial resources. The change may be incremental or fundamental.*

There are a few things that need to be noted from this definition. First, it deals with both products and processes. Secondly, the definition refers to the creation, development, implementation of a product/process developed in-house or the implementation and or adaptation of a new product or process developed elsewhere. Thirdly, all products and processes have to be new or novel. And finally, the aim has to be improving efficiency, effectiveness or increasing competitive advantage.

Defining each of these concepts will help to characterise the definition and identify the measures to quantify innovation in a common metric.

Products and processes

Products can refer to both goods and/or services. Goods refer to the actual end product sold to the customer and services are how the product is sold and supplied to the customer. Processes include technological processes referred to the plant and equipment used in the production process and organisational innovations involving business processes or non-domestic structures.

Development and already-existing innovations

Innovation can refer to new innovations developed in-house or making use of already-existing innovations.

New innovations developed in-house, either alone or in conjunction with external partners include R&D and other activities such as:

- Applied research to acquire new knowledge, direct research towards specific inventions or modifications of existing techniques;
- Development of a new product or process concepts or other new methods to assess whether they are feasible and viable.

Already-existing innovations adopted from other firms or organisations are many non-R&D activities used by the firm as part of innovation. This includes:

- Identifying new innovative solutions (process, products) from its own or others' basic or strategic research; monitoring competitors; and by using consultants.
- Buying technical information, paying fees or royalties for patented inventions (which usually require research and development work to adapt and modify the invention to its own needs), or buying know-how and skills through engineering, design or other consultancy services.
- Developing (through internal training) or purchasing (by hiring) human skills so that innovation will be the resulting new organisational model (organisational structure, skill set, etc)
- Investing in equipment, software or intermediate inputs that embody the innovative work of others.
- Reorganising management systems and its overall business activities.
- Developing new methods of marketing and selling its goods and services.

Innovation and novelty

By definition, all innovations must contain a degree of novelty. Four concepts of the novelty of innovations are discussed below (OECD, 2008):

New to the firm: The minimum threshold level for an innovation is that it must be new to the firm. A product, process, marketing method or organisational method may already have been implemented by other firms, but if it is new to the firm (or in case of products and processes: significantly improved), then it is an innovation for that firm.

New to the market: Innovations are new to the market when the firm is the first to introduce the innovation in its market. The market is simply defined as the firm and its competitors and it can include a geographic region or product line.

New to the country: An innovation is new to the country when the firm is the first to introduce the innovation for all domestic markets and industries.

New to the world: An innovation is new to the world when the firm is the first to introduce the innovation for all markets and industries internationally.

New to the world therefore implies a qualitatively greater degree of novelty than new to the market.

What is not innovation

It is important to clearly differentiate innovations from other changes taking place within the firm but that cannot be considered as innovations. Hence, in our definition we will ensure that the following are not included as innovation.

- It is not an innovation to stop doing something, even if it improves a firm's performance (e.g. ceasing to use a certain marketing or organisational method is not an innovation).
- The purchase of identical models of installed equipment, or minor extensions and updates to existing equipment or software, are not process innovations. New equipment or extensions must both be new to the firm and involve a significant improvement in specifications.
- A change in the price of a product or in the productivity of a process resulting exclusively from changes in the price of factors of production is not an innovation (e.g. an innovation does not occur when the same product is produced and sold at a lower price simply because the price of inputs falls).

Innovation inputs and outputs

The economic literature traditionally has differentiated between innovation inputs and outputs. Innovation inputs include enterprise strategy, knowledge, capital and human resources. In some occasions it also includes the public policy environment (R&D policy, taxes, intellectual or property) and innovation infrastructure (quality of research in universities and availability of skilled human resources). Outputs include customer value and efficiency measures such as cost reduction, profits, revenues and better quality for consumers.

3 International comparisons

This chapter provides an international comparison of R&D expenditure and intensity in the utility sector across nine countries at a similar level of economic development. These are the G7 countries, Canada, France, Germany, Italy, Japan, United Kingdom and United States, plus Australia and Spain.

A comparison between the level of R&D in the UK and in other countries could give us a relative measure of the different extent water companies around the world are engaged in innovation.

A first comparison is carried out using OECD data for R&D expenditure and intensity in the utility sector (electricity, gas and water)[16]. We then present evidence of R&D expenditure for the water and wastewater industry for England and Wales and Australia. Finally, we compare OECD data on patents in the water and wastewater sector for the nine countries.

The main observations are:

- R&D expenditure in the utility sector declined for almost all countries in our sample in the period 2000-2003[17] (2004 for some countries).
- In terms of R&D expenditure levels in electricity, gas and water, Japan and France were the countries spending more in that period, the first spending around $550-600m[18] and the second slightly less than $450m. UK R&D expenditure in electricity, gas and water fell from $250 m in 2000 to $68m in 2004. Canada experienced the second largest drop, with R&D expenditure falling from $151m in 2000 to $99m in 2003. Spain had a notable increase, from $47m to $77m between 2000 and 2004.
- R&D intensity (which is R&D expenditure as a percentage of the value of production) in the period 2000-2003 ranged from more than 0.75% in France to 0.04% in the USA, with the average across all countries declining from 0.27% in 2000 to 0.21% in 2003. France and Canada were the two countries with an higher R&D intensity, but while France experienced a limited drop, 12% between 2000 and 2003, R&D intensity in

[16]OECD only discloses limited data detailed by International Standard of Industrial Classification (ISIC) Revision 3, and we were therefore unable to undertake a comparison at the water industry level. We also spoke to the Office of National Statistics R&D department, but they were not able to disclose any data disaggregated by single industry in the UK.

[17] These are the latest data available. See 3.1.1 and footnote 20

[18] All data are in US dollar PPP, unless otherwise stated.

Canada decreased from 0.52% to 0.35%, a fall of one third. In the UK R&D intensity more than halved, dropping from 0.32% in 2000 to 0.14% in 2003. Germany, Italy and the USA were the three countries with the lowest ratio (between 0.12% and 0.04%) of R&D intensity, but they did not experience such large declines in this measure in the period.

- R&D intensity in the water and wastewater industry in England and Wales is around 0.25% and it is comparable to R&D intensity in the Australian water and wastewater industry at 0.33%.

- Germany and the United States were the most active countries in patent applications in the water and wastewater industry between 2000 and 2006. The overall number of applications in all countries has gone down between 2000 and 2006. Germany filed around 200 patent applications per annum in the period, while the USA halved their number of applications in the period, down to 80 in 2006. Great Britain had a large fall in the two last available years, with the number of applications in water & wastewater treatment declining from 54 in 2004 to 27 in 2005 and 16 in 2006. Using 2006 figures for patent applications in water & wastewater treatment, it can be seen that the figure for Great Britain is similar to that of Australia and Canada.

3.1 Cross-country comparison of R&D expenditure

3.1.1 OECD Data

The OECD publishes comparative data for R&D expenditure, R&D intensity, defined as the ratio R&D/production[19], and share of R&D expenditure for a given industry compared to the total expenditure across all industries. For our purposes these data suffer from a major limitation, i.e. OECD only publishes aggregate data for the category "Electricity, Gas and Water Supply". It is not therefore possible to distinguish or compare the water industry across countries or with other utility sectors. Moreover almost all national statistical offices report R&D expenditure according to the OECD standards, which makes it infeasible to undertake country to country comparisons.

[19] R&D is defined as business enterprise Research and Development, while production is equal to Turnover + Net change in stocks of finished products and work in progress produced by the unit + Net change in stocks of goods and services purchased for resale - Purchases of goods and services purchased for resale + Capitalised (own-account production)

Therefore, for this exercise we used OECD data for the aggregate category "Electricity, Gas and Water Supply" for nine countries: G7 countries plus Australia and Spain. The most recent data available for R&D intensity refer to 2003[20], while data for R&D expenditure are available up to 2004 for some countries.

Even if we are not able to disentangle the water industry from the other utilities, this analysis can show the relative efforts towards R&D and innovation in utilities around the world.

In Figure 1 we present data on R&D expenditure in the electricity, gas and water industry for the nine countries between 2000 and 2003 or 2004.[21] All data are in millions of US dollars Purchasing Power Parity (PPP). Japan was spending more than $550m and France around $430-450m. The UK followed with $250m, but experienced a substantial drop, while Canada and the US were investing comparable amounts in R&D in 2000, but experienced different trends. The overall trend saw a decline of 14% in nominal terms of R&D spent in electricity, gas and water.

The UK experienced a substantial decline in the overall level of R&D expenditure in the utility sector, which ranged from $250m in 2000 to $68m in 2004, with the figure dropping to a quarter of the 2000 value.

The UK was in the top three countries for R&D expenditure in 2000, but by 2003 the USA and Spain had surpassed it and by 2004 R&D expenditure in the UK was also lower as compared to R&D expenditure in Canada and Germany.

There is considerable variation in trend by country, with some economies increasing or maintaining their expenditure at similar levels (Spain, Germany, Australia, Italy), others having a limited reduction (France, the US, Japan) and the UK and Canada experiencing the largest drops.

Spain increased R&D expenditure in the utility sector from $47m to $77m between 2000 and 2004 and Germany moved from $84m to $97m in the same period. On the other hand Canada reduced R&D expenditure to around one third of the initial value, dropping from $151m in 2000 to $99m in 2003.

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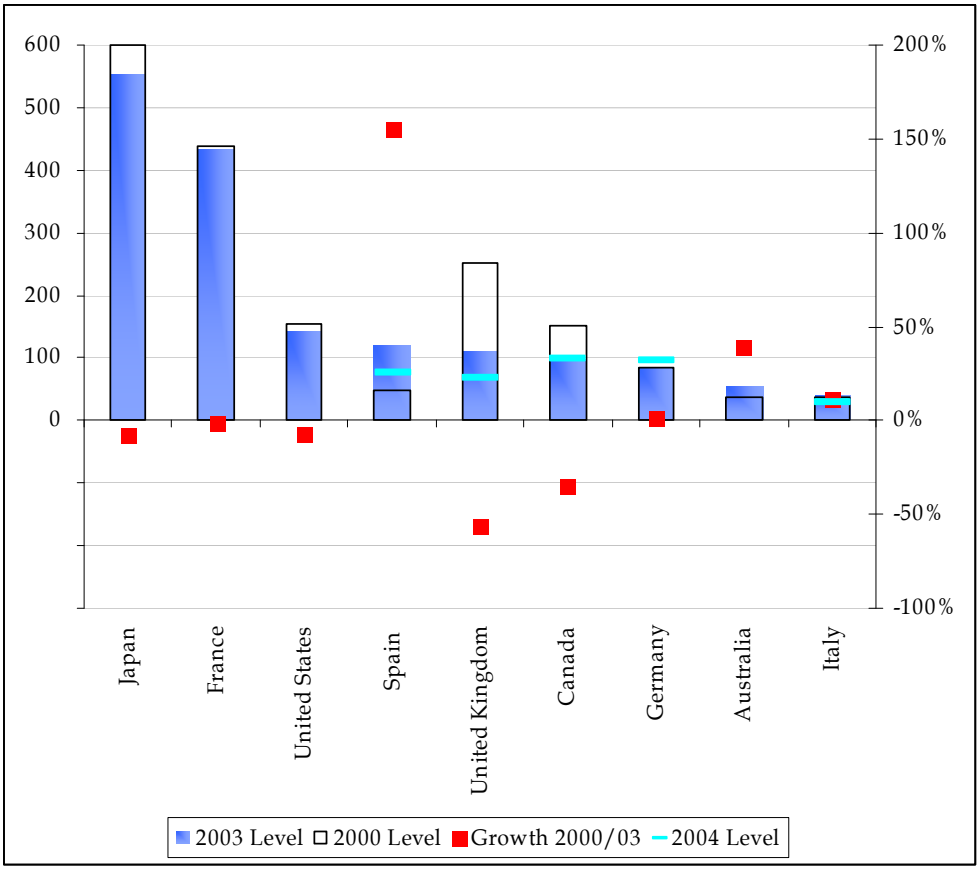
[20] The last available edition of the ANBERD (Analytical Business Enterprise Research and Development) database was published in 2006 and therefore the last available series for R&D expenditure refer to 2004 for Canada, Germany, Italy and the UK and up to 2003 for all remaining countries. A new update is going to be published later in 2009.

[21] As explained in footnote 20.

Figure 1: Business enterprise expenditures in Research & Development (current $m PPP)



Source: OECD, ANBERD database, 2006.
Note: data are not available for 2004 for Japan, France, USA and Australia

Figure 2 presents R&D intensity for seven countries[22] for the years 2000 to 2003. Utilities in France and Canada had the highest R&D intensity in the relevant period, with French companies spending around 0.7% of their production in R&D (0.35-0.52% for Canada[23]). The United Kingdom and Japan followed, both

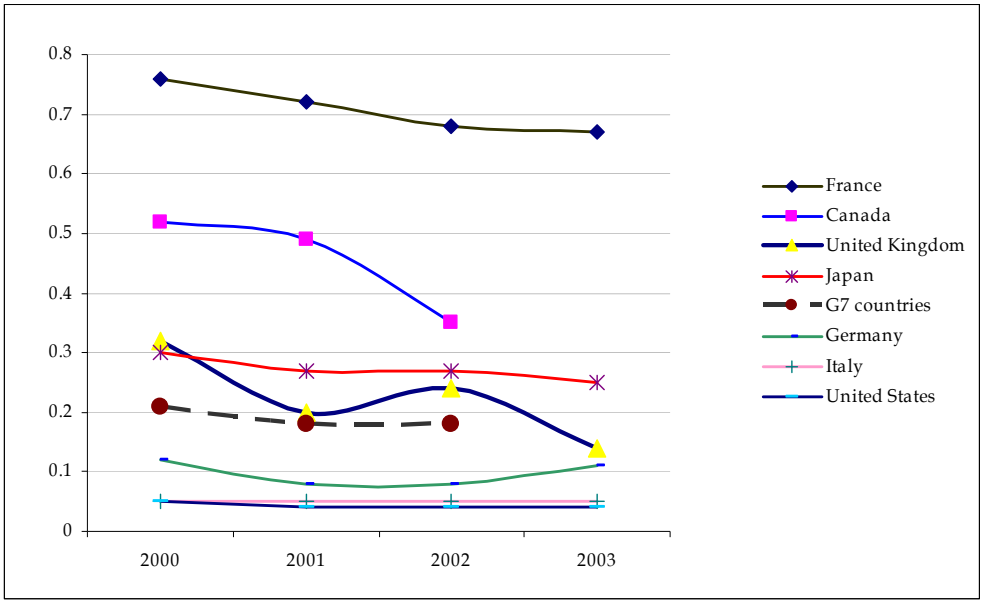
[22] Data are not reported for Australia and are only available for 2000 for Spain.

[23] Data are not available for Canada for 2003.

with an average R&D intensity above the G7 average, which was between 0.2-0.3%, with a stronger declining trend for the UK. Germany, Italy and the US consistently ranked low in the comparative order (always spending less than 0.15%).

As a general trend it seems that effort in R&D intensity declined between 2000 and 2003, the average value declining from almost 0.3% in 2000 to just above 0.2% in 2003. The UK experienced the biggest percentage drop with R&D intensity falling to less than half of the starting value (0.32%in 2000 down to 0.14% in 2003). Canada also experienced a significant drop in the period (one third), while R&D intensity decreased by less than 20% in the remaining countries. Germany, Italy and the USA did not experience a notable change in the measure, with R&D intensity in 2003 roughly similar to the 2000 value.

Figure 2: R&D intensity using production (%) – Electricity, Gas and Water Supply



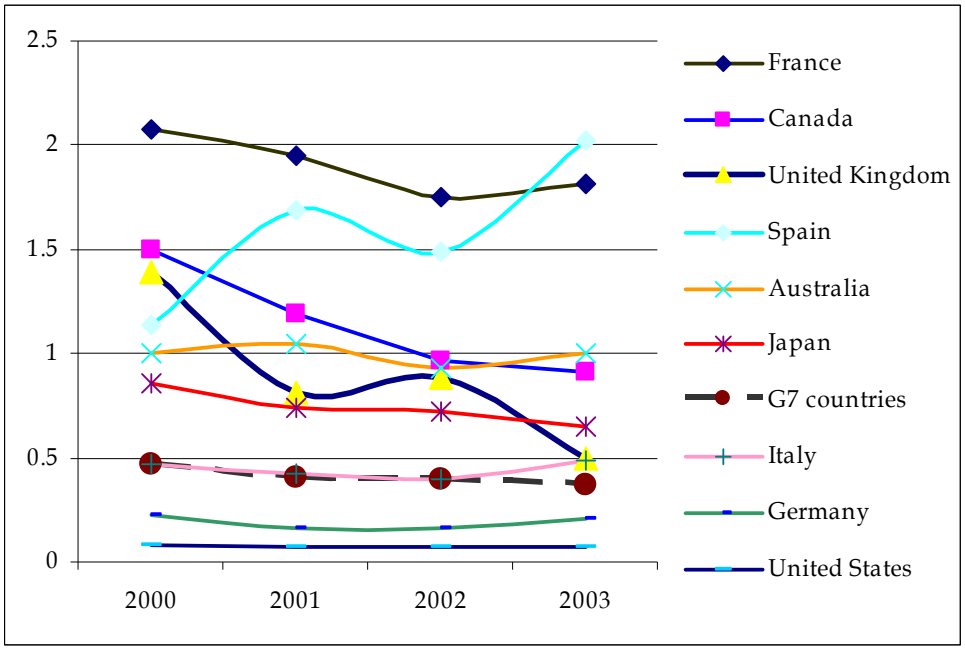
Source: OECD, STAN Indicators, 2005.
Note: R&D intensity using production is defined as the percentage ratio of business enterprise Research and Development and production at current prices. Data for Australia are not available for any year. "G7 countries" is the average of the seven countries. Data for Spain are only available for 2000. In 2000 the figure for R&D intensity in Spain was 0.14%. Data for Canada and G7 are not available after 2002.

Figure 3 shows the proportion of R&D expenditure in the utility sector as compared to total R&D spent in all industries. France was the leading country in

2000, with a share around 2%, followed by Canada, the United Kingdom, Australia and Japan, all between 0.5% and 1.5%. The figure for Spain was just over 1% in 2000 and rose to more than 2% by 2003. Germany and the US still ranked at the bottom of the table, with a value around 0.2% for the former and below 0.1% for the latter.

The proportion of total R&D expenditure by the "Electricity, Gas and Water Supply" sector decreased in six of the nine countries between 2000 and 2003, with the average figure falling from 0.9% to 0.67%. Similarly to what happened with R&D intensity, the two countries that experienced the largest drop were the UK (from 1.4% of in 2000 to 0.5% in 2003) and Canada (down from 1.5% to around 0.9%). All other countries, except Italy, Spain and Australia, saw a drop in their proportion of R&D expenditure in the utility sector compared to R&D for all industries. As mentioned, Spain had the strongest increase in this indicator between 2000 and 2003 and in 2003 was the country with the highest proportion spent in R&D in the utility sector compared to R&D expenditure in all other sectors.

Figure 3: Share of R&D expenditure in Electricity, Gas and Water Supply compared to R&D in all industries.



Source: OECD, STAN Indicators, 2005.

Note: For each country, this indicator shows the R&D expenditures for the gas, electricity and water industry relative to the R&D expenditures for all industries. This indicator highlights the distribution of business enterprise research and development efforts relative to all sectors in the economy.

3.1.2 R&D expenditure in the water and wastewater industry

As previously mentioned, it was not possible to obtain data disaggregated by single industry (i.e. water and wastewater) for almost all countries. The Australian Bureau of Statistics (ABS) does publish disaggregated data on R&D for the water and wastewater industry. Using data from the Australian Bureau of Statistics and the data collected by LE in the interviews[24] for England and Wales it is possible to compare R&D intensity in the two countries.

Figure 4 shows R&D intensity for the last available year reported by the ABS for Australia, which was 2006/07, and data for 2007/08 for England and Wales, as collected by LE in the survey of water and sewerage.

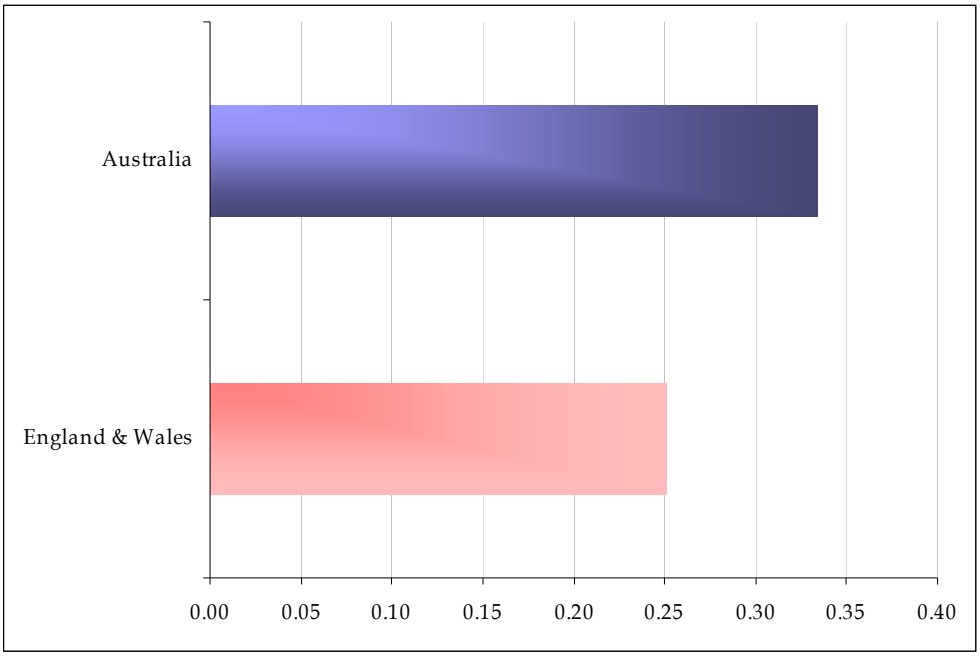
R&D intensity (i.e. R&D expenditure in terms of total income[25] in Australia and turnover[26] in England and Wales) in Australia was around to 0.33% in 2006/07 while in England and Wales was about 0.25% in 2007/08.

[24]As mentioned in footnote 16 the ONS could not provide us disaggregated data to compare with our estimates.

[25] Total income comprises sales and service income, interest income, funding from government for operational costs, and other income.

[26] Turnover comprises charges to customers for water, sewerage and other services excluding value added tax and is derived only from the United Kingdom.

Figure 4: R&D Intensity in the Water and Wastewater Industry – Australia and the UK



Source: Australian Bureau of Statistics, LE questionnaires, UK water companies' 2007/08 Annual Reports.
Note: R&D intensity for Australia is defined as the ratio of Total R&D Own funds/Total Income (data relative to the last available year, 2006/07). R&D intensity for the UK is defined as the ratio of Total R&D Expenditure/Total Turnover (data relative to 2007/08) and refers to 19 of the 22 regulated companies.

3.2 Data on Patents

Another measure of the effort in innovative activities is the number of patent applications filed by water and wastewater companies. Data on patents[27] are divided into water and wastewater collection, and water treatment. Counts for both measures are presented in the charts below, for the years 2000 to 2006[28], for the nine countries considered in the international comparison in this chapter (G7 countries, Australia and Spain).

[27] Data on patents was supplied to us by the Cave Review. The original source is the OECD.

[28] Data were also available for 2007 and 2008, but they were probably still partial data, given a large drop between 2006 and 2007 (from 444 to 115), while for 2008 only eight applications were registered for the nine countries. We therefore decided to limit our analysis to the period 2000-2006.

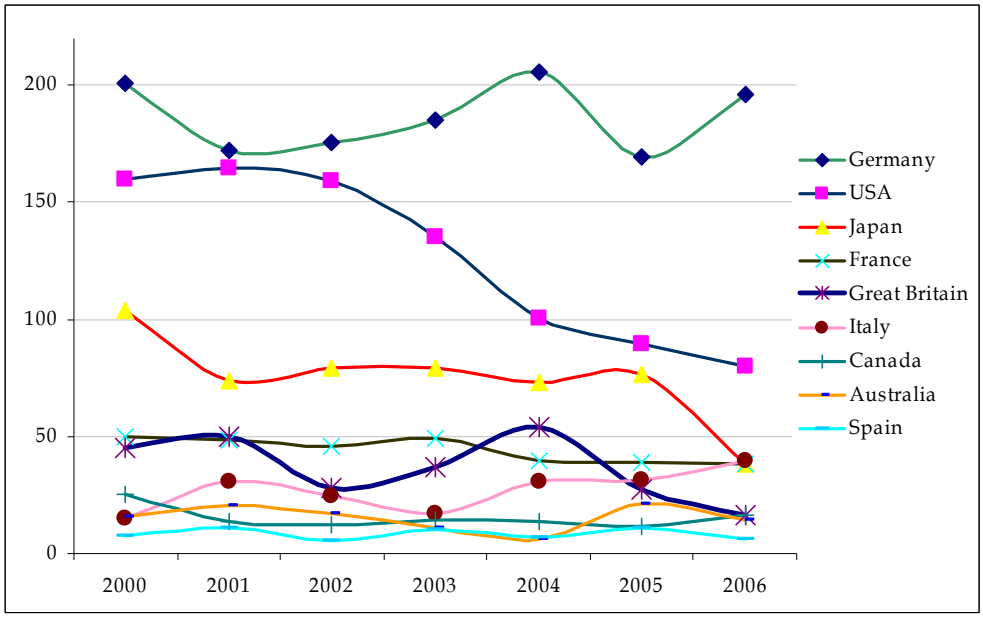
As shown in Figure 5, Germany and the US were the countries with the highest number of patent applications for water and wastewater treatment between 2000 and 2006. Japan ranked third followed by France and Great Britain. Apart from Germany all these countries experienced a decline in the number of patent applications over time and the overall number across all countries also declined.

Germany maintained a level of around 200 applications per annum, while the US saw a steep decline in this indicator, with the number of applications halving (from 160 in 2000 to 80 in 2006).

The number of patents applied for in Great Britain ranged from 45 in 2000 to a maximum of 54 in 2004 and a minimum of 16 in 2006, with a decline of nearly two thirds between 2000 and 2006. Japan saw a comparable decrease in the number of patent applications filed for water and wastewater treatment, dropping from more than 100 in 2000 to 38 in 2006 while France and Canada experienced a smaller, but still sizeable fall (around one third).

Australia and Spain were able to maintain a similar level of patent applications while Italy increased it over time.

Figure 5: Data on patent applications - Water & Wastewater Treatment



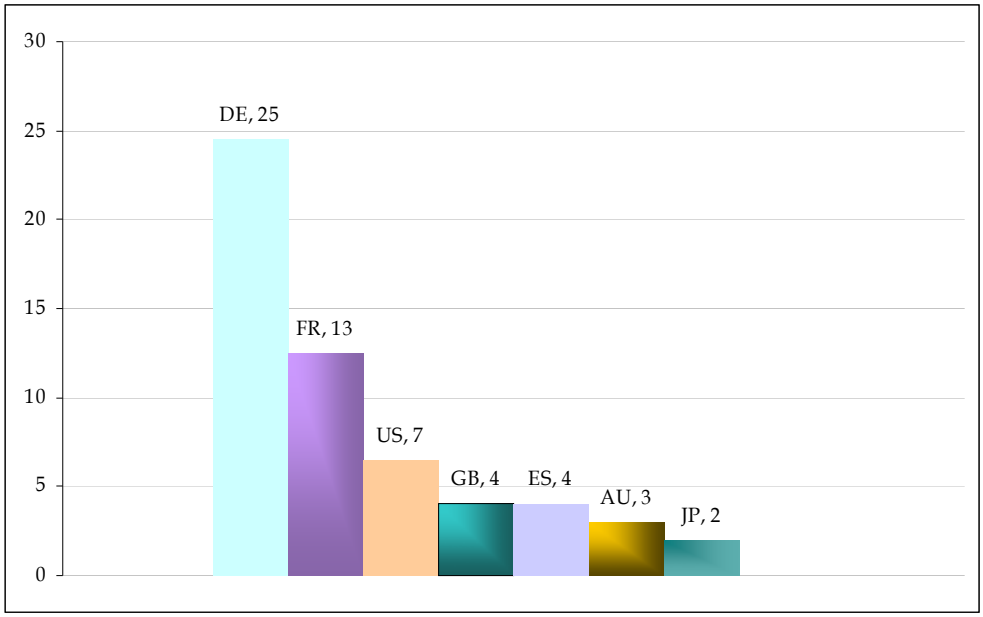
Source: OECD data
Note: Count of relevant patent applications, classified by inventor country (using fractional method).

In water collection there were significantly less patent filings, with an overall figure of fifty seven patent applications filed across eight countries between 2000 and 2006.

Great Britain had at least one application filed in only two years, 2001 and 2006, while Germany, the USA and, in recent years, France were more active in this area.

Great Britain totalled four applications for patents between 2000 and 2006, compared to twenty-five in Germany, thirteen in France and seven in the USA.

Figure 6 Total count of patent applications between 2000 and 2006 - Water Collection



Source: OECD data.
Note: Count of relevant patent applications, classified by inventor country (using fractional method). There were no patent applications filed in the period in Canada. Data for Italy are missing.

3.3 Conclusions

- The charts presented in this chapter give an overall picture of falling investment in R&D in the utility sector (electricity, gas and water) between 2000 and 2003.
- For many countries this is true both in absolute (i.e. as measured by R&D expenditure) and relative terms (as measured by R&D intensity and by proportion of R&D expenditure in the utility industry compared to all industries).
- The UK was among the top three countries in each of the three indicators considered (R&D expenditure, R&D intensity and proportion of R&D expenditure in the utility industry compared to all industries) in 2000, but experienced a considerable drop in all three measures between 2000 and 2003. Values in 2003 corresponded to between half and two thirds of the respective 2000 values.
- The decline for other countries was usually not so strong and some countries saw an increase in the indicators used. An example is Spain, which saw an increase in both R&D expenditure and the proportion of R&D spent in the utility industry compared to R&D spent in all industries.
- From the analysis of R&D intensity[29] in the water and wastewater industry in Australia and in England and Wales; in Australia it was 0.33% while in England and Wales it was 0.25%.
- There was a decline in the overall count of patent applications filed in the water and wastewater industry between 2000 and 2006. The number of patent applications in Great Britain fell from 45 in 2000 to 16 in 2006. The size of the reduction was comparable to that experienced by the USA and Japan.

[29] As mentioned in section 3.1.2, R&D intensity was computed as the ratio of R&D expenditure on total income in Australia and turnover in England and Wales

4 Survey of water and sewerage companies

This chapter reports the approach selected to measure innovation in water and sewerage companies, and the main features of the innovation questionnaire design.

4.1 Methodological approach

Measuring innovation is far from being an easy task. First of all, innovation can be measured in terms of both inputs and outputs. It is especially difficult to derive accurate and well-defined estimates of innovation in relation to outputs. This is because of the difficulty in measuring the contribution of a specific component (such as innovation) in the multidimensional process affecting outputs.

Moreover, it is necessary to carefully understand what the innovation generating process is within each water company, i.e. if there is a basic environment favourable to innovation; how innovation is generated and encouraged; and who might take the decision to pursue a new idea, etc...

Another crucial area is the identification of drivers and barriers fostering or hindering innovation in the water industry.

To capture the different aspects of innovation, we have designed a questionnaire on innovation, which covers four main areas:

- innovation inputs;
- innovation outputs;
- renewable energy; and
- regulatory framework.

The questionnaire was first tested with a small number of water companies and stakeholders. The revised version of the questionnaire was then sent to all water companies and to a set of contractors that supply specialist services to the water and sewerage companies. Answers to the questionnaire were collected by London Economics through phone interviews with representatives of water companies and contractors. The interviews lasted between 1.5 and 2.5 hours each.

4.2 The innovation questionnaire

The innovation survey has been designed to provide both qualitative and quantitative data on firms' innovation performance. The questionnaire differentiated between innovation inputs and outputs as suggested by the literature (see chapter 2), and also includes questions related to the barriers to innovation.

- Questions on innovation inputs refer to aspects related to the companies' internal "innovation environment" and record how different actions have been used to improve the firm's performance. Such questions are comprised of high-level questions related to the resources dedicated to innovation. In cases where potential responses provided by the companies are difficult to quantify, qualitative responses have been sought.

- Questions for innovation outputs are related to the June Returns that water companies submit to Ofwat. There are several reasons for using the reporting headings from the June Returns. Firstly, companies are familiar with them and this should facilitate completion of the questionnaire with a minimum of additional burden being placed on the companies. Secondly, this approach provides a quantitative metric to measure companies' innovation. Finally, the metric is common to all companies and it makes it more straightforward to benchmark the responses of different companies. Questions related to innovation outputs differentiate between four categories of innovations: Service and performance, Drinking water quality, environmental outputs, and water efficiency methods[30].

- The questionnaire also asks qualitative questions in regard to the drivers and barriers to innovation, so that recommendations as to how to improve the incentives for innovation in the water sector can be made.

Previous versions of the questionnaire were tested with a number of stakeholders to check the interpretation and validity of the questions. Using the feedback from the comments provided by respondents in the testing phase[31] and to minimise the burden on water companies the questionnaire has been kept as simple as possible while providing information required to

[30] The measures are DG2 to DG9 (Table A of the June Returns), and sewage and water quality measures (Tables A, and Tables B, for sewage companies only).

[31] Comments made by respondents during the testing stage, and how these comments were addressed are summarised in Annex 4.

facilitate a systematic comparison of water companies' innovation. The innovation questionnaire for the water companies is presented in Annex 3.

5 Findings from the survey of water companies

In this section we use the information collected in the water company interviews and from published sources such as annual reports, to compare innovation across the water companies. Following our methodological approach, we report our findings separating between innovation input and output measures in the next two sub-sections. The last subsection benchmarks the water and sewerage companies using a summary of the measures.

5.1 Innovation input measures

Innovation input measures consist of all the resources dedicated to promote innovation. It includes all scientific, technological, organisational, financial and commercial steps which lead to, or are intended to lead to, the development of innovation.

Innovation comprises a number of activities not necessarily related to R&D, such as later phases of development, implementation of new processes, new organisational methods not necessarily related to product and process innovations, and acquisition of external knowledge (which is not part of R&D).

To account for these different dimensions, we have analysed the following measures:

a) Innovation environment and philosophy;

b) R&D expenditure;

c) Innovation infrastructure; and

d) Links with external R&D institutions.

We review each of these measures in turn.

5.1.1 Innovation environment and philosophy

Innovation activity undertaken within a firm depend on the variety and the structure of links to information, knowledge, awareness, the flow of ideas, work practices and human resources dedicated to innovation.

To understand how innovation activities are encouraged within the companies we asked companies to describe what is their internal environment and philosophy to promote the facilitation of innovation.

The overwhelming majority of companies are aware of the importance of innovation and maintain a special focus on innovation underpinned by the business strategy or key vision of company directors, or by having a culture of innovation and thinking. Interestingly, five companies mentioned that they consider themselves as second adopters of innovations, in the sense that they aim at being aware of new methods in the industry and to adopt innovations tested or implemented by other organisations.[32]

In general, there seems to be a positive environment towards innovation within the industry as all companies have some sort of process for encouraging employees to generate new ideas that could be developed into useful innovations. However, the process for generating new ideas within the water and sewerage companies is very different.

- Many companies have a formal process for the generation of new ideas. These formal processes vary from a simple ideas forum (sometimes hosted on the company's intranet), to a project assessment of the costs and benefits of the innovation. Monthly staff meetings, staff away-days, and staff performance appraisals are all tools used to encourage generation of ideas.

- Other companies have a more informal process where staff can approach their line managers to raise a new idea. The line manager can then forward the idea to other divisions in the business.

Once the idea has been proposed, there is some form of evaluation process (including attractiveness, cost benefit analysis, or achievability) in all of the companies. However, the approval of new ideas can occur at different levels. Approval takes place at the line manager level if the investment is of a smaller size. For larger investments, the level of approval rises up to managing director and board level. For companies with R&D units, or R&D managers, the decision usually involves staff in such units or divisions.

There is much less evidence on the amount of ideas being generated within companies. In general, companies were unable to provide a measure on the number of ideas being generated and the degree which these get developed at a later stage. Exceptions to this are: ANH (which record about 300 ideas being generated per year, of which 80 are developed at a later stage); MSE (100 ideas per year, 1-2 implemented); WSX (their internal "Eureka"

[32] The other companies did not mention explicitly whether they considered themselves as first adopters or not.

programme coordinated 74 successful ideas in 2007 and 53 in 2008); and SST (about 300 ideas per month).

Finally, it is interesting to investigate the current drivers of innovation for both water and sewerage companies, and the incentive they provide to contractor firms.

Not surprisingly, water and sewerage companies identify efficiency performance targets as a driver of innovation. All companies state that Ofwat's comparative performance measures are challenging and difficult to achieve and that this creates an environment that encourages searching for innovative solutions to increase efficiency.

A majority of companies report that customer service quality (including water quality supplied to customers) is also an important driver of innovation. Finally, as many as seven companies cited environmental measures or targets including those set by the Environment Agency as an important driver of innovation.

Water and sewerage companies acknowledge the importance of innovation in contractor firms. With this aim, contracts between water and sewerage companies and contractor firms are usually designed in ways to allow for a margin for innovative solutions. As many as 15 companies use some form of risk-sharing (of profits and losses) in their contracts with suppliers.[33] Other innovation incentives used by the companies include testing new solutions in conjunction with their contractors (NWT), sharing training and management programmes (YKY), and in some instances locating contractors within the water company's main offices (YKY).

5.1.2 R&D expenditure

As part of the information gathering exercise, companies were asked to provide R&D expenditures for the years 2002 to 2008. In a few cases companies were unable to provide any data for R&D expenditure. In such cases we imputed the information by using data from the companies' annual reports (although for three companies, CDW, DVW and THD, we were unable to gather any relevant data). Full details of the data construction process are provided in Annex 1. Unless specified, all figures refer to the last available year (2007/08).

Total R&D expenditure for water companies in England and Wales in 2007/08 is in the order of £23 million. However, the expenditure is very different for two groups of water companies:

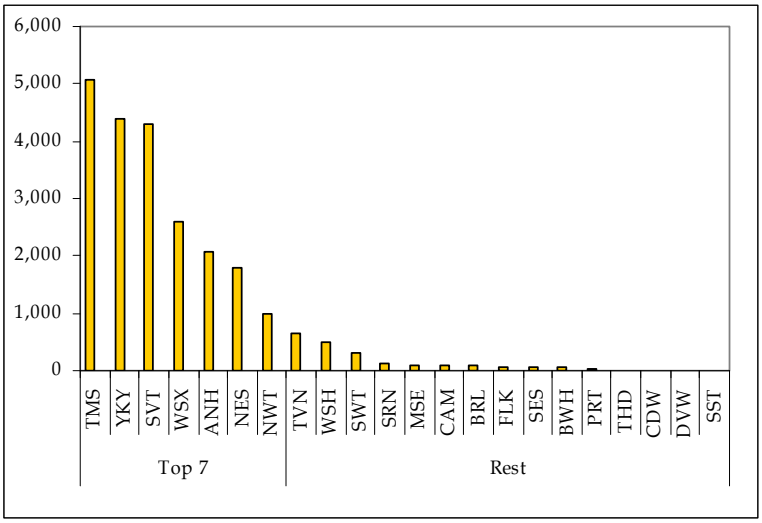
[33] These are TMS, YKY, SVT, WSX, ANH, NES, NWT, SWT, SRN, MSE, CAM, BRL, BWH, DVW and SST.

- A group of seven companies ("Top 7") spend over £1 million each in R&D, in 2007/08,

- A group of remaining companies ("Rest") are spending less than £0.5 million, in 2007/08.

The "Top 7" group comprises seven companies (TMS, YKY, SVT, WSX, ANH, NES and NWT) and account for more than £21 million in total (around 91% of all R&D expenditure[34]). The "Rest" group comprises twelve companies (WSH, TVN, SWT, SRN, MSE, CAM, BRL, FLK, SES, BWH, PRT, and THD) and account for less than £2 million in total (less than 9% of total expenditure). See Figure 7.

Figure 7: Water companies R&D Expenditure 2007/08 (£'000s), by group



***Source:** interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.*

Interestingly, the two groups can be broadly characterised by the size of the companies and the type of services provided. Hence:

- "Top 7" are companies with more than 2 million customers providing both water and sewerage services (excluding SRN and including WSX); and

[34] For comparison, the largest three companies (TMS, SVT and YKY) account for almost £14 million (nearly 60% of all R&D expenditure).

- "Rest" are companies with less than 2 million customers (including SRN) or water only companies.

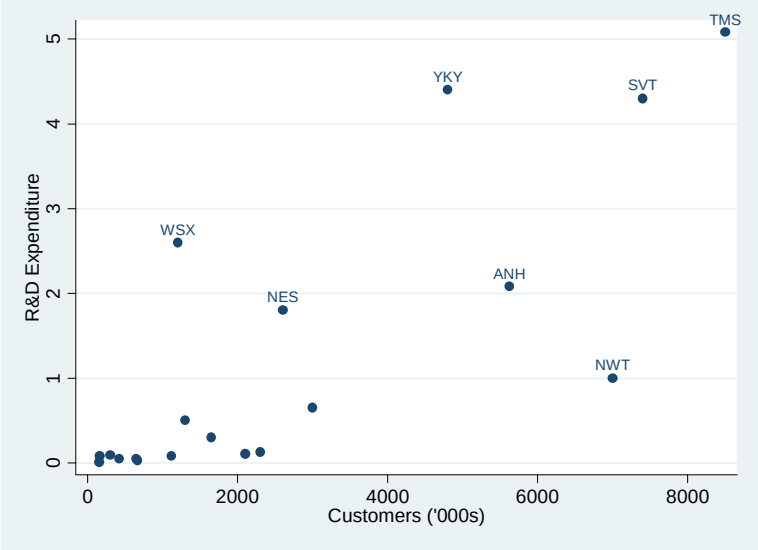
Table 3: Characterisation of groups "Top 7" and "Rest"		
Size (customers)	**Water and Sewerage**	**Water only**
More than 2,000,000	**Top 7:** TMS, SVT, NWT, ANH, YKY, NES **Rest:** SRN	**Rest:** TVN, MSE
Less than 2,000,000	**Top7:** WSX **Rest:** SWT, WSH,	**Rest:** BRL, PRT, SES, BWH, CAM, FLK, THD

Note: Information on R&D expenditure missing for SST, DVW and CDW.

R&D expenditure and company size

To a large extent, total R&D expenditure can be explained by companies' size (measured as number of customers). With very few exceptions (WSX, YKY, NWT), there seems to be a linear relationship between company size and R&D expenditure (Figure 8).

Figure 8: R&D Expenditure by company size (2008)



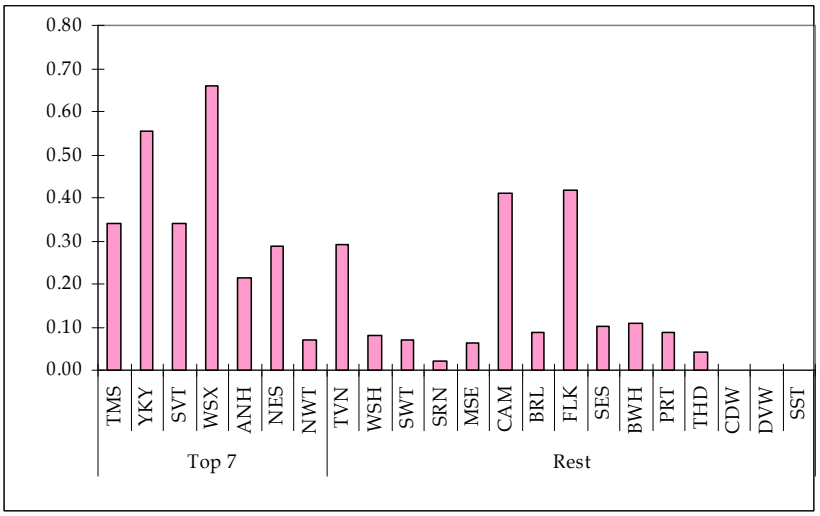
***Source:** interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.*

R&D intensity

As total R&D expenditure is mainly driven by company's size, to compare the relative effort of each company in R&D we use the ratio of R&D expenditure to the company's turnover. As it can be seen in Figure 9, companies' expenditure in R&D ranges from 0.02% of company turnover (SRN) to 0.66% (WSX) of turnover.

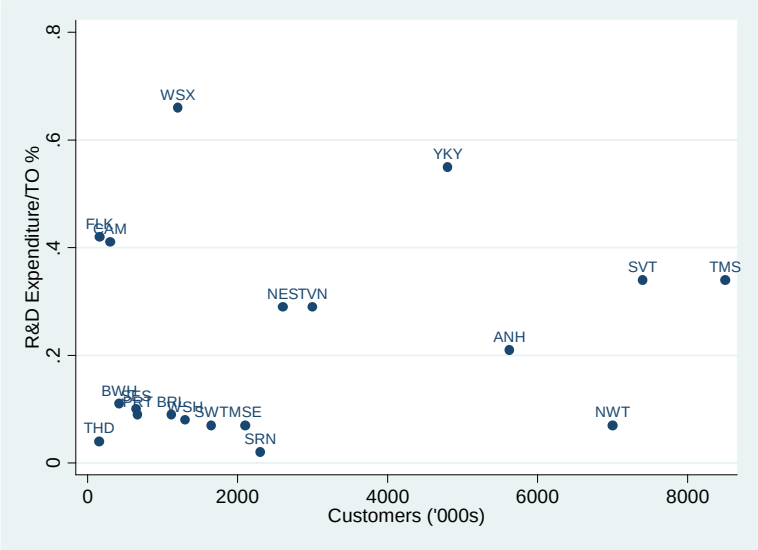
We also observe that the average of companies in "Top 7" is around 0.35%, while the rest of the companies spend on average less than half of that percentage (0.15%). Specifically, with the exception of NWT, companies in the "Top 7" are all among companies with a higher R&D Expenditure/Turnover ratio, with two of them spending more than 0.5% and the other four spending between 0.20 and 0.40 percent. In the "Rest" group, companies spend less than 0.1% of their turnover with the major exceptions of CAM, FLK (expenditures in the order of 0.4%) and TVN (0.3% of turnover).

Figure 9: Water companies R&D Expenditure/Turnover (2008)



It is also worth observing that the R&D expenditure ratio does not seem to be driven by size or type of activity: four of the ten companies with largest R&D expenditure to turnover ratio are water only companies and three of them have less than 500,000 customers (Figure 10). Moreover, five of the six companies spending less in R&D in relation to their turnover have more than 1,300,000 customers and four of them provide both water and sewerage services. Smaller companies (with less than one million customers) all spend less than 0.15% of their turnover on R&D, apart from FLK and CAM, which spend around 40%.

Figure 10: R&D Expenditure intensity by company size (2008)



Source: interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.

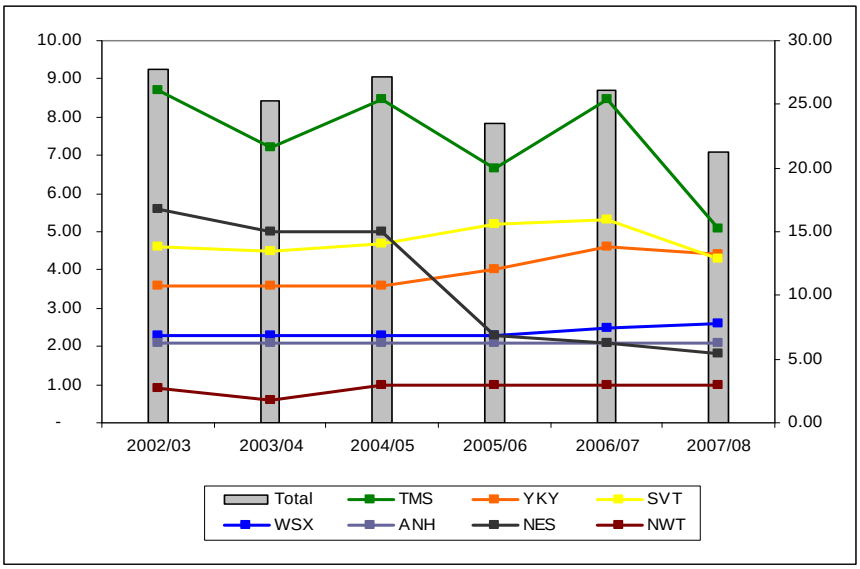
R&D expenditure over time

It is difficult to construct a time series for all companies as many companies provided only a single value (for a single year or for the aggregate over the period). Time series for the entire period 2002-08 were available only for three of the seven companies. For the remaining four companies we proceeded as follow:

- For WSX, YKY we imputed missing values by using the next available figure (for YKY the value for 2002 was imputed by using the value of 2003, for WSX the values for 2002-2004 were imputed by using the value of 2005).
- For NWT the series is completed with data coming from the Annual Reports 2004 and 2005.
- For ANH an aggregate for the period 2002-08 was provided and we allocated equal shares for each of the periods (hence, there are no movements in the series).

The evolution of R&D expenditure in the period 2002-08 for the group of the "Top 7" shows a decreasing trend, although very minor (Figure 11).

Figure 11: Evolution of R&D expenditure over time (£million): "Top 7" companies (left axis) and Total (right axis)



Source: interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.

As for the rest of the companies, there is no data available although most of them reported a constant value in nominal terms dedicated to R&D expenditure in the last five or six years.

5.1.3 Innovation infrastructure

As part of input measures we also consider any infrastructure used for research, development or innovation purposes. As part of the data gathering exercise, companies were asked to provide information about the internal resources used for R&D purposes, including whether they have an internal R&D department.

The results are the following.

- All "Top 7" companies have an R&D department, with the only exception of WSX, which reported that all R&D activities are outsourced through collaboration with universities and private research companies (Table 4).

- The number of people dedicated to the R&D department varies, but is typically between 15 and 20 (major exceptions are TMS, with 45, and NWT, with 2).

- There is also not a definite role for the R&D department in the companies' organisational structure: in some cases the team is separated into water and wastewater, in others it sits under a single unity (e.g. Asset Management)

Table 4: Innovation approach and infrastructure: Top 7.

Name	R&D Dept	Approach to R&D (responsibility and role)	Staff (FTE)*
TMS	YES	**Responsibility:** Operations. **Role:** To deliver a cost effective programme, aligned with business needs to address challenges for the current AMP, PR09 and beyond.	45
SVT	YES	**Responsibility:** Water unit / Wastewater unity. **Role:** R&D teams aim to achieve current and future standards in a cost effective way (for example to reduce Capex and Opex, to meet Health and Safety requirements, to decrease CO2 impact).	15.5
NWT	YES	**Responsibility:** Division of strategy, waste water and management. **Role:** To coordinate and generate new ideas	2
ANH	YES	**Responsibility:** Asset Management. **Role:** To broaden the skill base of the company in pursuit of innovation.	15
YKY	YES	**Responsibility:** Regulation and Investment Unit (strategic R&D); Water Unit / Wastewater Unit (R&D teams focused in management operationally). **Role:** To work with the whole regulated business, university partners and other suppliers to define, prioritise and promote a programme of R&D.	18.5
NES	YES	**Responsibility:** Asset Strategy department. **Role:** To gather external information (coming from scientific research, UKWIR or other sources) and evaluate if any innovation could be usefully applied in the company.	20
WSX	NO	**Responsibility:** -- **Role:** R&D is outsourced through universities and private research companies	.

Note: * Staff measured as full time equivalent. Breakdown of staff available for the following companies. SVT: 7 (water unit), 2 (wastewater unit), 4.5 (universities), 2 (admin); NWT: there are 30 additional people working as project leaders, typically dedicating one day a week; ANH: includes engineers, scientists, and environmental graduates; YKY: Staff in R&D department. In addition, there are a number of employees who undertake R&D projects but which do not form part of the R&D structure. YKY are also supported by a number of students and other academics under their contracting arrangements; NES: 2 employees working in the R&D department, 6 permanent staff for the Business Improvement Team, and 10-15 secondees from other business departments.
Source: interviews with water companies.

Companies in the "Rest" group do not have a specific department. The only exception is TVN, a water-only company with 3 million customers, which reported to have an R&D division (Table 5). In WSH, there is no specific R&D department but individual teams have innovation as a remit. Four other companies have some ways to develop new ideas internally (for example setting up special teams for specific projects).

Almost all the companies in the "Rest" group mainly outsource their R&D, especially through projects developed with UKWIR and WRc. Most of them also collaborate with universities and/or private consultancies on a permanent or *ad hoc* basis, and only three (SRN, MSE and DVW) do not have any collaboration with external partners.

Table 5: Innovation approach and collaborations: Rest of companies.

Name	R&D Dept	Approach to R&D	Coll.* (I/X)
TVN	YES	Water Quality Department (R&D team, 4.5 FTE) introduce improvements to current practices and technologies, especially to respond to regulatory change in standards (e.g. test different ways to remove pesticides in response to a change in regulation).	I
WSH	NO	Outsourced (UKWIR and WRC) Individual teams have innovation as a remit Development of ideas presented by contractors and third parties	I/X
SWT	NO	Outsourced (UKWIR and WRC) R&D coordinator considers all internal and external opportunities for R&D developments Collaboration with universities and specialist consultancies Collaboration with suppliers. One member of staff is dedicated to R&D.	I/X
SRN	NO	Outsourced (UKWIR and WRC) Operational and Asset Managers can develop new ideas	I
MSE	NO	Outsourced (UKWIR and WRC) Individual departments conduct their own R&D	I
CAM	NO	Outsourced (UKWIR and WRC) Collaboration with local universities. Project teams are set for the development of specific projects	I/X
BRL	NO	Outsourced (UKWIR and WRC) . The other principal programme is a collaboration with Bristol University	X
FLK	NO	Outsourced(UKWIR and WRC) Through parent company Veolia	X
SES	NO	Outsourced (UKWIR and WRC) Engaging specialist contractors	X
BWH	NO	Outsourced (UKWIR and WRC) External consultants (rarely)	X
PRT	NO	Outsourced (UKWIR and WRC) Collaborations with universities (occasionally)	X
THD	NO	Outsourced (UKWIR and WRC) External companies	X
CDW	NO	Bought-in solutions	X
DVW	NO	Planning and Regulation department consider and decides to develop proposals	I
SST	NO	Outsourced (UKWIR and WRC) Operational Managers keeps an eye on industry developments Graduate entry programme	X

Note: * Collaborations. I: Developed internally, X: with external partners.
Source: interviews with water companies.

We also asked water companies if they have a way of assessing cost and benefits deriving from expenditure in R&D (Table 6). Overall, only some companies (four, plus one organisation who has recently introduced it and one which is currently developing it) conduct a formal CBA for each project. Surprisingly, the majority of companies do not have a standardised process to assess innovation projects: some projects go through a formal CBA, some others are assessed on qualitative, more subjective basis. Sometimes post-projects appraisals are also carried out to evaluate the impact of the project.

By company groups we observe the following:

- All companies in "Top 7" have some sort of evaluation process (either formal or informal),

- Up to eight companies in the "Rest" group (i.e. companies with a low level of total R&D expenditure) do not have any formal process of evaluation.

Table 6: Assessment of innovation projects: all companies.

Name		F: Formal I: Informal N: No process	Description
Top 7	TMS	F	Measuring the impact on the business as a whole.
	SVT	F	Cost of the innovative project is compared to the cost of the project that would have been implemented without innovation.
	NWT	I	Currently in the developing a process to justify R&D expenditure.
	ANH	F	Formal process for assessing the expected benefits for all research projects over 5 year periods.
	YKY	F	Formal assessment of benefits; for the period 2005-2010.
	NES	I	There is not a formal, standardized process for each project, but the Business Improvement Team assesses the potential benefits coming from a project before implementing it.
	WSX	I	There is not a formal assessment: expected benefits are estimated before going ahead with a new project, but there is not a standard way to estimate the realised benefits.
Rest	TVN	I	No standardized assessment for every project. Some projects do have a formal assessment.
	WSH	I	No measure for aggregate benefits. There is some assessment of individual projects
	SWT	I	No formalized process for every project. Some projects undergo a formal CBA ex ante, other projects a judgement on potential benefits. Also post project appraisals are carried out (formal or informal assessment)
	SRN	N	No formal process
	MSE	N	No formal process
	CAM	N	No formal process
	BRL	I	There is not a formal standardized procedure, but major projects do have post-project appraisals. Most projects are implemented considering the costs informally
	FLK	N	No process, but a formal system will be introduced in the next couple of years
	SES	N	No formal process
	BWH	I	There is not a formal process; often the decision to go ahead with a project is taken with a qualitative, subjective analysis, but some projects have a post project appraisal
	PRT	I	There is not a formal procedure: CBAs and post project appraisals are carried out, but not based on standardized procedures
	THD	F	A tool to evaluate projects' costs and benefits has been recently developed. Before that there was no formal, standardized procedure.
	CDW	N	No formal process
	DVW	N	No formal process
	SST	N	No formal process

Source: interviews with water companies.

5.1.4 Links with external R&D institutions

Table 7 presents a list of the typical number and value of contracts with external institutions for the different companies: companies in the "Top 7" usually have a higher number of contracts and overall value, though it is important to point out that, on average, these companies do not only invest more in-house (having a dedicated R&D department), but are also pro-active in building external networks for the development of innovative projects.

A few of the companies in "Rest" have permanent links with universities and research centres, but most of them (especially small companies) typically do not collaborate on permanent basis with external institutions.

Table 7: Assessment of R&D links with external institutions.

	Name	Number of contracts and value	Value (£)
Top 7	TMS	<100	.
	SVT	98 (2004) 111 (2005) 96 (2006) 73 (2007) 88 (2008)	£976,000 (2004) £1,110,000 (2005) £673,000 (2006) £636,000 (2007) £492,000 (2008)
	NWT	Funding (50%) for 3 external and 1-2 temporary researchers.	£ 440,000 UKWIR projects
	ANH	20 in 2002-2008	£5 million
	YKY	30 per year 137 projects (2005-10) undertaken for AMP4 (with Cranfield, Sheffield, Imperial and Leeds University) 44 projects in the UK and overseas. 86 projects with WRc were undertaken	2008/09 UKWIR subscription is £295,000. Combined value of the strategic partnerships with university between 2005 and 2010 is £4.9M.
	NES	Around 20 per year	Typically 90% of annual investment in R&D (ca £1.6m)
	WSX	4 projects developed with universities (Bath, East Anglia Sheffield,) between 2005 and 2008. Projects developed with other partners (e.g. Waterwise)	With universities: £1,885,000 ca. in the last two years. Waterwise: £90,000 since 2005
Rest	TVN	5 contracts per year, one with UKWIR and four with WRc and others	Typically £150,000 per annum
	WSH	.	.
	SWT	Usually 3-4 programmes running at the same time.	Typically £5,000-10,000 for each programme with universities
	SRN	.	Costs are in total R&D expenditure and cannot be extrapolated
	MSE	None	.
	CAM	Collaboration with Judge Business School (once a year) Collaboration with Cranfield University	Around £10,000 per contract
	BRL	Collaboration with Bristol University Collaboration with Serco Group	Ice cleaning for water mains: £350,000 Asset investment planning tool: £10,000
	FLK	0	.
	SES	No permanent links with universities or other centres	.
	BWH	.	.
	PRT	No collaborative links on permanent basis.	.
	THD	0	.
	CDW	Collaboration with British Geological Survey (BGS)	Hydrological survey by BGS: £10,500
	DVW	.	.
	SST	0	.

Note: "." Denotes not identified.
Source: interviews with water companies.

5.2 Innovation output measures

Analysing innovation input can give a measure of the effort each company makes to develop innovative solutions. However, in order to measure the way such effort materialises it is important to account for the results of this research effort. In other words, whether the innovation has been successful or not needs to reflect some kind of net benefits for the water companies.

We followed three different routes to identify the impact of innovation:

- We asked the water companies to produce an estimate of the cost and benefits associated with innovative projects; such an estimate could show the yield of an R&D and innovative investment in different areas and from different companies.
- As innovation can have an impact on several measures affecting the companies' performance, we asked the companies to identify whether innovation had any impact on a number of measures we identified from the June Return. If so, we asked companies for the description of the project and a quantitative estimate of its impact (net from other influencing factors, such as investment or weather).
- Water companies were also asked to quantify the impact innovation has had on the development of renewable energy and on any other measures the company considered important.

It has proved difficult to collect complete and accurate estimates of output measures. This has been for several reasons. On the one hand, only a few water companies conduct formal cost and benefits analysis for all innovation projects. Moreover, the few companies that do undertake CBA analyses were unable to provide an aggregate figure of the benefits.[35] Most of the time, only qualitative judgements are carried out instead of quantitative estimates.

On the other hand, many water companies also had difficulties in identifying the impact of innovation on the efficiency measures of the June Return (although sometimes they were able to identify the effect of innovation on alternative measures).

The results of the interviews show that overall innovation has had little impact for some companies, while many others are not able to estimate the impact. For the companies that were able to identify and quantify the impact of innovation, a summary of the results is presented in Table 8 below.

[35] A possible explanation is that it is complicated to estimate exactly the benefits connected to an innovative project because multiple and interacting factors and effects have to be taken into account (on both inputs and outputs).

In general, it seems that innovation had a bigger impact on measures referring to consumer service and performance (DG2 to DG9), rather than for the indicators on drinking water quality and environmental water outputs (measures 12, 13, 17-19 of Table A of the June Return).

Furthermore, companies providing water and sewerage services were able to identify a relevant effect of innovation: half of the companies identified some effect on measures related to sewerage services (indicators 4, 5 and 10-13 of Table B of the June Return). This may reflect a greater impact of innovation on wastewater activity.

Some companies commented on the difficulty of reporting benefits for such measures. Instead, they reported a number of other innovations related to different concepts (reduction in Opex and Capex; customer service; leakage; environmental measures or water quality).[36] These different measures are reported in the last column of Table 8.[37]

[36] For example, YKY mentioned the difficulty of reporting the benefits of innovation investments because in some cases data correspond to several periods. Nevertheless, they estimate that during the asset management period 2005-2010 (AMP4) they have invested so far £11.8M which has generated £62.5M of combined OPEX and CAPEX benefits. In the previous AMP they invested £11.7M in R&D and returned around £40M to the business in the form of OPEX and CAPEX savings.

[37] In addition, there seems to be no relationship on the efficiency rankings and bands calculated by Ofwat for water and sewerage services and the rankings provided by innovation input measures calculated in previous paragraphs.

Table 8: Indicators Output Summary Table

Comp.	Service and Performance (DG)								DQ	EA	Sewerage		REN	Other
	2	3	4	5	6	7	8	9	12-13	17-19	4-5	10-13		
TMS	i	i	YES	i	i	i	i	i	0	0	0	YES	YES	.
YKY	.	.	.	.	.	.	.	.	.	.	.	.	YES	OX CX CS
SVT	.	.	.	.	.	.	.	.	.	.	.	.	YES	OX WQ EN
WSX	.	.	.	.	.	.	.	.	.	.	.	.	YES	OX WQ
ANH	YES	YES	YES	.	YES	YES	YES	YES	YES	.	YES	YES	YES	OX CX EN
NES	.	.	.	.	.	.	.	.	.	.	.	.	YES	.
NWT	YES	YES	.	.	.	.	.	.	YES	0	YES	YES	NO	CS
TVN	.	.	.	.	YES	YES	YES	YES	0	0	--	--	NO	OX
WSH	.	.	.	.	.	.	.	.	0	0	YES	0	YES	.
SWT	0	YES	YES	0	0	0	0	YES	YES	0	YES	YES	YES	OX CX CS LK EN WQ
SRN	.	.	.	.	YES	YES	.	.	0	0	.	YES	YES	.
MSE	0	0	0	0	0	0	0	0	0	0	--	--	NO	CS
CAM	0	0	YES	0	0.	0	YES	0	0	0	--	--	NO	OX CS
BRL	.	.	.	.	.	.	.	YES	0	0	--	--	Test	OX CX WQ CS
FLK	0	0	0	0	0	0	0	0	YES	.	--	--	NO	.
SES	0	0	0	0	0	0	0	0	0	0	--	--	NO	LK
BWH	0	0	0	0	0	0	0	0	.	.	--	--	Test	OX CS
PRT	i	i	i	i	i	i	i	i	0	0	--	--	YES	LK
THD	0	0	0	0	0	0	0	0	0	0	--	--	NO	OX
CDW	--	--	--	--	--	--	--	--	--	--	--	--	NO	.
DVW	.	.	.	.	.	.	.	.	.	.	--	--	YES	LK
SST	0	0	0	0	0	0	0	0	0	YES	--	--	NO	.

Note: DQ: Drinking water quality output measures (measures 12-13 of Table A of the June Return); EQ environmental water outputs (measures 17-19 of Table A of the June Return). REN; innovations occurred in renewable resources; YES: innovations taking place in different measures. Test: Innovation tested but not implemented on a large scale. "." Denotes not able to identify; 0 denotes no impact of innovation on the relevant measure; i denotes incremental innovation; "—" denotes that the measure does not apply to the company; OX: Opex; CX: Capex; CS: Customer service; LK Leakage; EN environmental measure; WQ water quality.

Source: survey of water companies. Further details in Table 16-Table 20, in Annex.

5.3 Benchmarking water and sewerage companies

So far, we have provided a range of measures for both input and output measures.

Before proceeding further we should acknowledge the limitations of the measures insofar as they are based on subjective perceptions of the interviewees, and in the case of R&D expenditure, they may reflect different measurements or accounting practices (it could also be that R&D figures can sometimes be subject to variations for tax purposes).

Companies are ranked using the measures of R&D: total expenditure and expenditure as a percentage of turnover (Table 9). It is interesting to note that six companies (TMS, YKY, SVT, WSX, ANH and NES) are both at the high end in terms of total expenditure (more than £1.8 million) and all spend more than 0.2% of their total turnover.

Table 9: Water companies R&D expenditure rankings (2007/08) (total expenditure and as % of turnover)

Company	R&D (000)	Rank	R&D (%)	Rank
TMS	5080	1	0.34	5
YKY	4400	2	0.55	2
SVT	4300	3	0.34	6
WSX	2600	4	0.66	1
ANH	2083	5	0.21	9
NES	1800	6	0.29	8
NWT	1000	7	0.07	16
TVN	650	8	0.29	7
WSH	500	9	0.08	15
SWT	420	10	0.10	11
SRN	130	11	0.02	19
MSE	105	12	0.06	17
CAM	85	13	0.41	4
BRL	80	14	0.09	14
FLK	75	15	0.42	3
SES	52	16	0.10	12
BWH	50	17	0.11	10
PRT	30	18	0.09	13
THD	6	19	0.04	18
CDW	.	.	.	.
DVW	.	.	.	.
SST	.	.	.	.

Note: "."denotes where company was unable to provide a figure for R&D.

Finally, the analysis undertaken so far can be used to gather a picture of the range of activities undertaken by companies. All the different measures are summarised in a table where we identify the companies fulfilling a minimum criterion on innovation based on our own judgement. The table can also be used to identify the type of activities "Top 7" companies are undertaking. Hence, in Table 10 we record a ✓ in cases where:

- R&D Expenditure is greater than £1m,
- Ratio R&D/turnover is greater than 0.2,

- Company has an R&D Department,
- R&D Department has more than 10 FTE,
- R&D is undertaken internally,
- R&D is undertaken externally,
- R&D goes through an evaluation process (formal or informal),
- Company has contracts with universities,
- The value of contracts is more than £100k,
- Innovation played a role in improving service and performance measures,
- Innovation played a role in improving drinking quality,
- Innovation played a role in improving environmental outputs,
- Innovation in renewable resources,
- Any other type of innovation mentioned in interview.

As it can be seen in Table 10, most of the ✓'s are concentrated on the rows corresponding to the "Top 7" companies (top section of the table). This indicates that these companies are developing a broad range of activities (e.g. internally, externally, investing in renewable resources) to effectively promote innovation.

It is difficult to indicate exactly what all this effort is yielding in terms of output. This is because many companies were not able to identify the impact of innovation on the output measures, or to provide an aggregate estimate of the benefits generated by R&D activities.

Table 10: Innovation Summary Table.
Companies sorted by R&D expenditure (in decreasing order)

	Company	Inputs									Outputs				
		R&D Expenditure > £1m	% R&D > 0.2	R&D Dept	FTE R&D > 10	R&D Internally	R&D Externally	R&D Evaluation process	Contracts with universities	Value of contracts more than £100k	Service and Performance (DG measures)	Drinking Quality	Environmental Outputs	Renewable Resources	Other relevant measures
Top 7	TMS	✓	✓	✓	✓	✓	✓	✓	✓	.	✓	.	✓	✓	.
	YKY	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
	SVT	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
	WSX	✓	✓	.	.	.	✓	✓	✓	✓	.	.	.	✓	✓
	ANH	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	NES	✓	✓	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	.
	NWT	✓	.	✓	.	✓	✓	✓	✓	✓	✓	✓	✓	.	✓
Rest	TVN	.	✓	✓	.	✓	.	✓	✓	✓	✓	.	--	.	✓
	WSH	.	.	.	.	✓	✓	✓	.	.	.	.	✓	✓	.
	SWT	.	.	.	.	✓	✓	✓	.	.	.	✓	✓	✓	✓
	SRN	.	.	.	.	✓	.	.	.	.	✓	.	✓	✓	.
	MSE	.	.	.	.	✓	.	.	.	.	.	.	--	.	✓
	CAM	.	✓	.	.	✓	✓	.	.	.	✓	.	--	.	.
	BRL	.	.	.	.	.	✓	✓	.	✓	✓	.	--	.	✓
	FLK	.	✓	.	.	.	✓	.	.	.	.	✓	--	.	.
	SES	.	.	.	.	.	✓	.	.	.	.	.	--	.	✓
	BWH	.	.	.	.	.	✓	✓	.	.	.	.	--	.	✓
	PRT	.	.	.	.	.	✓	✓	.	.	.	.	--	✓	✓
	THD	.	.	.	.	.	✓	✓	.	.	.	.	--	.	✓
	CDW	.	.	.	.	.	✓	.	.	.	.	.	--	.	.
	DVW	.	.	.	.	✓	.	.	.	.	.	.	--	✓	✓
	SST	.	.	.	.	.	✓	.	.	.	.	✓	--	.	.

Note: ✓ . Indicates the condition is fulfilled; "." Indicates no evidence the condition has been fulfilled; -- The measure does not apply to the company.
Source: data sourced from Table 16-Table 20, in Annex.

Alternatively, we can rank the companies using R&D intensity (the ratio of R&D over turnover) instead of total R&D expenditure. This is presented in Table 11 and shows how it is difficult to observe a relationship between the rankings and the different innovation activities undertaken by the companies.

Table 11: Innovation Summary Table.
Companies sorted by R&D intensity (in decreasing order)

Company	R&D over turnover (%)	Rank	R&D Dept	FTE R&D > 10	R&D Internally	R&D Externally	R&D Evaluation process	Contracts with universities	Value of contracts more than £100k	Performance (DG measures)	Drinking Quality	Environmental Outputs	Renewable Resources	Other measures identified
WSX	0.66	1	.	.	.	✓	✓	✓	✓	.	.	.	✓	✓
YKY	0.55	2	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
FLK	0.42	3	.	.	.	✓	.	.	.	.	✓	--	.	.
CAM	0.41	4	.	.	✓	✓	.	.	.	✓	.	--	.	.
TMS	0.34	5	✓	✓	✓	✓	✓	✓	.	✓	.	✓	✓	.
SVT	0.34	6	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	✓
NES	0.29	8	✓	✓	✓	✓	✓	✓	✓	.	.	.	✓	.
TVN	0.29	7	✓	.	✓	.	✓	✓	✓	✓	.	--	.	✓
ANH	0.21	9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BWH	0.11	10	.	.	.	✓	✓	.	.	.	.	--	.	✓
SWT	0.1	11	.	.	✓	✓	✓	.	.	.	✓	✓	✓	✓
SES	0.1	12	.	.	.	✓	.	.	.	.	.	--	.	✓
BRL	0.09	14	.	.	.	✓	✓	.	✓	✓	.	--	.	✓
PRT	0.09	13	.	.	.	✓	✓	.	.	.	.	--	✓	✓
WSH	0.08	15	.	.	✓	✓	✓	.	.	.	.	✓	✓	.
NWT	0.07	16	✓	.	✓	✓	✓	✓	✓	✓	✓	✓	.	✓
MSE	0.06	17	.	.	✓	.	.	.	.	.	.	--	.	✓
THD	0.04	18	.	.	.	✓	✓	.	.	.	.	--	.	✓
SRN	0.02	19	.	.	✓	.	.	.	.	✓	.	✓	✓	.
CDW	.	.	.	.	.	✓	.	.	.	.	.	--	.	.
DVW	.	.	.	.	✓	.	.	.	.	.	.	--	✓	✓
SST	.	.	.	.	.	✓	.	.	.	.	✓	--	.	.

Note: ✓ . Indicates the condition is fulfilled; "." Indicates no evidence the condition has been fulfilled; -- The measure does not apply to the company.
Source: data sourced from Table 16-Table 20, in Annex.

In summary:

- Companies are well aware of the benefits of innovation and have measures implemented to generate innovative ideas and facilitate their diffusion throughout the company.

- This is because water and sewerage companies believe that innovation plays an important role in making them comply with efficiency performance targets, reducing costs and improving the quality of the service.

- In terms of innovation infrastructure, essentially we found that seven companies – TMS, YKY, SVT, WSX, ANH, NES, and NWT are the organisations are best equipped in terms of resources dedicated to primary research and development.
- It has been hard to quantify the effects of innovation on outputs. This is because of the inherent nature of innovation (and in some cases the difficulty to clearly separate between investment and innovation) and because, in general, companies do not keep records on the impact of the different innovations.

6 Contractor survey

Six contractor firms were interviewed in January and February 2009. SBWWI contacted their members on London Economics behalf and invited them to participate in this study.[38] The six interviews were conducted over the phone and lasted between 1.5 and 2 hours each.

The contractors are a mix of Tier 1 and Tier 2 firms, and they supply services across the water and sewerage value chain.

We do not identify the individual contractors here, as many have requested that we maintain their anonymity. Instead, we call the contractors C1 to C6. The main characteristics of these contractor firms are the following:

- C1 specialises in sewer and drain services including surveying and inspection sewerage mains and road drainage systems. This firm is a Tier 2 contractor (i.e. a sub-contractor).
- C2 specialises in water and sewerage supplies to domestic and business premises. The firm is a Tier 2 contractor.
- C3 works on all aspects of maintenance and renewal for both distribution and trunk mains networks. The firm is Tier 1 contractor.
- C4 supplies whole life asset solutions to the water industry including the provision of civil engineering, utilities, mechanical & electrical services across the whole supply chain and project lifecycle: design, build, maintenance & rehabilitation. The firm is a Tier 1 contractor.
- C5 provides waste water asset and pipeline rehabilitation. The firm is usually a Tier 2 contractor, but has received one contract as a Tier 1 contractor.
- C6 main areas of work are in repair and maintenance of mains networks, including metering and the development of mains for new urban developments. The company is usually a Tier 1 contractor.

6.1 Innovation inputs

The main driver of innovation in the contractor firms is competition in the contractor market: reduction in costs and improved service delivery to their

[38] We also asked a number of water companies if they could invite their contractors to participate. We received no response from contractors via this route.

customers. The contractors have two broad approaches to innovation. These can be grouped as follows:

- Second adopters, where new technologies and processes are bought in; and
- In-house research and development

Those firms that undertake in-house R&D also undertake second adoption.

Of the six contractors interviewed, four have internal R&D departments.[39] These are, C2, C3, C4 and C6. The remaining two, C1 and C5, use different methods to ensure knowledge transfer is maximised. For example, trade shows, word of mouth, informal networks with suppliers and manufacturers, and trade organisations such as SBWWI.

R&D expenditures for these organisations as a proportion of turnover are presented in Table 12.

Table 12: Contractor research and development expenditure as a proportion of turnover 2007/2008

Company	R&D/turnover (%)	Number of staff (full time equivalent)
C1	No department	Nil
C2*	25	10
C3	10	5
C4	0.004	6
C5	No department	Nil
C6**	Not reported	1

Notes: The percentages were reported by the contractors during the interviews. C2* has established a separate engineering business which conducts R&D. C6** did not report their expenditures. C6 has "virtual" R&D department with 10 members that meet once a year we count this as one full time staff equivalence. From the reported figures in Table 11, C4 appears unusual, with a staff of six but a percentage of 0.004%. We double checked these figures with the company and they confirmed they are correct.

[39] One, C6, has a virtual R&D department which has no budget but draws its members from across the firm. The virtual group has 10 members and meets four times a year.

Linkages with external research organisations are presented in Table 13.

Table 13: Contractors and external research organisations

Contractor	Linkages
C1	One contract in 2007/08, £500 to employ a postgraduate student to undertake research into environmental management systems.
C2	Ad hoc arrangements with two university engineering departments which include materials selection for pipes and stress testing.
C3	Only one contract in 2002/03 with a university to undertake research into plastic pipes and their response to manipulation. Value £7,500.
C4	In 2007/08 £100k has been spent on approximately 10 contracts. Three contracts are investigating technologies in the areas of tunnelling. Flow modelling and stress analysis.
C5	No contracts
C6	One contract in 2007/08 focusing on reducing carbon emissions from the company vehicles

If we consider the input information, we observe that Tier 1 contractors are more likely to have an R&D department, which makes sense as these Tier 1 firms are generally larger firms which co-ordinate multiple contractors for the delivery of services, and therefore have greater capacity to invest in R&D in-house. Firm C2 is an exception to this as it has its own R&D business which is separate from the service delivery business and specialises in engineering innovations.

The number and value of contracts with external research organisations is quite low, and therefore contractors perhaps are not relying on external researchers to find new solutions. C4 appears to be an exception to this, with ten contracts in 2007/08 with a total value of £100,000.

6.2 Innovation outputs

Table 14 reports the innovations as identified by the contractors. The interviewer asked contractors to identify where they believed innovation had occurred in their business which had then fed through to the water companies. We observe that innovation efforts are mainly technical (as opposed to process orientated) and are focused towards reductions in supply

interruptions, complaints from discoloured water and reduced response and maintenance times for water and sewerage pipes.

Table 14: Contractors linking innovation to outputs

Contractor	Innovation description and benefits
C1	**Sewerage services**: Innovations have been directed at reducing labour costs, and decreasing the need to interrupt supply in order to complete maintenance. The company saved at least £35,000 per year due to new sewerage pipe surveying technology for residential properties (portable cameras). Data-capture technology for road drainage inspections has increased on-site productivity by and estimated 300 – 400% due to increased speed of data capture and real-time transfer to head office for analysis. Sonar technology for the surveying of water-filled pipes, which removes the need to empty pipes before survey undertaken. The company is now charging 50% more to users of the new sonar technology as compared to previous technologies.
C2*	**Sewerage services:** Innovation has been directed at the development of longer-lasting linings for sewerage pipes which in-turn reduces maintenance costs and disruptions to customers.
C3	**Customer service:** Innovations have been directed at reducing supply interruptions and mitigating the chance of water discoloration due to mains refurbishment and maintenance. These are: Mains freezing technology for fire service hydrant renewal programme, under pressure connections; line stopping to temporarily isolate live mains; ultra-sonic camera leakage for internal inspection of live mains.
C4	**Customer service:** Innovation has been directed at reducing the response time for water mains repair. The innovation example provided by the company was the development of a multi-purpose van. This facilitates a reduction in the number of vehicles that need to be sent to a mains replacement site by a third and educes the number of days that excavations need to be kept open.
C5	**Sewerage services:** Innovation has been focused on delivering a more integrated sewerage service to the water companies by co-ordinating the different parts such that a single point of contact, and project management, is provided to the water company (this was reported by C5, but it is not an innovation)
C6	**Drinking water quality:** Innovation has been directed at the removal of chlorination and disinfection of pipes when re-sealing is undertaken. This decreases water discoloration, and thereby customer complaints, and reduces the quantity of water used for flushing pipes which in-turn reduces the external impacts on the environment (i.e. nitrates and phosphate loads).

7 Competition upstream and in retail services

Competition should provide incentives for companies in the market (incumbents) to seek the "best" ways of providing services. Competition is regarded as a stronger system for creating incentives for the better supply of services because there is always the "threat" of new entrants, and because consumers of the good can switch between suppliers. These two forces encourage incumbents to minimise their costs and to provide high quality services such that (a) economic rents are maintained (or normal economic profit where price equals long-run average costs) and (b) that consumers who pay for the service, choose to purchase from the "best" supplier given the value the consumer places on the good or service.

If we consider the force exerted by the potential of losing a consumer (i.e. consumer switching), water is not like many other goods. Water is to a large extent a "credence good" which essentially means that even through consuming the good the consumer cannot determine different qualities of the good (beyond a number of basic attributes i.e. suspended solids making the water dirty, and some taste attributes).[40] Sewerage is also a credence good; the consumer wants the sewerage to be removed and treated, they cannot easily determine who removes it optimally. Therefore, consumers can mainly differentiate between water and sewerage suppliers by quality of service i.e. how easy it is to pay bills, or what level of customer service is provided at, say, call centres.

Introducing competition at the consumer/retail end of water supply including the ability to switch suppliers of water, will encourage firms to seek out better ways of providing the service by reducing price and/or improving quality of service (if not the quality of the good itself due its credence characteristics). The companies will do this in the best way for them. This may include seeking new solutions either through internal innovations or adopting innovations from others either in the water sector or in other sectors. In other words companies will make investments to ensure that they minimise their costs and will try to differentiate their product through better service delivery mechanisms.

[40] Other goods such search and experience goods – where the consumer can either find out about the quality of the service/good through research (i.e. through consumer publications), or by actually consuming the good they can learn the quality of the good, then competition between companies and the choice for consumers to switch suppliers, places competitive pressures on the incumbents to ensure they provide the best quality good.

One issue considered in Australia, where retail competition has also been investigated, is the use of scarcity pricing. Scarcity pricing signals to consumers the true value of the water they are consuming and can provide information to suppliers about whether consumers are willing to pay higher prices for water, and whether to invest in additional (potentially more expensive sources of water). As such the price of water can change depending on the cost of depletion (the cost associated with consuming the water now such that it cannot be consumed in the future). This means that as storage levels fall, during dry periods, the price of water will increase to reflect the increased (opportunity) cost of consuming today, as compared to in the future, and the increasing cost of augmenting future supply. Conversely, during wetter periods, the price of water will fall (because opportunity cost of current consumption falls and costs of augmenting future supply falls too).

In order to use scarcity pricing, consumers' water use needs to be metered (as opposed to based on value of the property), and abstraction licences need to also reflect the scarcity of the resource across time. Temporal and location based abstraction licences that reflect scarcity are discussed in Chapter 8.

Further, water pricing can be combined with environmental externality pricing, which reflects the external impacts of abstraction and discharge. Chapter 8 also discusses temporal and location based discharge and abstraction licences that reflect the magnitude of external environmental impacts.

Competition upstream, if it can encourage new entrants, should create the incentives for incumbents to also do their best here. The difficulty here is that it is not actual market competition, but rather the regulator is creating market-like incentives. This will open up the possibility of gaming due to the asymmetric information problem between the regulator and the companies. As the Cave Review states, this was a problem discovered by the Office of Electricity Regulation

> *The Office found that ensuring compliance was problematic to monitor and enforce because vertically integrated suppliers had the incentive and ability to use price discrimination and other tactics to secure higher revenues and discourage competitors and there was limited regulatory ability to detect and prevent such activity. As such, such an obligation is only likely to deter the most egregious examples of inefficiency.*

Therefore how these market-like incentives are created is very important and learning from incentive design literature, such as the principal agent model of regulation could help here (Laffont and Martimort, 2002). It may also be desirable to road test[41] the incentive designs to help identify the possibility of

[41] Road testing allows governments to ex-ante test and observe the operation of new policy and incentive

gaming and what features of the market-like incentives minimise the ability of companies to game (see section 8.4).

Competition cannot on its own encourage improved environmental outcomes. Competition can only encourage water companies to minimise the environmental impacts of their decisions if (a) it benefits them (i.e. there is a private benefit of reducing negative external impacts), or (b) companies can signal to consumers that they (the company) are environmentally responsible and if the consumer can choose to change suppliers if the consumer wants a "more" environmentally responsible supplier (such as through labelling schemes which are used for cars, food and white goods for example).

The basic principles of economics are that firms will equate their private marginal cost to their private marginal benefit (which is the reward/price they receive for their services), and in the case of externalities such as environmental impacts, the social marginal cost of firms' decisions is higher than the private marginal cost. Therefore regulation is introduced to shift the private marginal cost to the social marginal cost thereby internalising the externality. Competition should therefore be complemented with well designed environmental policy which efficiently internalises the environmental externality. Examples of innovative environmental policies which are used abroad are provided in section 8.1.

Competition should encourage better ways of doing things by incumbent companies due to the threat of new entrants, and or consumer switching. The design of the market-like incentives for upstream competition should, however, be considered carefully to avoid gaming of the market-like system.

Scarcity pricing may also want to be considered. Scarcity can take into account, across time and location, the change in the opportunity cost of current water consumption and the cost of augmenting future supply.

Competition alone will not encourage improved environmental and natural resource outcomes. Well designed environmental regulation, particularly those that price the external impacts of abstraction and discharge, could be considered.

designs before they are piloted in the field.

8 Barriers to innovation and recommendations

In this section we consider the barriers to innovation and how regulation can be modified to promote innovation in the sector.

From our survey of water companies, the regulatory barriers to innovation in the water industry appear to be in three main areas:

- Regulatory co-ordination and common agency
- Risk and flexible incentives
- Return on investment

We discuss each of these in turn.

New methods for testing policy interventions could also benefit the water sector. We provide a discussion of road-testing policy at the end of this chapter.

8.1 Regulatory co-ordination and common agency

In the water industry, the main regulator (Ofwat) creates market-like signals via comparative efficiency measures and price reviews. These signals on their own create incentives to improve efficiency in order to reduce costs and thereby the price of water to the final user.

- Ofwat is playing the role of the market, which is correct in the absence of market forces (i.e. the market failure of natural monopoly).
- The Environment Agency provides signals on externalities (such as emissions to water bodies and air sheds), and
- DWI signals on the required minimum standards for drinking water quality.

Therefore, in the water sector there are three regulators each introducing incentives into the sector such that firms allocate resources to achieve the different objectives.

When regulators play the role of markets, in conjunction with the role of mitigating externalities and ensuring minimum standards of safety, coordination can be reduced, and from our survey of water companies and

contractors this appears to be the case in England and Wales. The responses provide by water companies include the following:

- *There is lack of joined up direction in public policy clarity. For example, climate change targets and the use of carbon pricing in business decision making (Environment Agency) is not aligned with the drive to treat water to a higher standard (Drinking Water Inspectorate).*

- *Seeking renewable energy solutions to meet environmental objectives and the costs associated with these activities are not taken into account in the economic regulation.*

- *Water conservation and economic assessments are providing conflicting incentives in some areas. For example, there exist new metering technologies that can allow the consumer to monitor their water use more effectively. These technologies are, however, more costly to install than the existing metering technology. If companies elect to invest in the new technology they can only include the cost of the old technology in their economic reporting.*

This problem is not new, nor is it only water sector regulation which suffers from this co-ordination problem.[42] The problem is known as common agency; where the agent (in this case the water companies) have multiple principals (Ofwat, EA and DWI). In this situation each principal tries to influence the behaviour of the agents. The agents therefore face multiple separate signals and incentives, each one designed to align the agents' preferences with those of the specific principal.

The impact of multiple separate signals is the following:

Multiple principals with different objectives (economic, environmental and safety) might counter each others' incentive scheme by encouraging effort in those activities that matter to the individual principal while the risk averse agents underperform on other tasks.

There is some evidence of this asymmetric effort level across different regulatory targets in England and Wales. Namely, in our interviews of water and sewerage companies all reported the economic performance measures as

[42] Although the co-ordination problem in water is larger compared to other industries because of the nature of the good. Namely, in water, regulators must create market-like signals (because of the natural monopoly market failure) plus environmental externality incentives for both water impacts and air quality impacts (carbon) and minimum safety standards for drinking water (because of the credence nature of the good and the irreversibility of unfit drinking water). In other sectors the regulators need only manage the environmental externality and minimum safety standards (i.e. car markets). Or, in electricity and gas, the regulator creates market-like signals to manage natural monopoly features and environmental externalities but not minimum standards of safety for the good itself (except in terms of how the good is delivered such as safety switches for example).

a main driver of innovation in the company; fewer indentified environmental objectives as a driver (see Chapter 5).[43]

Regulatory economists have known about this problem for a significant length of time and have written extensively in the literature[44]. Further, incentive design economists recognise the problem and refer to it as the principal agent problem and the multi-task incentive problem (see for example, Laffont and Martimort (2002), Tirole (2001), and Dixit (1996)).

Using regulation to mimic markets is not an easy task, and becomes even more complicated when there are trade-offs between regulatory objectives. Improved efficiency and improved environmental and natural resource outcomes can involve trade-offs, and these trade-offs need to be understood and co-ordinated across the regulators.

Therefore one route to consider is how the regulatory targets set by Ofwat, the Environment Agency and the DWI operate together and isolate where the signals created by the regulations are conflicting and why. In addition it is necessary to explicitly recognise what the trade-offs are between the different regulatory objectives. These actions will facilitate an alignment of targets across the regulators, and then improved coordination in the signals given to the water companies. This co-ordination will need be long-term and adaptive, and therefore the institutional design across the regulators should be considered as well.

Different ways to promote regulatory coordination include:

- All regulation that impacts upon the water sector is co-ordinated and managed by one principal. It is unlikely that such an approach would be recommended due to the high cost of creating such a principal/regulator. However, the creation of one principal that designs and manages all incentives for water would internalise the trade-offs between the regulatory objectives (economic, environmental and health related) inside the one department/organisation and therefore co-ordination of incentives and objectives could potentially be improved.

- The reward and penalty scheme for each target is interrelated such that reward (or penalty) in one target is dependant on performance in other targets. This perhaps is more feasible, but it would require an

[43] This does not mean that water and sewerage companies do not strive to meet their environmental targets, and in fact a number provided examples of investments they are making to improve their carbon footprint, for example the carbon impact of the company vehicles. But, all companies identified the economic targets as a main driver of innovation.

[44] For example, Armstrong, Cowen and Vickers (1994) in their reference book *Regulatory Reform Economic Analysis and British Experience*.

investigation of the incentive design features. One interesting design is the following proposed by Sinclair-Desgagne and published by the Canadian research organisation CIRANO. [45] We present this design as an example, though we do not propose it as the answer, rather as an example of what incentive design can do to help regulators co-ordinate incentives across multiple objectives which involve trade-offs.

The Sinclair-Desgagne model of contingent monitoring[46]: Consider two principals/regulators, Regulator 1 (R1) and Regulator 2 (R2). R1 sets objective A and R2 sets objective B, both of which the company must meet. R1 monitors the company's performance against objective A and rewards the company for performance against this objective. R2 monitors performance against objective B, and rewards the company for performance against B *only* if the company's performance against A meets a pre-specified level. Therefore, reward for objective B varies according to the company's performance against objective A. The contingent monitoring and reward system makes the amount of effort expended by the company on objective A and B complementary as opposed to substitutes.

In order to design such a contingent monitoring and reward system, government will need to understand to what extent effort spent on objective A is a trade-off (substitute) as compared to objective B, such that the contingent rewards can be set so that they are achievable. For example, there is no point tightening cost objectives while increasing the renewable energy objective without understanding how costs may increase as renewable energy is adopted otherwise the contingent monitoring and reward will simply break down.

It should be noted that the co-ordination/common agency problem can also be reduced by using some of the new environmental and natural resource management policy designs, particularly those that use tradable property rights/licences for discharge and abstraction.[47] This is because by using property rights, which account for the location and timing of abstraction and discharge, the scarcity of water quantity and the impact on water quality is reflected in the price of the licence.[48] The companies' internalise the environmental externalities

[45] http://www.cirano.qc.ca/bref.php?lang=en

[46] CIRANO, Montreal, 2001.

[47] Of course it is also possible to use taxes or command and control approaches, but these approaches do not limit the total damage from abstraction or discharge nor do they

[48] It is not necessary to trade to realise benefits of the property rights. The property rights can be held in perpetuity and the ability for companies to exercise the rights changes across time (see example from the Murray River below).

into their economic decision making. This means regulators do not have play such a hands-on role and therefore the number of co-ordinations across regulators can be reduced. Some of these new environmental policy designs which have been used abroad are discussed below.[49]

Recommendations:

Consider the trade-offs between regulatory objectives: It is not possible to improve economic efficiency and environmental impacts and drinking water quality all at the same time. Mitigating environmental impacts will most likely require an increase in costs to companies. Therefore regulators need to explicitly recognise these trade-offs and build them into the reward and penalty structure.

This can be done by;

Improving co-ordination across regulators, such as contingent monitoring and reward where companies are only rewarded for outperformance in the economic objectives if they have also met their standards for environmental impacts and drinking water quality. Likewise, companies are not penalised for failing to meet their economic performance if they have over performed in their environmental targets.

Using the new environmental policies – further discussed in the next section - which create tradable property rights/licences for environmental impacts such as abstraction and discharges can reduce the co-ordination problem, because the property rights define the rights and responsibilities, and the trade determines the price for abstraction and emissions. In this instance the regulator need only make the rules for the market, such as the definition of the property right and how, where and when they can be traded. This reduces the number of regulatory co-ordinations.

8.2 Flexible environmental and natural resource incentives

Innovation is inherently risky and many innovation investments may not come to fruition. From our interviews the water sector in England and Wales appears to be risk averse. The water companies are focused on meeting targets – economic, environmental and drinking water quality – and this

[49] We present the examples of flexible environmental incentives used abroad as areas in which the UK may gain insights about what is possible and the investments required to use such incentives. We do not propose that any of the examples are simply adopted in the UK because the water resource in the UK differs from other countries. For example, in Australia the water systems are "managed" which means they are dammed and the storage and release of water can be managed by the river manager.

encourages them to find historical solutions which have been tried and tested. Some flexibility in targets could encourage the trying out and implementation of new solutions.

Further, licences for abstraction and discharge could be designed to account for differences in river flows across time and the impact on environmental values and resources across geographic location. The flexibility in licences can be linked to flexibility in targets.

Examples of such flexibility, in both targets and licences, are in the field in other countries. One such country is Australia, where the design and implementation of innovative property rights for abstraction and discharge, and in-river targets (Caps), has been underway for the last decade. We provide operating examples of such incentives below.

By ensuring licences to abstract and discharge are linked to both private value (the value the company places on the licence) and the impact on the environment (the externality), it is possible to internalise the environmental impacts in the optimising private decisions of the company (the economic objectives that companies maximise).

The optimal social outcome, where the environmental externalities are internalised in the private decision making, will most likely be at a higher economic cost to companies as compared to the optimal outcome when only economic performance is included (where private marginal benefit equals private marginal cost but marginal private cost is less than the marginal social cost). However, the overall outcome for society will be improved when the social marginal cost is equal to the private marginal cost of a decision, because companies will take account of the environmental externalities in their private decision making.

Using flexible licensing schemes combined with the opportunity to trade licences, while accounting for the environmental impacts of any trades, is likely to be of lower cost to both companies and society as compared to the more prescriptive approaches such as command and control.

8.2.1 Examples of flexible environmental incentives

We present three ways to incorporate flexibility into the environmental regulation, using both flexible Caps and flexibility in abstraction and discharge licences.

Temporal based regulation for discharge to water bodies which allows flexibility across time

The Hunter River Salinity Trading Scheme, New South Wales, Australia, is an example of an operating policy which accounts for temporal flows in the river to which treated wastewater is discharged. The scheme introduces temporal

based discharge licences. This allows companies to discharge more during high flow periods but they must reduce or stop discharge during lower flow periods.

The scheme allows companies to trade their licences. Trading has been introduced to facilitate the transfer of discharge licences to their highest value user. However, the benefits of temporal caps and temporal discharge licences can still be captured even without trade. Without trade, the benefits include lower costs to companies who discharge because they do not have to meet high level standards when in fact the receiving water body does not need such high standards because dilution is high (due to high flow meaning the external impact of discharge is low). Conversely, when the receiving water requires higher discharge standards (because dilution is low) then these higher standards are introduced.

These flexible schemes require good monitoring and modelling of river flows. As the Cave Review has suggested, there should be additional work undertaken to develop an evidence base and technology for dynamic discharge. Insights for such an evidence base and technologies could be gained from the Hunter River Scheme.

The box below provides a summary of the scheme, and estimates of the benefits derived from the scheme as compared to the previous situation where discharge licences could not be traded and do not account for temporal differences in flow.

The Hunter River Salinity Scheme is a tradable discharge permit scheme for water quality objectives. It engages point source emitters of wastewater containing salt, but the principles also apply to phosphorous, nitrogen and suspended solids. In other words, any water emissions that have non-standard impacts (i.e. location and timing of emission matters)

The policy is managed by the Environmental Protection Agency and the NSW Government. The scheme engages industrial sources of pollution, e.g. electricity generators. These sources produce dicsharges as a by product of their processes. The sources are point sources, and therefore they can be relatively easily monitored (as compared to non-point sources). The sources can also store their emissions on site for short periods of time, and can manually elect when to discharge to the river.

There are three water quality targets, or Caps, located at different points in the river system. These quality targets cannot be exceeded. But, they are set at different levels depending on how close they are to drinking water sources or other high values assets (such a wetlands).

The river quality is monitored in real time using an integrated telemetry system, which measures the flow of the river within each 24 hour period. The river flow is modelled based on a 'river block'. A river block is the quantity of water that flows past a defined monitoring point within a 24 hour period, such that there are 365 blocks in a year. This means, the regulator can announce low flow, high flow and flood flow river blocks. This real time monitoring and the modelled river blocks are the backbone of this policy.

In order to meet the water quality targets, without reducing production, and thereby economic growth in the region, the environmental regulators allocated property rights or discharge licenses/permits. There are 1000 discharge permits available in total and each permit allows

the holder to discharge 0.1% of the total allowable discharge. These permits are temporal; they define the quantity of saline water that can be discharged given the real time flow conditions in the river. In low flow river blocks, no discharge is allowed. In high flow blocks sources can use their discharge permits to emit. In flood flow blocks, discharge is unlimited.

Licence holders can trade, buy or sell licences if they find their need to release saline waste water means they need more or less licences. The EPA has procedures for trading licences and a licence transfer is not valid unless approved by the EPA. http://www.environment.nsw.gov.au/licensing/hrsts/index.htm

In the 15 years prior to introduction of the trading scheme the salinity concentration in river exceeded the water quality standard 35% of the time. Since introduction of the scheme, salinity has exceeded the target 4% of the time, and average salinity levels in the river have decreased by 20%. Further, new developments have occurred in the region which most likely would not have been possible without a flexible economic incentive.[50]

Location based regulation that account for the non-standard impacts of abstraction

Abstraction reduces water flow in rivers and impacts upon underground aquifers leading to negative externalities such as increased concentration of pollutants in rivers and rising groundwaters, which bring, for example, salts to the surface leading to a reduction in the productivity of land.

This problem is pervasive in the Murray River in Australia. The Murray River is used by irrigators (point source abstractors) who have licences/permits to extract water from the river depending on river flow. Namely, the flow in the river is monitored and the amount of water the company is allowed to abstract (which is defined as the percentage of their licence they can exercise) is adjusted to account for changes in flow. Temporal abstraction licences were introduced to ensure that the river flow does not drop below a minimum standard, or cap, set at the end of the river system where a large city draws it drinking water. There is also work underway to introduce within river caps (as opposed to end of river caps) to ensure flows upstream are at a minimum standard to protect aquatic biodiversity and RAMSAR wetlands.

Abstractors can trade their licences, and this has lead to a situation where water abstraction licences that were held but not exercised (called sleeper licences), or those that were exercised but for low value use, have been traded to companies that have a higher value for the licence.

Trade in water abstraction licences can also account for location impacts. Namely, in regions where there are high value assets, the proportion of an abstraction licence that can be exercised is reduced. Conversely, in these sensitive areas it is necessary to hold more licences for every megalitre abstracted as compared to areas where the risk of damage is lower.

[50] The Australian Prime Minister's Science, Engineering and Innovation Council, 31 May 2002, "Australian Industry's Sustainable Competitiveness".

As mentioned above, it is not necessary to trade to account for either the temporal impact or the location specific impacts. The licences can be held in perpetuity and the flexibility in how much of the licence can be exercised and when it can be exercised will introduce benefits, but without trade the licence may not be held by the highest value user.

Temporal and location based abstraction licences help to ensure that the river flow is never "too" low for the multiple functions that the river undertakes.

A new feature of this water abstraction scheme is the introduction of the Commonwealth Water Holder. The government will buy water abstraction licences from holders. This will reduce the total amount of water abstracted from the system. The government will then use the abstraction licences to increase environmental flows in the river. The purchase of abstraction licences by government could also account for the geographic impact of abstraction by paying a higher price for licences removed (bought) from areas which are more sensitive to low flows.[51]

Again such a system requires good hydrological modelling of the river system including the aquifers, and good monitoring. While the Australian system may differ from that in the England and Wales, because a large number of water users in Australia are irrigated, the insights can still be transferred to England and Wales. As the Cave Review suggests, abstraction licences should be tradable, which will help to ensure that the licences are allocated to users with the highest value for the licence, the inclusion of temporal and location attributes in how the licences can be exercised will internalise the environmental externality.

Engaging other economic players in the management of water quantity and quality can also bring new solutions and innovations.

It is often more costly to upgrade a water treatment facility or to invest in new drainage systems as compared to engaging other economic players such as farmers and households in the management of water and emission flows in a water catchment.

There are a number of international examples that engage multiple players. Two examples, one from Australia which engages households in the management of storm-water, and one from the United States where farmers are included in reducing emissions to a water body are discussed.

Little Stringybark Creek Stormwater Management Auction, Victoria Australia is a competitive tender that engages individual households (diffuse sources) to manage storm-water impacts on the urban environment. 800 households

[51] http://www.environment.gov.au/water/environmental/cewh/index.html

are currently participating in the scheme. Regional sewerage undertakers and local councils are also participating.

The scheme is a collaboration between Melbourne Water Corporation, Yarra Valley Water (both water companies) the University of Melbourne and Monash University. A competitive tender, or auction, is used to encourage individual households in the Port Phillip Catchment (near the city of Melbourne) to adopt rainwater tanks and rain-gardens. These activities reduce the surface and sub-surface flow of storm-water in urban areas, and therefore can reduce the risk of floods, and decrease the nitrogen and phosphorous loads entering rivers and ultimately Port Phillip Bay where there is a legislated nitrogen and phosphorous target (or CAP).

The use of an auction mitigates the risk of governments overpaying for these investments, which can be the case with a centrally determined subsidy scheme because of the asymmetric information problem. Namely, the government does not know the private opportunity cost of implementing storm-water reduction measures across different households. An auction system can overcome this asymmetric information problem, while the competitive nature of the auction minimises the opportunity for households to game the system (ask for a very high price).

The auction is combined with an environmental benefits index, which takes account of the non-standard impacts of storm-water management. For example, if a household is located near a water body, then the environmental impact of additional storm-water may be greater (in term of increasing nitrogen or phosphorous loads) as compared to a household that is located further from a water body. Households located in flood risk zones can have greater impact on the risk of flood as compared to those located in drier areas. The environmental benefits index accounts for these non standard impacts using environmental modelling. Households can estimate their environmental benefit (using the following web based tool http://www.urbanstreams.unimelb.edu.au/) and can determine how to increase their environmental benefit score through on site actions.

The price offered by households is combined with the households' individual environmental benefit score such that government subsidies are paid on a price per unit of environmental benefit generated. The scheme increases household knowledge about the impacts from their own property on the wider environment, how individual households can mitigate their (own) impacts and how this translates to aggregate benefits for the catchment as whole.

Household actions are lower cost as compared to more costly storm-water investment by local councils, and sewerage treatment upgrades by sewerage undertakers.

The engagement of individual households provides an additional supply of storm-water mitigation, and therefore increases the aggregate reduction in negative environmental impacts.

The Cherry Creek reservoir watershed trading programme, Colorado USA, is point to non-point source trading programmes for phosphorous. In the watershed urban growth is placing increased pressure on sewerage treatment facilities, and increasing phosphorous loads to receiving water bodies in the region. In an attempt to reduce the cost of upgrading treatment plants, the trading scheme allows point source facilities to buy water quality improvements from diffuse sources, such as landholders and local government agencies, which can undertake approved phosphorous management actions at lower cost as compared to upgrading treatment facilities.

Because there is greater uncertainty, and lower ability to monitor diffuse source reductions, there is a minimum trading ratio, or exchange rate, of between 1.3:1 to 3:1 between diffuse source reductions and point-source demand e.g. every 3 pounds of phosphorous reduced by diffuse sources generates only 1 pound that can be bought by the point-sources.

There is extensive modelling of the river system in order to understand the non-standard impacts, geographical differences, of diffuse source phosphorus management, such that changes in phosphorous loads can be estimated depending on the location of different diffuse sources in the catchment. (www.cherrycreekbasin.org).

The requirement to calculate the trading ratio on a project by project basis is costly. By 2006 there had only been two trades which accounted for 115 pounds or 52.2 kilograms of phosphorous. However this was most likely driven by low cost abatement technology available to point-sources which meant that there was no need to trade. As opportunities for retro-fitting treatment works become more limited and as growth increases in the region, more trading between point and diffuse or non-point sources is likely to increase.

These flexible incentive designs require robust hydrological modelling and landscape modelling, good real time monitoring combined with economic design to create the incentives. Investments made in other countries, such as Australia, could provide insights on how such incentives could be used in the UK.

Recommendation: Consider investigating more flexible approaches to environmental and natural resource regulation. Looking to examples particularly in Australia could help develop such incentives in England and Wales. Using innovative policy to integrate the external impacts of water use into the economic decisions made by water companies, can efficiently account

for these external impacts. Further, it can reduce the co-ordination problem across regulators (as discussed in the previous section).

In order to use these new policies it is necessary to model the catchments and (often) monitor them in real time to account for changes in flow. This has been done in the Murray River and the Hunter River in Australia. Furthermore, the Australian "e-water" co-operative investment scheme (discussed below) is investing in these tools to support integrated water management.

England and Wales should look to see how science is supporting policy design for environmental outcomes in other countries, and consider how they can be used here.

8.3 Return on investment

As stated in the Cave Review, under the current regulatory framework companies can retain the benefits of outperformance for five years. This may dampen the incentive to innovate because only a portion of the net present value can be captured by the investing firm.

In competitive markets, economic profits are accrued by leading firms until competitors catch-up at which point normal economic profits are then restored.

The difference between these two set-ups may lie in the fact that in competitive markets there are property rights, such as patents and trade marks, which protect knowledge and allow the owner to accrue above normal returns for the life of the property right.[52] Firms can also protect new processes and inventions by keeping them secret. Secrecy is not possible in water because companies can easily observe what others are doing and new investments and innovations are public knowledge because they are published in the companies' business plans and June Returns. Regulation aims to increase the transparency between companies and therefore private incentives for innovation are reduced.

We agree with Ofwat[53] that the government does not want to pick winners. Allowing economic rents for greater than five years on projects that are considered break-through innovations can lead to this situation. This is because the process will change the opportunity cost of investments which

[52] This is not to say that patents remove the risk associated with innovation. The investor still faces uncertainty about the future state of the world.

[53] Ofwat response to the independent review of competition and innovation in water markets, January 2009.

are considered "innovation" as compared to all other investments. This means a rational company will put more effort into "innovation" investments at the expense of other (perhaps more efficient) investments. The policy may create a situation where companies over-invest in innovation and the performance of the sector is in fact reduced. Further, the policy is essentially a subsidy for innovation (because it changes the opportunity cost relative to other investments), and the regulator is centrally determining which activities should get this subsidy. It is well known that due to the asymmetric information problem between central government and private firms that governments can misallocate the subsidies.[54]

We therefore suggest the return on investment issue deserves in-depth consideration. Some issues that could be considered include the following:

- How can collaborative research efforts fill this role (such as UKWIR and/or the Technology Strategy Board[55])? Because innovations in water can flow quickly between firms (as discussed previously), the incentive to innovate is reduced. Therefore investment should be made at the level of the market failure. In other words the level at which (or extent to which) the public good benefits are realised, and this is at the water industry and society's level. Which implies funding should come from the industry and from central government. For example, new methods of sealing pipes so that chlorination is removed or reduced is a benefit that accrues to the water sector[56] and to society[57], not the electricity, gas or telecommunications sector. Improved integrated water management tools including modelling and monitoring of water quality accrue to the water sector and society. Other research such as carbon reductions and renewable energy flow across industries, and to society, and therefore the public good market failure is at a cross-industry level and could be co-operatively funded as such. We provide a case study of an industry level cooperative investment organisation in Australia in the box below.

Co-operative schemes to manage the public good element of innovation investments

In order to encourage a higher level of investment in innovative technologies for integrated water management in Australia, the "e-Water" co-operative research centre was established in

[54] Akerlof (1970) and Rothschild and Stiglitz (1976), Laffont (1990).

[55] Ofwat's head of Regulation informed us that Ofwat is investigating with the Technology Strategy Board the possibility of a competitive tendering approach to R&D.

[56] Via reduced costs and increased productivity of pipe replacements and upgrades.

[57] Because the negative externalities of chlorine emissions to the surrounding environment are reduced, and because the quantity of water to flush the pipes is reduced thereby reducing demand for a scarce resource.

2005. e-Water is a technology development initiative with the objective to research, develop and build water management tools and bring the tools to market internationally.

e-Water is a co-operative investment between water industry organisations such as water companies, sewage undertakers and engineering firms; the public sector including local government, central government departments and environment agencies; and, research organisations such as the Bureau of Meteorology, universities and government funded industrial research institutes.

Commercial products and technologies supplied by e-Water to the international water industry include the following:

- *Tools for ecological management, including monitoring & assessment or restoration of freshwaters and floodplains;*
- *Tools for forecasting and managing catchment water yield and quality in variable and changing climates and land-uses;*
- *Tools for integrated management of urban water, including water security;*
- *Tools for managing and operating rural river systems and water supplies.*

These "next-generation" software tools link water management to land-use practices, at a range of scales - from small (down to lot-scale in urban areas) to very large.

e-Water also plays an active role in training the next generation of specialists in the areas of water-management, climate change, catchments and aquatic ecosystems. E-Water provides funding for postgraduate research at its partner universities, and water-industry-focused professional training to augment students' research development.

In December 2008, e-Water launched a commercial company called eWater Innovation Pty Ltd. The objective of this company is promote eWater's technologies and to provide product support and training to the wider water industry internationally. Further information on e-Water can be found at http://www.ewatercrc.com.au

- Ofwat's regulations do (already) encourage innovation in cost reduction. And, the development of more innovative menu regulation and the incentive multiplier (Ofwat Setting price limits for 2010-15), have the attributes of improved incentive design for truthful revelation of private costs by the companies. In this study we do not evaluate Ofwat's incentive design, but from our reading of the PR09/02 documents the idea behind the design should go some way to tackling the asymmetric information problem (between companies and regulator) and should improve incentive compatibility. Whether the outperformance incentives are at the "right" level or within the "right" range, and whether they should be symmetric, we cannot comment on in this report. A consideration of the costs of increased information burdens for more detailed out performance incentives relative to the benefits of increased detail should however be considered. Further, through iteration improvements could be made and the incentive scheme could be road tested using economic experiments to pre-test the comparative statistics of truthful cost revelation under different outperformance incentives (we discuss road testing of policy in section 8.4). Staged introduction is also a wise tool,

namely see how the menu regulation performs with capital and expenditure and consider extending it to operating expenditure in the future.

Recommendation: The return on investment issue should be considered further. It is not clear that allowing economic rents for greater than five years on projects that are considered break-through innovations is the best way forward.

Instead the role of co-operative research should be considered. In many cases the innovation public good is at the industry level (not cross-industry level), and at society's level, and therefore co-operative research should be funded by the water sector and government (carbon emissions is one exception as it is cross-industry and society).

The use of innovative incentives such as Ofwat's menu regulation should be trialled. A consideration of the costs of increased information burdens for more detailed out performance incentives relative to the benefits of increased detail should however be considered further.

8.4 Road testing tools for policy

As regulation in water becomes more sophisticated due to the interdependency of different targets and objectives (as discussed in 8.1). As incentive design knowledge improves leading to more sophisticated and incentive compatible regulations (such as Ofwat's economic regulation incentives). And, as new flexible incentives for environmental and natural resource management become available (section 8.2). Road testing policy can become a useful tool for policy designers.

Road testing allows governments to ex-ante test and observe the operation of new policy and incentive designs before they are piloted in the field. It also allows the comparison of policies to inform selection. Policy road testing efforts are being considered by other government agencies in the UK.[58] Road testing new (or adapted) policy is used in the United States and Australia before policies are piloted in the field.[59] The flexible environmental incentives presented in section 8.2.1, were road tested before field implementation. Road testing can expand the policy toolbox available to regulators because it allows policy designers to test out a policy before implementation, it therefore mitigates policy mistakes which can be costly and sometimes irreversible.

[58] Particularly in consumer remedies.

[59] For example, testing the design and performance of management contracts for nitrate and phosphate reductions from farmers, Cason et., al. 2004.

We provide a short discussion of the different methods available to governments to road test policy.

Road testing regulatory interventions

An important role for government is to intervene in the market system to mitigate market failures and consumer detriment. The difficulties for policy makers is to understand ex-ante which intervention is best at reducing the market failure or consumer detriment, how an intervention will impact upon companies' behaviour, and how interventions can be fine tuned in order to maximise their effectiveness.

Road testing interventions can help. Road testing is the trying-out of interventions before they are introduced into field. Two of the main ways road testing can help policy makers are:

- To **compare** how **different interventions** perform in relation to the objectives of the intervention. For example, if we wanted to compare menu regulation and outperformance incentives to the current system of penalties and rewards for capital expenditure, we could use a road testing method to observe the differences in outcomes between the two in terms of truthful revelation of companies' private costs.

- To **investigate** how **a given intervention** is expected to operate in relation to the objectives of the intervention. For example, if we want to see how abstraction licences with temporal and geographical elements may operate if used in the field then we could road test.

There are different methods available for road testing; many of which are commonly known and used, such as qualitative surveys, quantitative surveys and simulation models. One new method which is becoming available to policy makers is economic experiments.

The available main road testing methods are the following:

- **Qualitative methods** focus on understanding respondents' knowledge, attitudes, beliefs and fears. They inform the policy maker about how companies and consumers think they will behave in different circumstances/interventions and provide insights as to why they think they will behave in certain ways.

- **Economic experiments** focus on measuring how and how much consumer and firm behaviour changes under different circumstances/interventions. Experiments use either students or people drawn from the general population (or some sub-set of the population) to make decisions (or undertake tasks) under different circumstances/interventions. The experiment environment mimics the real world field and participants in the experiment make monetary gains

and losses depending on their decisions just as firms and consumers do in the real world. Economic experiments test how different interventions perform, or how specific design features of a given intervention perform, in relation to the objectives of the intervention. Economic experiments are conducted in a stylised environment, which is a benefit because it allows disentangling of different features of interventions. However, the policy maker needs to be careful how results are extrapolated outside the stylised environment. This is a method which is not used very much in the UK, but is used widely in the United States and Australia, to pre-test interventions and has helped Australia in particular to develop new environmental policy to manage water quantity and quality (most of the policy incentives presented in section 8.2.1 were road tested using experiments).

- **Numerical modelling and simulation** focus on simulating data using computer generated firms and consumers such that patterns in the simulated data can be used to deduce how different interventions, or features of interventions, may perform against the policy objectives. The difference between simulations and experiments is that in simulations it is necessary to create the firm and consumer using production and utility functions. Therefore it is necessary to make assumptions about how different agents will behave before testing. In experiments, humans make the decisions under the incentives and therefore bring their own behavioural beliefs and objectives to the task just as they do in the real world. Again simulation has been used historically to test interventions.

- **Quantitative surveys** focus on collecting information on firm and consumer characteristics, knowledge and experience such that statistical inference can be used to understand how they may behave under different circumstances. A certain set of quantitative surveys, called non-market valuation surveys, are used extensively in impact assessments particularly environmental. Non-market valuation methods do however suffer from a number of biases the main one being that consumers may over-report (under-report) the value they place on the change/difference in design depending on how the question is asked.[60]

[60] Practitioners that use non-market valuation methods have numerous ways to mitigate these problems. But the hypothetical bias, that the researcher is asking the respondent to respond to a situation that is not actually happening, remains a weakness and is one that economic experiments overcome. Although economic experiments have their own weaknesses and extrapolation from the experiment setting to the field must be carefully done (called external validity).

Recommendation: Consider the use of policy road testing to pre-test new incentive designs before piloting in the field. Observe how new methods for road testing, such as economic experiments, have been used abroad.

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Annex 1 R&D data

Companies were asked to provide R&D expenditures for the years 2002 to 2008. During the interviews, 5 companies (CDW, DVW, WSH, SST, THD) were unable to provide any data for R&D expenditure. We completed the data for 2 companies (WSH, THD) by using R&D expenditure data from the companies' annual reports.

We noted that for some companies there were significant differences between interview data and data collected through the annual submission reports (differences in columns 1 and 2 in Table 15). This could be because data in the annual report refer only to R&D expenditure accounted for under Operating Costs, while the company keep more accurate records (including also R&D expenditure for fixed assets or employment costs).

We decided to use the following process:

- Include data from the interviews (whenever possible) and
- Include data from reports only when data from interviews were missing (this was done for WSH and THD).

For YKY we decided to use data from the annual report instead of the disaggregated value from the interview. This is because YKY provided an aggregate value (£18.8m) for the period 2002-2008 whereas data from their annual report gives annual expenditures with figures of a comparable magnitude to the overall expenditure reported by YKY.

Table 15: Water companies R&D expenditure (2008)						
	R&D Expenditure (000)			R&D Expenditure as % of turnover		
Company code	**Interview[1]**	**Report[2]**	**LE Estimate[3]**	**Interview[1]**	**Report[2]**	**LE Estimate[4]**
ANH	2,083	500	2,083	0.02	0.05	0.21
BWH	50	.	50	0.30	.	0.11
BRL	80	100	80	0.09	0.11	0.09
CAM	85	.	85	0.43	.	0.41
CDW	.	.	.	.	.	.
DVW	.	.	.	.	.	.
WSH	.	500	500	.	0.08	0.08
FLK	75	6	75	0.50	0.03	0.42
NES	1,800	1,800	1,800	0.29	0.29	0.29
PRT	30	.	30	0.09	.	0.09
SVT	4,300	4,300	4,300	0.34	0.32	0.34
MSE	105	.	105	1	.	0.07
SST	.	.	.	.	.	.
SWT	420	200	420	0.10	0.05	0.10
SRN	130	1,300	130	0.05	0.21	0.02
SES	52	.	52	0.10	.	0.10
THD	.	6	6	.	0.04	0.04
TMS	5,080	4,100	5,080	.	0.27	0.34
TVN	650	351	650	0.33	0.16	0.29
NWT	1,000	1,000	1,000	0.10	0.07	0.07
WSX	2,600	200	2,600	0.70	0.05	0.66
YKY	3,133	4,400	4,400	0.60	0.55	0.55
Total	**21,558**	**18,763**	**23,331**	**--**	**--**	**--**
Average	**--**	**--**	**--**	**0.31**	**0.16**	**0.22**

Note: R&D figures refer to the last available year (2007/08) for nineteen of the twenty-two regulated water companies. * Estimated as (total expenditure for last 6 years)/6. Data estimated as midpoint of interval provided by ANH, CAM, FLK, MSE,

***Source:** [1] interviews. [2] water companies' 2008 Annual Reports and 2008 Regulatory Financial Statements. [3] LE best estimate: equals [1]; or equals [2] if value is missing; or equals [2] for YKY. [4] LE best estimate: (LE estimates R&D expenditure)/(total turnover from companies' annual reports).*

Annex 2 Summary of output measures

Table 16: Measure from DG2 to DG9 of the June Report (Table A)

Company	Innovations reported
TMS	There was little innovation across these measures. **DG4:** exception - new modelling systems developed in-house.
YKY	.
SVT	**DG3:** No innovation (weather had a major impact) Unable to identify any impact of innovation on the other measures.
WSX	.
ANH	**DG2–DG4:** Innovation occurring: The company developed control systems for regulating pressure and re-treated water to power stations and also developed system for modelling aquifer water levels to address the impact of abstraction. Innovation was developed in house. Impact on innovation can be seen on improved outcomes and is around 1-2% (the rest is due to investment) **DG6–DG9:** Innovation occurring: Internal communication programme to improve business-wide communication and customer service. The innovation was imported from other firms working in other sectors. Impact on innovation can be seen on maintained levels and is around 2-3% (the rest is due to investment)
NES	.
NWT	**DG2:** focus of innovation - water network modelling. **DG3:** focus of innovation - water network modelling.
TVN	**DG6-DG9:** Technology improvements in customer service area. General comment: indicators are not a good measure for innovation, it could be that some other event is going on and outweighs benefits from innovation.
WSH	.
SWT	**DG2:** only minor investments no innovation. **DG3:** major impact of investment in rehabilitation network, which has reduced unplanned interruption and also the development of relining material Overall that has led to a reduction in unplanned interruption and an improvement in pressure management. The mains rehabilitation programme had a component of innovation around 30% and a component of investment around 70%. **DG4:** impact of a new technology used to effectively detect leakage, which led to quicker and more efficient repairs. Overall the impact of innovation has been around 20-30%, while investment has accounted for the remaining part. **DG9 bis:** a new information system has been implemented ensuring that the right person will answer to customers' queries in short time, reducing the length and number of phone calls and providing a better service. Impact of innovation: 10%, the remaining 90% is attributable to investment.
SRN	**DG6–7:** Innovation within water industry - responding to customers is now all done offshore. This includes correspondence (standard replies) and updating customer account details. This may be a common practice in other industries, but within the water industry is innovative. No other details available
MSE	Most of innovation was carried out prior to 2002 – 2008 period therefore company has not felt the need to invest in further innovation in this area.
CAM	**DG3:** adoption of Geographical Information Systems, which identifies interruption to supply, has driven the observed improvement. **DG8:** Innovation has had a 50% contribution to its improvement. This innovation involved the installation of 35,000 new meters at a marginal cost of £50 for each unit, plus a fixed cost of £200,000 to build and operate the system giving a total cost of £ 1,9750,000
BRL	**DG9:** Innovation has impacted upon this company's customer service measures for DG9 - when customers call, they are now told how long they can expect to wait for a customer service consultant. This technique has been used in other service industries, and therefore is not innovation in a strict sense, but it is an example of a company adopting innovative solutions from other industries.
FLK	The company bought in existing technology.
SES	0

Table 16: Measure from DG2 to DG9 of the June Report (Table A)

Company	Innovations reported
BWH	**DG9:** improvement in the customer service measures have been achieved by investment in pre-existing technology. **DG4, DG6, DG7 and DG8:** maintenance of strong performance has been achieved through investment in pre-existing technology not innovation.
PRT	The company did not report any innovations that contributed to improvements in, or maintenance of, these performance measures. Incremental changes overtime have driven any observed improvements. Variations in the table are driven by small changes introduced gradually over time, rather than breakthrough innovation.
THD	0
CDW	.
DVW	.
SST	Innovation didn't have any impact upon these measures. (100% investments). However there was innovation in the area of customer service dealing with debt collection (profiling customers' payment behaviour).

Note: "0" denotes where company answered that innovation had no impact on the measures. "." denotes where company was unable to quantify impact.
Source: Interviews with water companies

Table 17: Additional measures from Table A of the June Report

Company	Innovations reported
TMS	Innovation occurred prior to 2002. Company is now reaping benefits of that innovation so no additional innovation is being pursued.
YKY	The company was unable to identify any innovation that had impacted upon these measures
SVT	The company was unable to identify any innovation that had impacted upon these measures
WSX	The company was unable to identify any innovation that had impacted upon these measures
ANH	**12**: Development of treatment system using phosphoric acid (reduces lead in water) has allowed the company to maintain water quality without having to replace lead pipes. The innovation was developed in-house and had an impact of 2% on the measure, with external factors accounting for 10% and investment for the remaining 88%.- - - - **13**: The company developed in-house a treatment to remove iron from water which has maintained water quality. Impact of innovation was 3%, external factors 10%, investments 87%.. **17-19:** No innovation occurring**.**
NES	The company was unable to identify any innovation that had impacted upon these measures
NWT	**13** Innovation played a major role: in-house modelling; mains replacement (new materials, new processes treatment, process control (for iron)-telemetry).
TVN	**12-13:** The major impact on these indicators is connected to investment. No new methods were introduced. **17-19** Improvements are related to studies being carried out, rather than innovative solutions being introduced
WSH	Innovation has had no impact on these measures.

Table 17: Additional measures from Table A of the June Report

Company	Innovations reported
SWT	**12:** Innovation has occurred in the supply chain (UV disinfection, granulated carbon) **13:** Mains rehabilitation programme had a major impact on this indicator, and the contribution of innovation is approximately 30%, with the remaining 70% ascribed to investment **17-19:** No impact of innovation on these measures (the impact of a de-stratification equipment scheme on reservoirs can be seen on quality related outputs, e.g. percentage of chemicals)
SRN	Innovation has had no impact on these measures.
MSE	Innovation in drinking water not reflected by these measures (number of complaints would be appropriate)
CAM	Innovation has had no impact on these measures.
BRL	Innovation (ice cleaning for water mains) has improved drinking water quality in specific water mains, but this is not captured in these measures.
FLK	**12-13:** introduced new membrane technology to treatment plants to reduce cryptosporidium. This was developed by Veolia R&D and had the effect of maintaining high quality levels of drinking water. Impact of innovation: 100%
SES	Innovation has had no impact on these measures.
BWH	The company was unable to identify any innovation that had impacted upon these measures
PRT	Innovation has had no impact on these measures.
THD	Innovation has had no impact on these measures.
CDW	Innovation has had no impact on these measures.
DVW	The company was unable to identify any innovation that had impacted upon these measures
SST	**12-13** Innovation has had no impact on these measures. **17-19** Partners in a programme to educate farmers regarding the use of nitrates. So far no results are available but the expectation is that there will be financial savings related to tackling pollution at source.

Source: Interviews with water companies

Table 18: Measures from Table B of the June Report (water and sewerage companies only)

Company	Innovations reported
TMS	This is a key area for innovation In 2002 – 2005 innovation has occurred within waste water treatment. Also R&D on trickling filters. Most innovative end of research concerns developing bio-fuels from waste products e.g. using sludge as a bio-fuel. Grey water recycling. Also external factors i.e. weather had a major effect on figures in this area.
YKY	The company was unable to identify any innovation that had impacted upon these measures
SVT	The company was unable to identify any innovation that had impacted upon these measures
WSX	The company was unable to identify any innovation that had impacted upon these measures

Table 18: Measures from Table B of the June Report (water and sewerage companies only)

Company	Innovations reported
ANH	**4-5:** Minimized increase in figures caused by adverse weather conditions. Surface water was leaking into sewers causing them to flood. Innovation in modeling critical assets (developed in-house) enabled swifter and more accurate detection of where problem was occurring so it could be fixed. Innovation had an impact of 1%, weather 30%, investment 69% **10-13**: Measures were maintained or improved thanks to innovation such as: modeling systems enhanced activated sludge, improved use of trickling filters, biological aerative filters, nutrient removal, biological phosphorus removal. Innovations were developed both in-house and bought from firms from other sectors. Innovations had an impact of 2%, external factors 20%, investment 78%.
NES	The company was unable to identify any innovation that had impacted upon these measures
NWT	**4-5:** Innovation had an impact on mitigating flooding. This may not be reflected in Ofwat indicators, but the company implemented it to reduce customer dissatisfaction. **10-11:** Innovation provides solutions that reduce costs (lower cost, lower risk, increase success).
WSH	**4**: sewer flooding / pollution reduction in 2007-2008 as a result of innovation: the 'hawkeye', a level sensing probe utilising phone technology to monitor sewer levels. This enabled the company to increase effectiveness in dealing with sewer overflows. System was brought in to WSH by partner Kelda.
SWT	**5:** Adoption of a statistical modeling tool (Clementine) to prevent flooding. The system would divide the whole pipeline system into cells and then identify and forecast which cells are in bigger danger of flooding **10-11**: More reliable techniques concerning UV disinfection and membrane technology solutions both in water and wastewater management **12:** Impact of the Clementine programme (overflooding modelling) **13**: Lime stabilisation technology to improve the quality of sludge, being able to recycle the sludge for agricultural use, treating virus and bacteria. The performance is due to innovation for 20% and investment for 80% The Clementine programme cost around £2m and had a notable impact on both indicators 5 and 12 (around 50%, with the other 50% attributable to investment)-
SRN	Impact on sewerage works performance: SRN developed new system of looking at sewerage works performance, focusing investment more on the risk matrix. In the short term this involved increased expenditure on proactive maintenance, however the money was spent more effectively. The long term savings are now becoming evident: in the past two years only 2 sewerage works have failed, compared with failures in double figures in the preceding years. This reduced failure rate has also had environmental benefits by reducing pollution. The innovation was developed in house and had an impact of 40% (external factors 10% and investment 50%)

Source: Interviews with water companies

Table 19: Innovation in renewable energy

Company	Projects implemented	Activity reported
TMS	YES	Bio-fuels
YKY	YES	Biogas; tested flow-based renewable energy devices, but not implemented
SVT	YES	Bio-fuels; wind turbines
WSX	YES	Use of sewage sludge to generate biogas
ANH	YES	Bio-gas Water and wind turbines; combined heat and power system
NES	YES	Series of projects on renewable energy
NWT	NO	
TVN	NO	Considered, but not implemented (wind power)
WSH	YES	Combined heat and power; hydro-power
SWT	YES	Hydro-energy including micro turbines
SRN	YES	Combined heat and power
MSE	NO	
CAM	NO	Considered, but not implemented
BRL	Tested	Tested, but not implemented on large scale (solar and wind power)
FLK	NO	
SES	NO	Use of existing innovations
BWH	Tested	Tested, but not implemented on large scale (water and wind power)
PRT	YES	Recycling materials from excavation
THD	NO	
CDW	NO	
DVW	YES	Solar power
SST	NO	Considered, but not implemented (wind turbines)

Source: Interviews with water companies

Table 20: Other relevant measures

Company	Indicators reported
TMS	General point: deciding upon a definition of innovation should be a joint process between the water companies and the regulators. This would ensure that everyone was reporting on the same thing.
YKY	Other measures of customer satisfaction. Reduction in Opex and Capex.
SVT	Opex,Nitrates – water treatment, Phosphorous removal, Carbon footprint, Arsenic removal
WSX	Opex, phosphoros removals, taste and odour requirements, network management

Table 20: Other relevant measures

Company	Indicators reported
ANH	Reduction in carbon footprint Opex/Capex benefits Amount of capital efficiencies achieved through innovation Pesticides treatment, pollutants detection.
NES	No other performance measures were mentioned.
NWT	Reduction in customer dissatisfaction.
TVN	Opex
WSH	No other performance measures were mentioned.
SWT	Leakage detection Opex, Capex,Customer service Number of quality obligation, i.e. compliance with the quality standards coming from the DWI and EA (e.g. pesticides and chemicals removal)
SRN	No other performance measures were mentioned.
MSE	Number of complaints per 1000 of population in relation to drinking water quality.
CAM	Opex, fewer customer complaints thanks to the introduction of a new metering system.
BRL	Opex, Capex, Water Quality, Financial Innovation, Customer service,
FLK	No other performance measures were mentioned.
SES	Leakage performance to be linked to targets and how much is spent.
BWH	Financing efficiency, customer satisfaction. In general the water industry has converged at a high performance level so it is difficult to differentiate between companies. Therefore the current measures may have outlived their usefulness for performance comparisons.
PRT	The company reported that there has been an improvement in the total leakage measure, thanks to the introduction of a blending water system to reduce the amount of nitrate.
THD	Opex
CDW	No other performance measures were mentioned
DVW	Leakage and pressure management
SST	No other performance measures were mentioned.

Source: Interviews with water companies

Annex 3 Reproduction of the innovation questionnaire

Innovation Questionnaire

Innovation in the water industry in England and Wales

London Economics has been commissioned by the Cave Review to undertake a study on innovation in the water industry in England and Wales. The objectives of the study are the following:

- Benchmark innovation amongst the water companies,
- Identify the key barriers and drivers of innovation within the industry,
- Provide recommendations to address the barriers and preserve the drivers of innovation in the water sector.

This questionnaire is used to collect both qualitative and quantitative information on innovation in water companies in order to address these issues. We would appreciate your help in completing this questionnaire.

The questionnaire will be completed over the phone with a representative from London Economics. However, we would appreciate it if you could please consider the questionnaire and collect any necessary information prior to the interview.

The interview will take approximately 1.5 hours to complete.

You may not be able to answer all questions, and some questions may not be relevant for your company. But we appreciate as much information as you can provide.

All information will be treated as confidential and will be used for informing Cave Review only.

We thank you for your time. If you have any queries please contact Dr Charlotte Duke, cduke@londecon.co.uk, ph. 020 7866 8193

General details

Name of Respondent(s): _____

Role within company: _____

Date of interview: _____

Name of interviewer:_____

Definition of innovation

For the purpose of this study innovation is defined as:

the creation, development and implementation of a new product, technology, service, tariff design or process of production with the aim of improving efficiency, effectiveness or competitive advantage. It includes new ways of acquiring or deploying inputs, such as financial resources. The change may be incremental or fundamental.

It should be noted that:

1) It deals with both products and processes.
2) It refers to the creation, development, implementation of a new product/process developed:
    a. In-house
    b. By other companies/sectors.
3) All products and processes have to be new or novel.
4) The aim has to be improving efficiency, effectiveness or increasing competitive advantage.

Innovation inputs

Where possible we would like to understand how innovation inputs have changed overtime in you company. You can refer to Cave review responses or June returns whenever appropriate.

Where appropriate, we would appreciate if you could report for the time period 2002 – 2008. Namely, 2002-03, 2003-04, 2004-05, 2005-06, 2006-07, 2007-08.

1. Please describe the innovation philosophy and environment in your company.

2. What is the main driver of innovation in your company? Prompt if necessary – what is the role of targets (financial, service and environmental)

3. How does your company encourage innovation in your contractor firms? For example, how do the contracts with these firms create incentives for innovation?

4. Who in your company can generate new ideas?

5. What process does a staff member go through to introduce a new idea?

6. Who determines (approves) if the new idea should be pursued?

7. Does your company have an R&D department?
    a. Yes (go to 7)
    b. No (go to 8)

8. Company has an R&D department:
    a. Where does the R&D department sit within your organisation? _____
    b. Describe its role _____
    c. Number of staff (full time equivalents) _____
    d. R&D expenditure (for the years 2002 – 2008) _____
    e. Ratio R&D expenditure/turnover (for the years 2002 - 2008) _____
    f. Benefits (leveraging of benefits) from the R&D investments:
        i. Do you have a measure/process for estimating the benefits from R&D? Yes/No
        ii. If your company does have measure could you provide this information for the years 2002 – 2008 _____

9. Company does not have an R&D department:
    a. How is R&D undertaken within your company?_____

b. How do you measure expenditure on R&D? _____

c. If your company does measure expenditure on R&D can you provide this expenditure for the years 2002 – 2008? _____

d. Ratio R&D expenditure/turnover (for the years 2002 - 2008) _____

e. Benefits (leveraging of benefits) from the R&D investments:

   i. Do you have a measure/process for estimating the benefits from R&D? Yes/No

   ii. If your company does have measure could you provide this information for the years 2002 – 2008 _____

10. Programmes/links does your company have with other centres or universities

    a. Number of collaborative R&D contracts for the years 2002 – 2008 _____

    b. Value of these contracts _____

    c. Topics/areas they include _____

Innovation outputs

Questions for innovation outputs are related to the June Returns that water companies submit to Ofwat. In order to compare across water companies the Key outputs and service delivery measures are used. Please consider the following reported measures that are taken from Table A and B of your company's June Returns for the years 2002 – 2008 (Note: for water only companies there are no Table B measures).

Further, while we present only a small number of the Key outputs and service delivery measures in order to decrease information burden on you, please tell us what other output measures you consider should be used to measure innovation in your company.

First we will discuss **measures DG2 to DG 9.**

Description	Units	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
SERVICE AND PERFORMANCE Table A							
DG2 Percentage of properties receiving low water pressure	%						
DG3 Overall performance score (the security of supply index)	nr						
DG4 % population - hosepipe restrictions	%						
DG4 % population - drought orders	%						
DG6 Percentage dealt with within 5 working days	%						
DG7 Percentage dealt with within 10 working days	%						
DG8 bills for metered customers - performance	%						
DG9 percentage of calls abandoned	%						
DG9 percentage of calls receiving the engaged tone	%						

For DG2 to DG 9 please provide the following estimates:

1. In which of the above measures has innovation had an impact? Namely, innovation may have improved the outcome or it may have helped to maintain the measure at the same level overtime.

For those in which you consider innovation has occurred, please provide the percentage driven by the following variables, and describe how the innovation has impacted upon the measure:

A. ___% external factors (weather, …)

B. ___% investment or upgraded equipment (not innovation)

C. ___% innovations (describe name of innovation or programme)

2. Total cost innovation initiative_____

3. The Innovation was (please tick)
   i. New innovations developed in-house ( )
   ii. Already-existing innovations adopted from other firms ( )
      - Water sector firms ( )
      - Firms from other sectors ( )

We will now discuss **Drinking Water Quality Outputs** which also appear in your company's Table A.

		Units	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
	DRINKING WATER QUALITY OUTPUTS Table A							
12	Percentage mean zonal compliance with drinking water regulations	%						
13	Percentage mean zonal compliance with PCV for iron at the tap	%						

1. For those in which you consider innovation has occurred, please provide the percentage driven by the following variables, and describe how the innovation has impacted upon the measure:

   a. ___% external factors (weather, …)

   b. ___% investment or upgraded equipment (not innovation)

   c. ___% innovations (describe name of innovation or programme)

2. Total cost innovation initiative_____

3. The Innovation was (please tick)
   i. New innovations developed in-house ( )

   ii. Already-existing innovations adopted from other firms ( )
      - Water sector firms ( )
      - Firms from other sectors ( )

We will now discuss **Environmental Water Outputs**, which again appear in your Company's Table A.

			2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
	ENVIRONMENTAL WATER OUTPUTS Table A							
17	Environmental impact - number of investigations	nr						
18	Environmental impact - number of options appraisals	nr						
19	Other environmental improvements	nr						

1. For those in which you consider innovation has occurred, please provide the percentage driven by the following variables, and describe how the innovation has impacted upon the measure:

   a. ___% external factors (weather, …)

   b. ___% investment or upgraded equipment (not innovation)

   c. ___% innovations (describe name of innovation or programme)

2. Total cost innovation initiative_____

3. The Innovation was (please tick)
   i. New innovations developed in-house ( )

   ii. Already-existing innovations adopted from other firms ( )
      - Water sector firms ( )
      - Firms from other sectors ( )

We will now discuss **Sewerage Services,** which appear in your company's Table B.

			2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
	Sewer Flooding – Internal Table B	**Units**						

4	Properties flooded in the year (overloaded sewers)	nr						
5	Properties flooded in the year (other causes)	nr						
	Quality and Environmental Compliance Table B							
10	% of total p.e. served by sewage treatment works in breach of WRA consent (LUT)	%						
11	% of total p.e. served by sewage treatment works in breach of UWWTD consent (LUT)	%						
12	Sewerage improvements: % of satisfactory intermittent discharges	%						
13	Percentage unsatisfactory sludge disposal	%						

1. For those in which you consider innovation has occurred, please provide the percentage driven by the following variables, and describe how the innovation has impacted upon the measure:

   B. ___% external factors (weather, …)

   C. ___% investment or upgraded equipment (not innovation)

   D. ___% innovations (describe name of innovation or programme)

2. Total cost innovation initiative_____

3. The Innovation was (please tick)
   i. New innovations developed in-house ( )

   ii. Already-existing innovations adopted from other firms ( )
      1. Water sector firms ( )
      2. Firms from other sectors ( )

Renewable Energy

Please describe any innovations that may have occurred in renewable energy:

Why have these innovations occurred?

How can we measure these innovations?

Other performance measures

What other performance measures from the June Returns should we include to measure innovation? Please tell us the name of the measure(s), and how innovation has impacted upon the measure(s).

Regulatory framework

Below we ask a number of questions on the regulatory environment and how this promotes or discourages innovation. Please answer those you can.

1. Is there sufficient public policy clarity and direction to provide certainty as to the direction in which to innovate (eg climate change)? If not, what could be changed?

2. How does Ofwat's current incentive system of comparative competition and price cap regulation encourage/discourage innovation in your company? (how does it affect inputs, outputs, the process of innovation)

3. How could Ofwat's current incentive system be changed to promote innovation further in your company?

   For example,
   - How would a change in the five-year time horizons for planning and capital budgeting facilitate innovation in your company? And, what change would you propose?
   - Opex/Capex incentives
   - Level of output monitoring
   - Detail of regulation
   - Service performance incentives
   - Other

4. How does the Environment Agency's command and control methods – environmental standards for abstraction and discharge – encourage or discourage innovation in your company? How could it be changed to promote innovation?

5. How could the Environment Agency's command and control regulation be changed to promote innovation.
    - How could more flexible incentive-based environmental regulation be used to promote innovation?

      For example,

      1. The ability for your company to negotiate contracts with different landholders (including farmers and developers) to 'offset' water quality impacts, and for these 'offsets' to be included in your company's environmental performance monitoring?
      2. The use of tradable permit systems between point-sources in a water catchment (i.e. permit trading between different sewage treatment plants)
      3. The use of auction systems to secure contracts for land management from diffuse sources of water pollution?
      4. More flexible interpretation of standards to be met

6. What role do you think a co-operative research organisation could play in helping the water sector to innovate in their activities?

Thank you for your time

Annex 4 Comments from questionnaire testing stage

The main comments provided during the questionnaire testing stage, and how the questionnaire was adapted by LE in light of the comments is provided in Table 21.

Table 21: Feedback and from testing stage and LE actions

Comment from water company	Action taken by LE
The questions for the regulatory incentives and barriers are interesting and good.	Some details have been removed from the questions to avoid being too prescriptive.
Input questions were too detailed, and in many cases impossible to answer.	Innovation input questions have been re-written and simplified.
The use of the June Returns and a limited number of performance measures was considered a useful way of measuring innovation outputs.	The number of output measures have been reduced in order to reduce the burden on the water companies.
Need to identify other performance measures where innovation may have occurred.	Incorporated on the final version of the questionnaire.
Need to add a question on innovation in renewable energy.	Incorporated on the final version of the questionnaire.
General appreciation for the use of an input/output approach	No action
Recognition that it is difficult to "get at" innovation, and that the questionnaire goes a long way to doing so.	No action

Note: summarises comments from Water UK, Defra, Yorkshire Water, Severn Trent and anonymous representatives from two water companies
Source: LE piloting exercise.

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