Water today, water tomorrow

A study on potential benefits of upstream markets in the water sector in England and Wales

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About this document

Ofwat considers that market mechanisms have the potential to help deliver sustainable water services. Climate change, population growth, greater concentration of population in the south east of England, more single occupancy households and higher consumer expectations mean that ensuring efficient use of water is more important now than ever before. Markets allocate scarce resources efficiently. Ofwat is therefore considering the extent to which it is appropriate to make greater use of market mechanisms in the water and waste water sectors, and how this might be achieved.

In December 2007 we published the first part of our review of competition in the water and sewerage industries[1]. It concentrated on the scope for greater competition at the retail level and recommended measures to improve the Water Supply Licensing regime. In May 2008 we published "Ofwat's review of competition in the water and sewerage industries: Part II"[2]. Part II recommended, among other things, the examination of new market models for upstream competition in water and sewerage in order to secure benefits for customers and for the environment.

In April 2008 the UK and Welsh Assembly Governments commissioned Professor Martin Cave to conduct an independent review of competition and innovation in the water markets in England and Wales. The Cave Review final report published on 22 April 2009[3] included some analysis of the benefits of upstream competition and made recommendations for some steps to remove barriers to upstream entry into the water and sewerage sectors, including unbundling new entrant licences to create upstream water and sewerage licences and the removal from legislation of the current access pricing rule (the so-called 'costs principle'). Cave recommended a step-by-step approach to market development.

In our published response to the Cave Review in June 2009 we said that we would continue to develop our views about the scope of 'first step' upstream market arrangements.

In doing this, we have been progressing two workstreams. The first workstream aimed to quantify as far as possible the benefits that upstream water markets could deliver for consumers and for the environment. This workstream did not consider the

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[1] "Market competition in the water and sewerage industries in England and Wales – Part one: Water Supply Licensing", Ofwat, December 2007 http://www.ofwat.gov.uk/competition/wsl/pap_con_mktcompwslpr1.pdf

[2] http://www.ofwat.gov.uk/competition/pap_con_reviewmrktcomp.pdf?download=Download

[3] http://www.defra.gov.uk/environment/quality/water/industry/cavereview/documents/cavereview-finalreport.pdf

costs involved in moving to upstream water markets but instead quantifies the 'size of the prize'. This document sets out the results of this workstream. We will build on this work and use it as we assess different possible upstream market arrangements and their associated costs.

The second workstream looks at possible 'first step' upstream market arrangements. This workstream is ongoing. We will be issuing a second publication in spring 2010 setting out our views on possible 'first step' upstream market arrangements. This work will refer back to the work completed under the first workstream, looking at the benefits from greater use of markets upstream.

Commenting on this paper

This study is not a consultation document. However, we would welcome comments on the study and we will consider whether to develop further our analytical work based on any comments we receive. Any comments should be sent by e-mail to Jon Ashley at the following address: jon.ashley@ofwat.gsi.gov.uk

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Section A: Context, purpose and overall approach

Context

1. The water sector is facing important challenges going forward including the impacts of climate change and population growth on water resources in England and Wales[4]. The future market and regulatory arrangements for the sector will need to enable the sector to respond to the uncertain and changing demands imposed by these challenges. Competition and market solutions are likely to drive improved efficiencies and the innovation required to meet the challenges of climate change, population growth, lifestyle changes, rising consumer expectations, new environmental standards and the difficult economic environment. The flexibility that competition and markets provide will be particularly important as the impact of these challenges on the water sector and the best ways to respond are uncertain.

Purpose

2. This document focuses on the upstream water sector. It looks at benefits that competition could bring in relation to development and efficiency of water resources, treatment and the distribution network. These processes account for around 90% of the total costs of water services and virtually all of their impact on the environment. The upstream water sector, including the distribution network, provides the biggest opportunity for tackling future challenges successfully. The purpose of this document is to present analysis which will contribute to the debate about the benefits which could result from upstream competition.

3. The study set out in this document quantifies some areas of potential benefit from the development of upstream markets and competition in the water sector. It draws on data and evidence available in the water sector and other network utility sectors. It builds on the analysis of the potential benefits from upstream competition set out in Ofwat's previous publications and in the Cave Review interim and final reports.

[4] For more detail on the challenges facing the England and Wales water industry see our publication 'Water today, water tomorrow – Ofwat and sustainability' March 2009 and pages 17 to 23 of the Cave Review final report, April 2009.

Box 1 – The definition of 'upstream'

In our consultation in March 2009[5] we confirmed the nine business units we would be using in accounting separation. Using these business units we can define upstream water as follows.

Upstream water = water resources; raw water distribution; water treatment; and treated water distribution.

In some instances we may exclude treated water distribution from the definition of upstream which has strong monopoly characteristics compared to the other parts of upstream water. We make clear in this publication when we are referring to upstream excluding treated water distribution.

Although this study does not consider upstream sewage the corresponding definition is given below:

Upstream sewage = sewage treatment (and disposal); sludge treatment; sludge disposal; and sewage collection.

Overall approach

4. Through the process of rivalry between competing upstream firms, there are many possible ways in which competition could drive benefits and we cannot predict their effects. Some such ways include: new services, the reallocation of water between areas, financial structure innovation, new management processes and technological innovation in response to climate change. Precisely because markets reveal previously unknown information and innovations, it is virtually impossible to quantify the benefits of market reforms in advance. Our study is not therefore an attempt to analyse or quantify the total benefits from upstream competition. Instead we examined the potential scale of benefits which could arise from two particular processes - processes which upstream competition is likely to be effective at driving.

5. The benefits from competition can be categorised under the economic terms of static and dynamic efficiency. These are defined in Box 2.

[5] "Accounting separation − consultation on June return reporting requirements 2009-10", Ofwat, March 2009.

Box 2 – Static and dynamic efficiency

Static efficiency - consists of productive efficiency (doing existing tasks with fewer inputs) and allocative efficiency (allocating resources to the right tasks).

Dynamic efficiency - is the ongoing process over time of better allocation and use of resources, including through revealing new information and innovating to find the most effective solutions to challenges. Competition also generally delivers improved dynamic efficiency gains by providing flexibility in response to and adaption to unforeseen changes.

Some terms related to dynamic efficiency are defined in Box 3.

6. In considering the benefits greater competition could bring in upstream water provision, we have used two approaches:

7. First, we have selected one of most important ways we believe that competition would improve static efficiency and estimated some of the benefits from additional interconnection between regions driven by competition using a 'bottom-up' approach which involves identifying a potential set of new interconnections.

8. Secondly, we analyse the largest potential source of benefits - dynamic efficiency gains – using a top-down approach which applies experience in other sectors to water.

What this study does not do

9. This study does not set out how markets may be applied to the upstream elements of the water value chain. It considers what markets might bring generally, rather than the specific benefits that specific market designs might bring. It does not set out and consider different options for market design. We are considering possible 'first step' market designs and will publish further work on this in spring 2010.

10. This study does not enable us to develop estimates of the total potential benefits of upstream competition. This study contributes evidence, for some particular areas, for the scope for competition to drive benefits.

11. This study does not consider the costs associated with moving to and operating upstream markets. This study has not tried to estimate the costs of competition (although it does look at the costs of interconnection). The costs depend on the nature of the upstream market arrangements themselves – the costs of setting up and running those arrangements, any impact on the cost of capital and the degree to which arrangements enable entry and innovation. We will consider costs, and

compare them to the benefits upstream competition might bring, as part of our ongoing work.

12. The study does not examine service and efficiency benefits arising in retail services as a result of competition, which have been looked at in some detail in the Cave Review's interim report. There are nevertheless likely to be important synergies between retail and upstream competition, and separated, competing retail businesses could, for example, be key drivers of cross-border upstream competition and trading of water. Similarly, upstream competition will make retail competition more vigorous as retailers will have an opportunity to source their water from different suppliers. With both retail and upstream competition the monopoly network service will be under pressure from both ends of the supply chain to improve its services.

13. This study does not look at the sewerage sector. It concentrates only on the water sector. We will be presenting more analysis of the sewerage sector in spring 2010.

Section B: Interconnection study

14. Water companies' appointed areas are split up into water resource zones within which water resources can be shared[6]. In this section we consider the benefits upstream competition can deliver by transferring water between these zones. We have considered new pipeline connections only for reasons of simplicity and to provide a conservative estimate of the benefits of interconnection. However, rivers, canals and existing pipes with spare capacity could also be used to provide interconnection.

15. The main reasons for looking at interconnection are that, first, by interconnecting two zones with different water resource development costs the cheapest water resources across the whole interconnected area can be developed and the water from the cheaper zone exported to the more expensive zone. This could lead to considerable reductions in water development costs and potentially environmental benefits from leaving more water in the environment in water scarce zones. A second reason for looking at interconnection is that by sharing water resources over a larger area the resilience of the water supply in interconnected zones can be increased.

16. Our impetus for looking at interconnection in the water sector, as a potentially major source of static efficiency, is the evidence from the Environment Agency[7] and water companies' draft Water Resource Management Plans (draft WRMPs) that both water scarcity and water resource development marginal costs vary significantly between (as well as within) company regions.

[6] The Environment Agency defines a water resource zone as "The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall."
[7] Environment Agency (2009) "Water for people and the environment – Water resources strategy for England and Wales" March 2009.

Box 3 - Water Resource Management Plans

Every five years, in parallel with price reviews, water companies prepare Water Resource Management Plans (WRMPs) for their water resource zones. In 1999 and 2004 these were submitted on a voluntary basis, but from 2009 water companies have a statutory duty to prepare, consult, publish and maintain a WRMP. WRMPs predict future supplies and demands (the 'baseline' forecast) and, if there is a supply shortfall, set out the options for helping bring supply and demand into balance and the preferred investment programme.

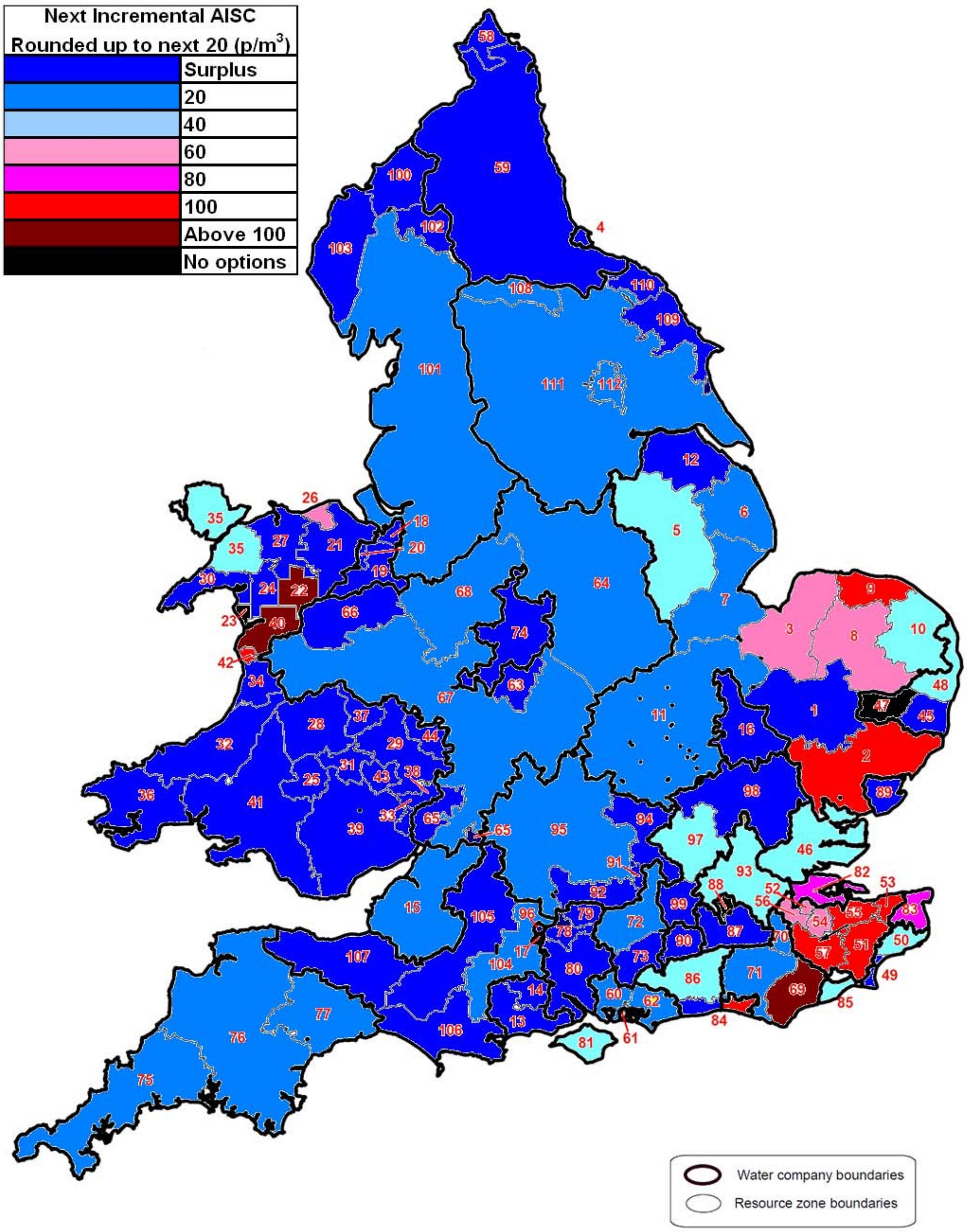
In general, water companies select options on least cost principles, using the unit Average Incremental Social Cost (AISC) in pence per cubic metre (p/m^3)[8]; this includes social and environmental costs (e.g. cost of carbon emissions), as well as the economic cost in terms of capital and operating costs and is calculated on a whole life basis as the total cost divided by the total volume produced, both discounted to the same base year.

The Environment Agency's 'Water resources planning guidelines'[9] explain in detail what the plans should contain.

In March 2008 companies submitted their draft plans covering the period up to 2034/35 to Defra and published them for consultation. On 3 August 2009 the Secretary of State for Environment, Farming and Rural Affairs decided that he was content for ten companies to finalise their plans and asked for further information from eight companies before making a decision. The Secretary of State also called for a public enquiry into two water companies' WRMPs and a public hearing into one other plan, for reasons including a lack of justification for the proposed water resource developments[10]. At the time of writing not all the plans have been finalised and so for consistency we have used information from draft WRMPs for all water companies.

[8] A m^3 or cubic metre is equivalent to 1,000 litres.
[9] The Environment Agency's 'Water resources planning guidelines' are available at: http://www.environment-agency.gov.uk/business/sectors/39687.aspx
[10] Defra's decisions on draft WRMPs are available at: http://www.defra.gov.uk/environment/quality/water/resources/planning/decisions.htm

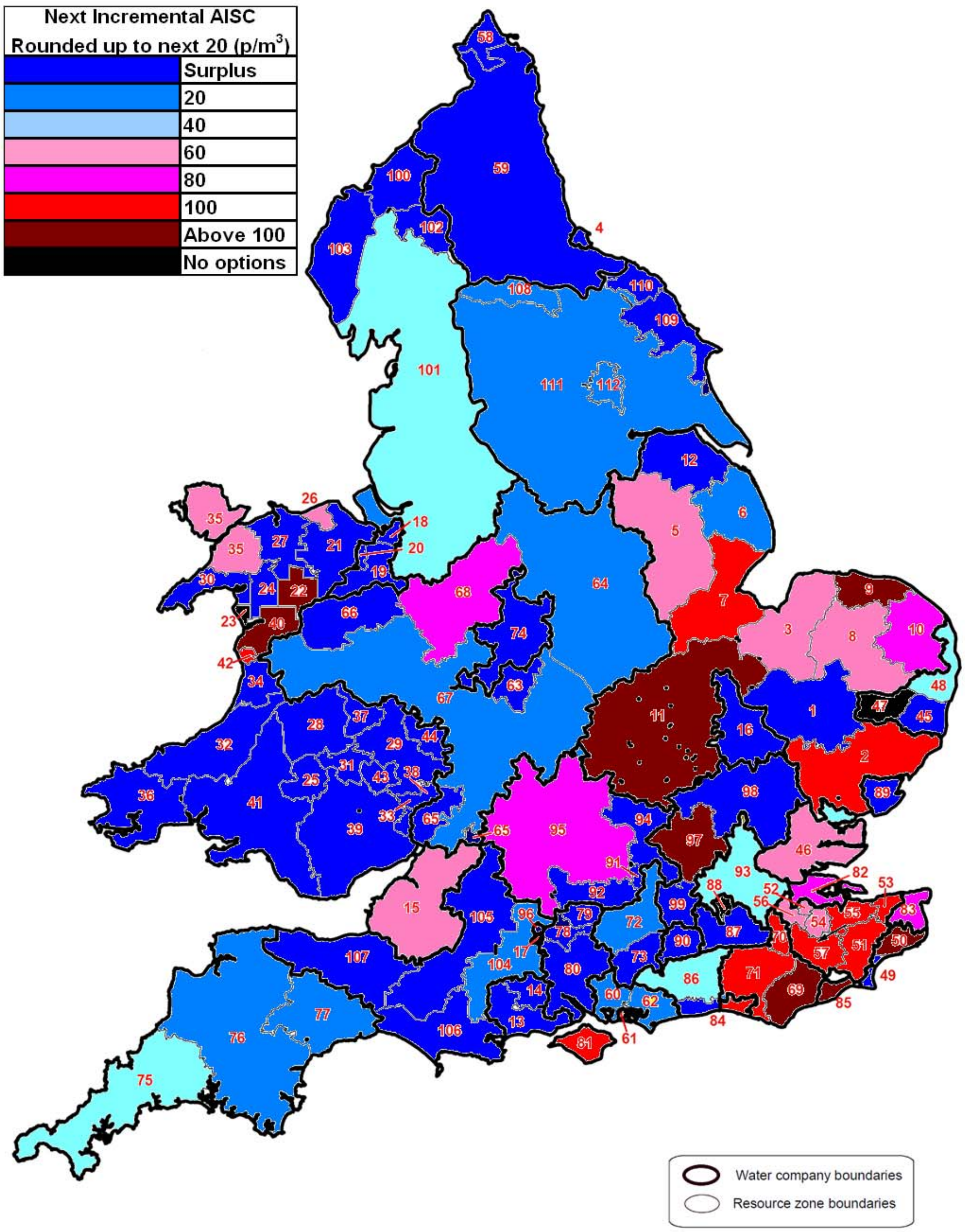
Resource Zones for Water Companies in England and Wales



Source: Ofwat calculations based on draft WRMPs

17. Map 1 above shows the cost of developing the next water resource in each water resource zone in England and Wales i.e. the first major supply side option water companies propose to build in their draft WRMPs. Where a company is in surplus (i.e. its current water supply schemes provide sufficient water to meet projected demand in 2034/35) the water resource zone is dark blue.

Resource Zones for Water Companies in England and Wales



Source: Ofwat calculations based on draft WRMPs

18. Map 2 shows the AISC of the marginal scheme required in each water resource zone to achieve balance in 2034/35 i.e. the last and the most expensive scheme in draft WRMPs required to achieve demand / supply balance in 2034/35.

19. The maps show that there are variations in the marginal cost of water between water resource zones now and that these will become much larger by 2034/35. Therefore there is increasing scope for interconnection to move water from where it

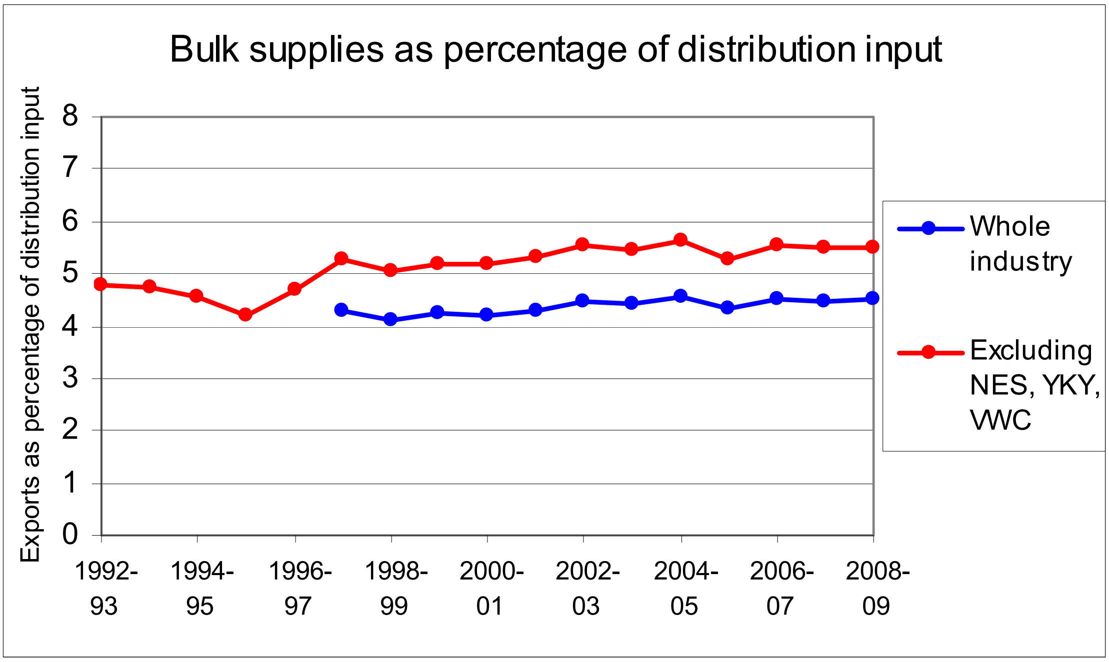
is cheaper to places where it is more expensive to develop water resources. Companies have been improving interconnection between their own zones (and have merged zones over the years) and their draft WRMPs include proposals for further internal interconnection in future. However, there are few proposals in water companies' draft WRMPs for moving water between water companies.

20. Water companies face some disincentives to looking across their borders when considering how to develop their water supply systems most efficiently. If water companies develop their own water resources the associated capital expenditure is added to their Regulatory Capital Value (RCV) on which they can earn a return. If water companies import water from a neighbouring region this is classed as operating expenditure. Whilst the regulatory system tries to reduce the impact of this effect, it is very hard to eliminate it.

21. In addition, legislation[11] effectively requires water companies to predict and provide for all water demand in their appointed area. In order to be certain they can meet this security of supply obligation companies prefer water resources they own and control rather than relying on water imported from neighbouring companies.

22. These disincentives to interconnection explain why the proportion of water companies' distribution input coming from inter-company bulk supplies[12] has remained fairly flat since privatisation as shown in the graph below[13]. This is despite the rising scarcity of water particularly in the south east. In addition, some of the existing bulk supplies take water from companies with expensive future water supply development options to companies with cheaper future options and it would be more efficient for those bulk supplies to be switched off or even reversed in direction in the near future.

[11] Water Act 1989 (as amended) section 37.
[12] A 'bulk supply' is a supply of treated or untreated water traded between individual appointed water companies. These supplies are often traded under long-term contracts and on non-standard terms. Such supplies are usually large in volume (i.e. bulk) although not always.
[13] The red line excludes Northumbrian Water, Yorkshire Water Services and Veolia Water Central (formerly Three Valleys Water) because there are no data for these companies' bulk supplies pre-1997-98. These companies lower the proportion of distribution input accounted for bulk supplies as they have lower than average bulk exports of water.



Source: Water companies' June returns and Ofwat's Special Agreements Register

23. We and the Environment Agency have recognised these disincentives to interconnection and have already taken measures to try to counteract them. These are described in the next section.

Promoting interconnection: regulatory measures versus upstream markets

24. There are various ways in which interconnection could be promoted. The two main ways we consider here are revised regulatory measures and the introduction of upstream markets. We have not considered the option of mergers of neighbouring companies as this would reduce the number of companies available to Ofwat to compare water companies' performance at price reviews.

25. We and the Environment Agency have already taken measures to promote inter-company interconnections under the existing regulatory system. As part of the Periodic Review 2004 process[14] we provided greater incentives for water companies to increase inter-company bulk supplies. We allowed exporting companies to keep any revenues above the costs of the bulk supply for five years before giving the benefit to consumers.

[14] Ofwat RD09/02 "Bulk supplies, competition and periodic review incentives" 28 June 2002 http://www.ofwat.gov.uk/legacy/aptrix/ofwat/publish.nsf/AttachmentsByTitle/rd0902_competition_and_bulksupplies_consultation.pdf/$FILE/rd0902_competition_and_bulksupplies_consultation.pdf

26. In addition, the Environment Agency has also promoted interconnection among the water companies in the south east by encouraging them to adopt the results of modelling work undertaken for the Water Resources South East Group (WRSE Group)[15] although the group's recommendations are only advisory. The Environment Agency has had some success in that water companies' final WRMPs have given shared water resources more consideration than their draft WRMPs.

27. Although regulatory measures have had limited success so far in increasing the proportion of water distribution input accounted for by bulk supplies (i.e. through interconnections) this does not mean that further regulatory measures would not be more successful. For example, the water companies could use the methodology in this study to indentify potentially beneficial interconnections to be investigated further.

28. We consider that upstream markets are likely to lead to greater benefits from interconnection than a revised regulatory approach. By upstream markets we mean a set of arrangements in which water companies buy and sell water resources freely. Such a system would also require measures to deal with water companies' near-monopoly control over water resources in their appointed regions. Our reasons for thinking upstream markets are likely to lead to greater benefits are set out below.

29. First, we consider upstream markets will reveal new information about the cost of future water resources, the costs and benefits of interconnection and the value of water. The WRMP process has been very useful in revealing information about water resource costs in different water resource zones. However, there is no requirement and little incentive for companies with predicted surpluses to investigate options for developing water resources that could be exported to neighbouring or nearby water resource zones. Upstream markets would incentivise companies to collect this information which would be likely to reveal profitable interconnections which cannot be identified on the basis of the information available under the current regulatory system.

30. Upstream markets would also reveal information about the value of water - the raw commodity in the water sector. The scarcity value of raw water is effectively zero at present, even in areas where it is clear there is significant scarcity, however, water has a value to abstractors and to the environment which is non-zero. Upstream markets would reveal the value of water and this would be factored into decisions leading to more efficient interconnections. An administratively determined value of water could be included in draft WRMPs but it would be unlikely to be as flexible to changes in local scarcity conditions as a market determined one.

[15] The WRSE Group consists of representatives from water companies in the south east of England, the Environment Agency, Natural England, Ofwat and the South East England Regional Assembly (SEERA).

31. Second, for interconnection to deliver its full benefits it requires there to be upstream competition in the markets which are being connected (this point is discussed below when discussing interconnection in other industries).

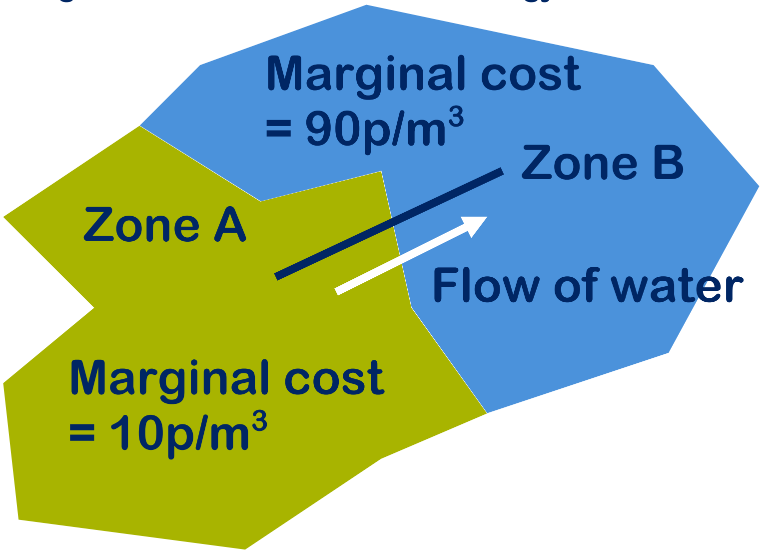
32. Third, upstream water markets allow more flexibility than regulation in adapting as the future pattern of consumer demand for water and the availability and relative values of water resources evolves over time.

The approach to modelling

33. We built a model based on data from water companies' draft WRMPs on the water supply options they plan to develop to meet demand in 2034-35. The model assessed whether there could be more efficient water resource development through interconnection rather than the schemes presented in draft WRMPs. Annex 1 gives a full description of the model. Consultants Design & Implement checked our model's design and we carried out internal checks of the input data.

34. As illustrated in the diagram below, our basic methodology was to identify neighbouring or nearby water resource zones which have large differences in their costs of developing future supply options. In the diagram below Zone B has a marginal cost of developing water resources of 90p/m^3 whereas the neighbouring zone A has a marginal cost of 10p/m^3. We then estimate whether a new interconnection would reduce the costs of meeting projected demand compared to those presented in draft WRMPs, factoring in estimated cost of developing the interconnection itself.

Diagram illustrating our interconnection methodology



35. We looked at zones projected to be in deficit (i.e. have insufficient current water resources to meet projected demand) in 2034-35. We selected the partner zone that maximised the benefit of interconnection, expressed as Net Present Value[16] (NPV) over the full asset lives. In this model the NPV of an interconnection is the cost saving it delivers compared to the schemes proposed in water companies' draft WRMPs. The interconnections were typically 10 to 40 kilometres in length (see Annex 1 for how we determine these lengths). These lengths are not unusual for the water sector and indeed many water companies have longer pipes within their areas.

36. There are around 100 water resource zones in England and Wales and several hundred neighbouring pairs of water resource zones[17]. To make our analysis tractable we looked at the cost in pence per cubic metre (p/m^3) of the first water supply scheme identified in the draft WRMP for each water supply zone and assumed the difference in development costs persists between them for the whole of the volume of the deficit[18]. We have only looked at supply side options, in order to simplify the analysis (as explained in annex 1). We called this methodology our 'base case' estimate.

37. The base case allowed us to identify those neighbouring zones with potentially profitable interconnectors between them. For the higher value estimates we then used the information on all water supply options in the two zones in draft WRMPs and produced a least cost joint programme to satisfy projected demand in both zones in 2034/35. We compared the cost of this with the least cost of meeting

[16] A Net Present Value is a way of expressing costs and benefits which extend over many years in one number which summarises the net benefit in current year prices.
[17] The precise number of water resource zones changes over time as companies merge their zones.
[18] For example if the first scheme in the exporting zone cost 10p/m^3 and the first scheme in the importing zone cost 40p/m^3 we assume that the 30p/m^3 difference in water resource development costs persists for all the schemes required to meet the project deficit in the zones in 2034/35.

demand without the interconnection. This provides a better estimate of the benefits of developing water resources in neighbouring regions and we term it our 'best estimate'.

38. A 'best estimate' is only available for about half the cases. This is because water companies with surpluses or small deficits projected in 2035 do not need to propose water supply options for their draft WRMPs which go beyond satisfying demand in their water resource zone in 2035 and we therefore do not have information on the cost of water resource schemes that they could develop for export.

39. Where we did not have a 'best estimate' we used our 'base case' estimate instead[19]. We combined these estimates in an overall 'hybrid' approach.

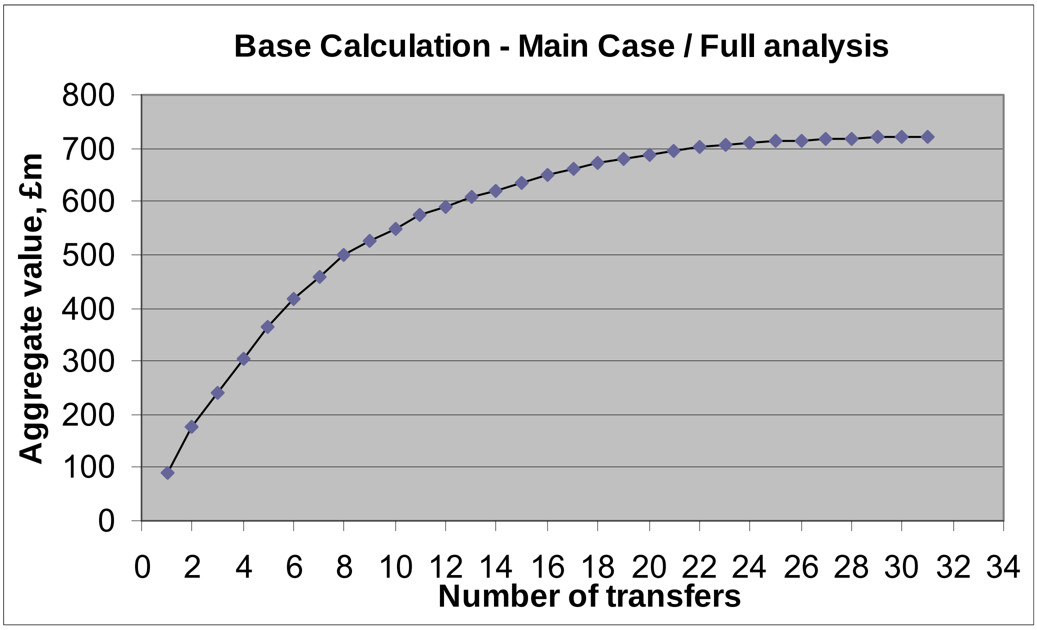
40. We recognise that the model makes some substantial simplifications and assumptions. The model does not claim that any individual interconnection would be cost-beneficial, nor does it provide a robust estimate for the overall benefits from interconnection. Instead the model provides a sense of the potential scale of overall benefits from greater interconnection. Water companies may have additional information with which such modelling could be further developed and refined.

Results

41. The base case estimate identified around 30 interconnection schemes with positive NPVs of over £1 million. In total for England and Wales the benefits of the interconnectors identified under the base case were £561 million.

42. Adding in 'best estimate' figures where we can, the graph below presents the data for this 'hybrid' approach, which is the most accurate we can be with the current level of information.

[19] Where the base case produced a small but positive NPV we did not undertake the considerable work needed to calculate a best case estimate as this was unlikely to have a material effect on the results.



43. The graph above presents the cumulative NPV of interconnections using our best estimate where data is available or our base estimate if not. The total benefits of interconnection on our 'hybrid approach' is a whole asset-life NPV of £722 million. Where we have done a full analysis, it increases the total NPV and assuming the same proportional increase for the other connections – where we have not carried out a full analysis - gives an estimate of £959m. That is the equivalent of saying that if inter-company interconnectors were built they would save the water sector around £1 billion over the lifetime of the assets compared to the cost of the schemes proposed in water companies' draft WRMPs which predominantly adopt a within company approach to developing water resources.

44. We have selected partner zones regardless of whether the interconnection was within or between companies. Of the 31 interconnections with positive value, 14 are within company and 17 between companies. Most within company interconnections relate to large rural areas particularly in Welsh Water and Anglian Water's appointed areas. However within company interconnections contribute less than 20% (£136 million) of the hybrid estimate of £722 million reflecting that water companies already have appropriate incentives to develop efficient interconnections within their appointed areas.

45. The overall estimate of £959 million is not a precise estimate of the cost savings interconnection could deliver but it gives an idea of the magnitude of these cost savings. There are several reasons for thinking that £959 million might be an underestimate of the savings.

46. First, we have found examples of connections where the base calculation gave a negative NPV but the full analysis gave a positive one. This means that the £959 million figure is likely to be an underestimate.

47. Second, the estimate does not take account of the benefit that joining zones results in a lower requirement for reserve supply or 'headroom' – i.e. zones can share reserve supplies reducing the net need for investment across the two zones. The size of this benefit will depend on the correlation of demand and supply variability in the two zones e.g. similarity of peak demands and rainfall variability. This benefit has not been taken account of in the modelling work as it depends on the specific nature of the supply systems being joined but it would increase the benefits.

48. Third, the scarcity value of water is not taken into account in the estimates of water resource development costs contained in draft WRMPs. As there is only limited abstraction trading and no upstream competition there is little information about the value of water – the raw commodity in the water sector. The scarcity value of raw water within current water supply arrangements is effectively treated as zero, even in areas where it is clear there is significant scarcity. However, the water has a value to abstractors and to the environment which is non-zero. The value of water is likely to be higher in areas of water scarcity than in areas of water surplus.

49. We undertook some additional analysis to estimate the sensitivity of the benefit estimates, derived from our model, to the relative scarcity value of water between zones. We found that including relative scarcity values of water based on the Environment Agency's assessment of the state of water resources in England and Wales generally increases the benefits of interconnection. This is because on average exporting water resource zones have better water resource availability than importing zones.

50. Fourth, the modelling is based on information from draft WRMPs and does not take account of the new information which upstream competition will reveal. One of the most notable features of the draft WRMPs is that companies with relatively cheap water supply options in the future do not identify options that go beyond those necessary to meet their own projected deficit in 2034/35, even if that deficit is very small. We have had to base our modelling on an assumption about the cost of such options relative to importing water resource zone options. However, if there was a thriving upstream competitive market those water resource zones would identify options for cheap water supply which they could export to neighbouring, more expensive, water resource zones.

51. Fifth, we have looked at pairs of neighbouring water resource zones. There could be larger benefits from 'chain' connections where there is a chain of

displacement from a water resource zone with abundant water supplies to a water resource zone with a large water supply deficit through a series of intermediate zones.

52. Our estimate of £959 million benefits from interconnection compares with work by the Water Resources South East group which identified the potential for savings of a few hundred million pounds from cross-border water resource solutions. The difference is partly because we are looking at the whole of England and Wales and not just the south east but also because our model allows us to consider imports into the south east from outside the region as well as interconnections within the region.

53. The table below shows which 10 interconnections our modelling work identified as being the most valuable in NPV terms.

Table 1 Top 10 most valuable interconnections identified by our modelling

Import		Export		
Map zone number	**Name of zone**	**Map zone number**	**Name of zone**	**Value (£ million over lifetime)**
97	Veolia Water Central - Central	94	Thames - Slough Wycombe & Aylesbury (SWA)	91
46	Northumbrian - Essex	98	Veolia Water Central - Northern	85
2	Anglian - East Suffolk and Essex	89	Veolia Water East - Veolia Water East	65
84 east	Southern - Sussex Brighton	90	Thames - Guildford	63
82	Southern - Kent Medway	87	Sutton and East Surrey - East Surrey	59
93	Thames - London	99	Veolia Water Central - Southern	51
50	Veolia Water Southeast - Hills	83	Southern - Kent Thanet	43
7	Anglian - Lincolnshire Fens	12	Anglian - South Humberside	40
57	South East - RZ7	87	Sutton and East Surrey - East Surrey	27
9	Anglian - North Norfolk Coast	1	Anglian - Cambridgeshire and West Suffolk	25

54. As the table shows the 10 most valuable interconnections are all in the south and east of England. The reasons for this are the largest forecast water deficits are in the south and east of England and there are smaller water resource zones in the south and east of England reflecting the number of water companies operating in the area. If we had considered chain connections it is likely that there would have been high value interconnections linking water resources zones with surpluses or small deficits in Wales and the north and west of England with water resource zones with large forecast deficits in the south and east of England.

55. We emphasise that our results are purely illustrative of the potential benefits which upstream competition could help deliver by incentivising interconnection. As mentioned above the actual benefits are likely to differ as existing companies and new entrants, especially in surplus areas, reassess the cost of their resource development schemes in the light of new information and with the prospect of supply for export not just for within-area consumption. It is by this process of incentivising companies and others to reassess their options, and of revealing more information, that upstream competition would lead to benefits, including through use of interconnection.

Evidence on interconnection from other industries

56. As well as modelling the benefits of upstream competition for interconnection we have looked at the evidence on interconnectors from other sectors. Most of the available evidence comes from the electricity sector and this section summarises our main findings in brief – more detail is provided in Annex 2.

57. Two recent studies look at the predicted benefits of electricity interconnectors between Norway and the Netherlands (NorNed) and between the Irish and UK electricity markets (the East-West Electricity Interconnector called 'EWIC'). The NorNed interconnector was predicted to increase the range of electricity sources open to both markets, lead to security of supply benefits, improve competition within the Dutch energy market and lead to environmental benefits due to the Netherlands importing hydropower from Norway. The business case for the Ireland-UK electricity interconnector anticipated that the interconnection would provide a security of supply benefit, allow Ireland to develop more wind-based power generation for which baseload back up is required which could come through the interconnector and promote further competition in the Irish electricity market putting downward pressure on prices.

58. There are also several studies on the effect of interconnection on price convergence between markets. One study[20] found that there was full convergence in prices where markets were functioning well at both ends of the interconnectors. The study implies that for interconnectors to deliver their full benefits in terms of price convergence there need to be effective upstream markets at both ends of the interconnector. Evidence from the USA[21] and Australia[22] also finds a link between greater market interconnection and greater price convergence.

59. One issue with interconnection is that, whilst it will reduce wholesale prices in historically higher cost importing markets, it might tend to increase wholesale prices in the exporting company's area. However, this tendency is likely to be countered by other effects. First, if the interconnector is used in both directions it is likely to reduce the wholesale price in the net-exporting zone at times of peak demand. Second and probably most importantly, the other benefits of interconnection mentioned above will put downward pressure on the wholesale price in the exporting zone – increased competition and security of supply benefits. An empirical example is that when the Queensland and New South Wales electricity markets were interconnected as part of Australia's NEM prices fell in both states.

60. Another concern about interconnection is that it might not be effective in practice. The UK / Belgium gas interconnector came into operation in October 1998. During the winter of 2000-01 gas flowed from the UK to the continent despite gas prices being higher in the UK market than on the continent. The European Commission[23] attributed the uneconomic flow to the continental market being less liberalised than the UK market and rigidities in the rules governing the interconnector. Since then gas has tended to flow from the continent to the UK during the winter although there are still physical constraints on the network supplying the Belgian end of the interconnector which are affecting flows. This example reinforces the point that functioning markets at each end of the interconnector increase the benefits from the interconnector. It also shows that other parts of the network might need to be strengthened to achieve the full benefits of interconnection.

[20] Neumann, A., Silverstovs, B. and Hirschhausen, C. (2005). Convergence of European Spot Market Prices for Natural Gas? A real- Time Analysis of Market Integration using the Kalman Filter, Working Paper, Chair of Energy Economics and Public Sector Management, Technical University of Dresden, pp. 1-12.

[21] Cuddington, John T. and Zhongmin Wang. (2006) "The Integration of U.S. Natural Gas Spot Markets: Evidence from Daily Price Data," Journal of Regulatory Economics 29 (2006), 195-210.

[22] Australian Energy Regulator (2007) "State of the energy market 2007" and Australian Energy Regulator (2008) "State of the energy market 2008".

[23] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/02/401&format=HTML&aged=0&language=EN&guiLanguage=en

Conclusion on the benefits of interconnection

61. This chapter has presented evidence from the Environment Agency and the water companies' draft WRMPs which show wide differences in water resource availability and the cost of developing water supply across England and Wales. We have attempted to quantify some of the benefits arising from interconnection between company areas. We estimate greater interconnection could lead to benefits of around £959 million NPV compared to the schemes in water companies' draft WRMPs. This result is purely illustrative of the potential benefits from interconnection and takes no account of the security of supply benefits or the improvement in market competition that interconnection provides. Our work is supported by examples from the energy sector that show that interconnection leads to a range of benefits including improved productive efficiency, improved security of supply and improved market competition in the interconnected markets.

62. We conclude that there is scope for greater efficiency in resource allocation by using increased interconnection between water resource zones. We think that the scale of the benefit is potentially very significant. Interconnection could be delivered through revised regulatory measures but we consider that upstream competition is likely to be the most effective way of realising these benefits as it: reveals new information about which interconnections are most beneficial; interconnection and upstream competition can work together to improve resource allocation; and upstream competition allows companies to respond more flexibly to changes in consumer demand and water resource availability.

Section C: Dynamic efficiency study

63. The interconnection benefits identified in section B are one example of 'static' or one-off benefits. Upstream markets should also be expected to deliver ongoing benefits through what economists call dynamic efficiency gains. This section looks at the evidence linking competition and dynamic efficiency.

64. Generally the main benefits of competition come through dynamic efficiency effects in the long run. In the Cave Review interim report (November 2008) Professor Cave said that he expected upstream competition to deliver dynamic efficiencies. The effect is driven by rivals competing for customers and therefore having constant pressure on them to reduce their costs and to tailor their product to what consumers want. Competition also drives companies to innovate to keep ahead of their rivals and win more customers.

Box 4 - Terms relating to dynamic efficiency

This box explains several closely related terms that we use in this chapter.

Dynamic efficiency – occurs when over time resources continue to flow to their highest value uses and outputs are produced with the minimum amount of inputs. As technology improves through innovation dynamic efficiency means that resources are continually reallocated and recombined to their most efficient use. Dynamic efficiency therefore tends to lead to productivity growth.

Productivity growth – productivity growth occurs when the amount of output for a given set of inputs increases over time. It can be defined more precisely as:

- **Labour productivity growth** – an increase in output for a given amount of labour input.
- **Total factor productivity growth** – an increase in output for a given amount of all inputs (labour, capital, raw materials etc.).

Innovation – the action of introducing new methods, ideas or products. Innovation is the main driver of total factor productivity growth and one of the main drivers of labour productivity growth. Dynamic efficiency helps innovation to raise productivity growth by allowing resources to flow to new processes and products created by innovation.

How competition across the economy leads to dynamic efficiency

65. Generally-accepted theory, derived from empirical evidence, sets out the ways in which competition increases productivity growth. The OFT (2007) studied the three main processes in depth[24]:

- **Within firm effects** - Competition places pressure on the managers of firms to increase internal efficiency.
- **Between firm effects** - Competition ensures that higher productivity firms increase their market share at the expense of the less productive. These low productivity firms may then exit the market, and be replaced by higher productivity firms. This effect is also known as ‘market sorting’ or ‘market selection’.
- **Innovation** - Innovation increases dynamic efficiency through technological improvements of production processes, or the creation of new products.

66. We recognise that the relationship between competition and innovation has been debated in the economic literature. The theoretical economic literature suggests that lack of competition reduces innovation as companies have little incentive given the super-normal profits they were already making. On the other hand, very high levels of competition limit the potential gains from innovating due to the number of competitors who could copy the innovation. This results in an ‘inverted U relationship’ as at medium levels of competition innovation is high as firms try to escape competition by innovating[25].

Empirical evidence on the relationship between competition across the economy and productivity

67. The OFT[26] carried out a comprehensive review on the relationship between competition and productivity and found “a strong body of evidence that competition enhances productivity”. Some of the studies referred to are summarised in annex 3. The OFT concluded that productivity gains are most beneficial to consumers if competition ensures that reduced costs or increases in quality are passed on to them.

[24] Productivity and competition: an OFT perspective on the productivity debate, 2007. London: OFT. www.oft.gov.uk/shared_oft/economic_research/oft887.pdf.
[25] Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P. (2005): Competition and Innovation: An Inverted U Relationship, Quarterly Journal of Economics, May 2005.
[26] See footnote above for reference to OFT (2007).

68. The OFT also found empirical evidence explaining how competition raises productivity growth. This is summarised in Box 5.

Box 5 – Empirical evidence on the channels by which competition raises productivity

Empirical studies have looked at evidence for the specific ways in which competition drives productivity: within firm effects, between firm effects and innovation.

Several papers have shown that competition increases productivity by sharpening managerial performance. For example, Bloom and Van Reenan (2006)[27] surveyed 732 medium sized manufacturing firms in the US, UK, France and Germany and found a relatively low presence of poor management in competitive markets.

Other papers have shown that competition increases productivity by more efficient firms expanding at the expense of less efficient firms ('market sorting'). For example, Scarpetta et al (2002)[28] suggest that market sorting accounts for 20-40 of total productivity growth across 10 OECD countries for varying time periods in the 1980s and 1990s. Disney, Haskel and Heden (2003) found that over the period 1980 to 1992, market sorting accounted for around 50 per cent of labour productivity growth and 80 to 90 per cent of total factor productivity growth.

There is also extensive empirical evidence on the link between competition and innovation which on the whole shows a positive relationship between competition, innovation and productivity despite the nuanced theoretical relationship mentioned above. Griffith, Harrison and Simpson (2006)[29] found the introduction of the European single market programme, by raising competitive pressures, increased innovation and the effect was largest in countries closest to the global technological frontier.

Empirical evidence on market reforms and productivity

69. The previous section considered the effect of competition on productivity, but there is also empirical evidence specifically on the effect of pro-competitive market reforms, such as liberalisation of previously monopolistic network sectors, on productivity.

70. The OFT found strong empirical evidence that market reforms in network utilities such as telecoms, electricity and gas and other non-utility sectors lead to

[27] Bloom, N. and Van Reenen, J. (2006). 'Measuring and Explaining Management Practices Across Firms and Countries', NBER Working Paper, No. 12216.
[28] Scarpetta, S., Hemmings P., Tressel, T. and Woo, J. (2002), 'The Role of Policy and Institutions for Productivity and Firm Dynamics: Evidence from Micro and Industry Data', OECD Economics Department Working Papers, No.329.
[29] Griffith, R., Harrison, R. and Simpson, H. (2006), 'The Link Between Product market Reform, Innovation and EU Macroeconomic Performance', European Economy Economic Papers No. 243.

improved productivity. We have summarised the most relevant articles from the OFT study on the effects of market liberalisation on productivity in annex 4.

71. Whilst the overall relationship between market reforms and productivity is clear in the empirical literature one subsidiary finding is that market reforms can sometimes lower research and development (R&D) spending and usually lead to a re-orienting of R&D towards more commercial objectives. One study found that the effect of liberalisation on 17 former telecoms monopolies was a decline in publication activity (a proxy for basic research) but a rise in patenting activity (a proxy for applied research)[30]. Although market reforms can sometimes result in a fall in measured R&D spending (see annex 3) this is only one measure of innovation; the evidence that market reforms lead to a reorienting of research towards more commercial applications combined with the overall increase in productivity market reforms generate suggests market reforms are beneficial for innovation.

Prospects for competition to deliver dynamic efficiency benefits in the water industry

72. Given the large body of evidence analysed by the OFT and others about a range of network sectors where market liberalisation has lead to productivity gains it seems reasonable to expect that the dynamic efficiency benefits that happened in other industries would occur in water. We have considered how the three mechanisms by which competition increases dynamic efficiency identified above (within-firm effects, between-firm effects and innovation) might impact on the water sector.

73. As regards within-firm effects, the additional pressure of competing for water resources would force upstream water companies to increase their internal efficiency. We would expect this to go beyond the pressure imposed by regulatory mechanisms. One of the main problems all regulators face is a lack of information compared to the companies being regulated. Whilst regulators often have extensive information gathering powers regulators will sometimes not know what information is available, wish not to impose too much of a regulatory burden on the companies they regulate and in any case do not want to micro-manage them. In addition, creating head-to-head competition would force water companies to understand their own cost structures better, their customers' preferences and the opportunities they have. Competition 'for the market', such as franchising or competitive tendering of operations, also incentivises companies to understand their cost structures better but

[30] Calderini, M. and Garrone, P. (2003). Liberalization and the balance of R&D activities: An empirical analysis, in Calderini, M., Garrone, P. and Sobrero, M., eds., Corporate Governance, Market Structure and Innovation, Edward Elgar: Cheltenham.

the infrequent letting of contracts means the effect is less than under head-to-head competition.

74. We would in principle expect 'between-company effects' to play a role in driving upstream efficiencies. At the moment the upstream part of each water company is effectively a regional monopoly with a guaranteed number of customers. Once upstream competition is introduced 'between-company effects' can act to stimulate dynamic efficiency in the industry as less efficient upstream firms lose market share to more efficient ones.

75. As regards innovation in the water sector we agree with the Cave Review that the introduction of more market mechanisms should be expected to improve innovation in the water sector. Both the Cave Review and the Council for Science and Technology (CST) argued that current levels of innovation in the water industry are relatively low[31]. Professor Cave discussed the potential bias of regulation to incentivise low-risk incremental change by focussing on innovation to increase cost efficiency or meet quality standards.

76. Whilst we consider that measured R&D in the water sector misses the innovation that does already occur, notably in the supply chains to water companies, we recognise that there is considerable scope for the water industry to be more innovative. Given that the England and Wales water companies are currently regional monopolies we would expect from the empirical evidence on other sectors that introducing upstream competition will stimulate innovation and dynamic efficiency.

Some empirical estimates of potential dynamic efficiency gains in the water and sewage industry

77. From the evidence above we expect that upstream competition will increase dynamic efficiency in the water sector. Both the Cave Review and we have made estimates of the potential scale of dynamic efficiency gains in the water industry as set out below.

78. The Cave Review interim report presented an example calculation of the potential efficiency gains from upstream competition. The Cave Review explained that abstraction and treatment account for around 40 per cent of the water value chain and treatment of wastewater and sludge treatment and disposal for 64 per cent of the wastewater value chain. The Cave Review then assumed that competition delivered a five per cent one-off increase in productive efficiency and a 0.25

[31] Council for Science and Technology (2009) "Improving innovation in the water industry: 21st century challenges and opportunities".

percentage point increase in dynamic efficiency a year for ten years. As a result extending competition upstream would result in initial savings of £280 million or 3.5 per cent of total turnover. Over the long-term, the present value, excluding costs, of such a change could be greater than £3.5 billion.

79. The Cave Review also took into account that productivity increases do not capture quality improvements. The Cave interim report argued that upstream competition could also result in greater and more rapid service and quality improvements than regulation because companies would have much greater incentives to respond to retailers. Improvements could include better resource management, reduced chemical use, and the greater use of renewable energy and different levels of security of supply.

80. In Ofwat's Review of Competition Part II we referred to work by Saal et al (2004)[32] and Saal and Parker (2005)[33] who estimated average Total Factor Productivity (TFP) growth in the water and sewerage industries in England and Wales of between 1.68% and 2.29% for the periods 1985-2000 and 1994-2003. We used this as our baseline to apply empirical estimates of increases in TFP growth observed in other sectors. Wei Li and Lixin Colin Xu (2005)[34] found that the introduction of competition into telecoms sectors increased the rate of TFP growth by 33% to 87%.

81. Applying Wei and Lixin's results to the TFP estimates of Saal et al and Saal and Parker we suggested in Ofwat's Review of Competition Part II that liberalisation in the water sector could result in an increase in TFP growth of between 0.55 and 2 percentage points per annum. Using this 'growth rate multiplier' methodology allows for the fact that different sectors may have different intrinsic rates of technological change and thus TFP growth.

82. If we assume that market reforms initially lead to a 2 percentage point increase in TFP growth which reduces to 0.55 percentage points over 10 years and then continues at that level then the reduction in upstream water (resources and treatment) industry costs over 30 years would be £3.6 billion in NPV terms. We recognise this estimate is simplistic and needs to be treated with caution. However, it demonstrates the possible scale of longer-term dynamic efficiency gains from competition.

[32] David S Saal, David Parker and Tom Weyman-Jones (2004) 'Determining the contribution of technical change, efficiency change and scale change to productivity growth in the privatised English and Welsh water and sewerage industries: 1985-2000'.
[33] David S Saal and David Parker (2005) 'Assessing the performance of water operations in the English and Welsh water industry: a panel input distance function approach',.
[34] 'The impact of privatisation and competition in the telecommunications sector around the world', Wei Li and Lixin Colin Xu, The World Bank, October 2002.

Addressing some arguments that have been made against the prospects for dynamic efficiency gains in the water sector

83. From the literature on dynamic efficiency we consider it is likely that introducing upstream competition will lead to dynamic efficiency effects in the water industry. However, this section looks at some of the opposing arguments. The four arguments we address are: (1) RPI + K regulation has already driven out most of the efficiency savings in the water industry; (2) water is an inherently low innovation industry; (3) high levels of regulation would hinder any beneficial dynamic efficiency effects from competition; and (4) water is heavy to transport making local markets small with little prospect for competitive pressure on incumbents.

84. First, some stakeholders might argue that the RPI + K regulation has already driven out most of the efficiency savings in the water industry. This argument assumes that there are a fixed amount of efficiency savings that can ever be achieved. In competitive sectors businesses continue to find efficiency savings and more productive ways of working year after year. The current regulatory system has led to customers' bills being 30% lower than they would otherwise have been. However, the future challenges facing the water industry will require new, innovative and more flexible responses. Upstream competition will reveal new information about water companies' costs as they seek to compete with one another and may allow new players into the market who will have new ideas and ways of working to achieve further efficiency savings.

85. Second, some have argued that the water sector is an inherently low innovation industry. We consider there is already innovation in the water sector and the many examples include improvements in leakage detection, underground repair of pipes, membrane treatment for drinking water and more sustainable use of chemicals in treatment works. We agree with the Cave Review and the Council for Science and Technology that there is scope for more innovation in the water sector. We also know that the future challenges will require more innovative solutions. We have set out evidence above that innovation increased in telecoms after competition was introduced and that innovation in the energy sector became more commercially-oriented. We recognise that all industries are different and that water is not the same as telecoms or energy. Nevertheless, innovation does not always involve high tech solutions to problems but can involve 'low tech' innovation such as better use of assets as occurred in air travel[35] and gas storage[36] following liberalisation.

[35] A Civil Aviation Authority (2005) report on "UK Regional Air Services" discusses how market liberalisation led to new entry, lower prices and more flights.
[36] See for example Ofgem (2000) "A review of the development of competition in the gas storage market".

86. A third argument which can be put against there being dynamic efficiency effects in the water sector is that the high level of water quality regulation and environmental regulation means competition will constrain deliver dynamic efficiency effects. However, many competitive industries face detailed health and safety regulation but still generate innovation including recently liberalised ones such as air travel and gas. In addition, some important and profitable innovations such as green technologies can be driven by regulation.

87. Fourth, dynamic efficiencies would not occur in the water industry if the cost of transporting water made upstream water markets too localised and uncompetitive. However, this argument does not take account of the fact that many water companies have large water resource zones already. The Cave Review final report presented data showing that the 10 largest water supply zones contain 57% of all water consumers, the 20 largest contain 74% and the 30 largest 81%. Nor does it take account of the evidence we presented in section B that upstream competition is highly likely to lead to more interconnection and larger water markets.

88. We are reasonably confident that upstream competition will deliver greater dynamic efficiency gains than current regulatory agreements. There is strong and consistent evidence from other sectors that competition and market reforms lead to dynamic efficiency gains over time. In assessing the arguments against dynamic efficiency effects occurring in the water sector we consider they show that the upstream competitive arrangements need to be adapted to the specific nature of the water sector, but they do not invalidate the fundamental point that it is reasonable to expect that upstream competition will deliver considerable dynamic efficiency gains in the water sector.

Conclusions on dynamic efficiency

89. The main benefits of competition come through dynamic efficiency effects. There is a strong body of empirical evidence showing that competition and market reforms lead to increases in productivity growth through dynamic efficiency. From this evidence we consider that it is reasonable to expect that pro-competitive market reforms will generate dynamic efficiency gains in the upstream water sector. Our rough estimate of the benefits upstream competition could deliver in water resources and treatment through dynamic efficiency effects is £3.6 billion over 30 years. This is in the same region as the assumption made in the Cave interim report. In assessing the arguments against dynamic efficiency effects occurring the water sector we consider they show that the upstream competitive arrangements need to be adapted to the specific nature of the water sector, but they do not invalidate the fundamental point that it is reasonable to expect that upstream competition will deliver considerable dynamic efficiency gains in the water sector.

Section D: Conclusions about the evidence in favour of upstream competition

90. The benefits of competition are inherently hard to measure in advance because one of the main advantages of competition is that it reveals new information, increases the flexibility of market participants to respond to new developments in the market and introduces new players with new ideas into the market. Nevertheless we have looked at two areas where we are able to find some evidence.

91. We have attempted to quantify the benefits from interconnection. We estimate this could lead to cost savings of around £959 million NPV compared to the schemes in water companies' draft WRMPs. This result is subject to the information available and a number of substantial assumptions, but there are several reasons for thinking it might be an underestimate as it takes no account of the security of supply benefits or the improvement in market competition that interconnection provides. Our work is supported by examples from the energy sector that show that interconnection leads to a range of benefits including improved productive efficiency, improved security of supply and improved market competition in the interconnected markets. We consider that while inter-company interconnection could be promoted through regulatory means it is likely that upstream competition would be more likely to bring these benefits.

92. There is a strong body of empirical evidence showing that competition and market reforms are linked to dynamic efficiency. From this evidence we consider that it is reasonable to expect that effective pro-competitive market reforms will generate dynamic efficiency gains in the upstream water sector. Our rough estimate of the benefits upstream competition could deliver in water resources and treatment through dynamic efficiency effects is £3.6 billion NPV over 30 years. Our assessment of arguments sometimes made against dynamic efficiency effects occurring in the water sector indicates that while upstream competitive arrangements will need to be adapted to the specific nature of the water sector it is still reasonable to expect that upstream competition will deliver substantial dynamic efficiency gains.

93. This work does not enable us to develop estimates of the total benefits of upstream competition but it gives some idea of the scope for upstream competition to deliver benefits. A summary table below sets out those benefits of upstream competition we have tried to quantify and some we have not. We have included the Cave review's estimates in its interim report for comparison.

Table 2 Summary of the benefits and costs of upstream competition

Benefit	Estimate of amount of the benefit (in NPV terms)
Interconnection leading to development of cheaper water supply options	£959 million
Interconnection leading to security of supply benefits	Unquantified
Interconnection improving the effectiveness of competition in interconnected markets	Unquantified
Upstream competition raising productivity growth through dynamic efficiency effects (water only)	£3.6 billion
New services provided to consumers	Unquantified
Improved quality of service to consumers	Unquantified
Financial structure innovation	Unquantified
Technological innovation in response to climate change	Unquantified
Unforeseen benefits of upstream competition	Unquantified
Cave estimate of the benefits of upstream competition	
Interim report - Assumed upstream competition would deliver a 5% one-off increase in productive efficiency and a 0.25 percentage point increase in dynamic efficiency a year for ten years. Estimate relates to water and sewerage.[37]	£3.5 billion

94. Competition will clearly have costs as well as benefits. We are not estimating the costs in this publication. The purpose of this publication is to outline a study of the potential for benefits in two main areas. The reason we are not estimating costs is that they depend on the nature of the upstream market arrangements – the costs of setting up and running those arrangements and any impact on the cost of capital for water company financing. Given the potential benefits identified here we plan to publish a document in spring 2010 which sets out some ‘first step’ arrangements for upstream competition in the water sector, building on the Cave review.

[37] The Cave Review also calculated costs for upstream competition and the results of the Cave review’s cost benefit analysis are on page 136 of the Final Report.

Annex 1: Detail on the interconnection methodology

95. We outline our approach to modelling interconnection in section B of the publication. This annex sets out the methodology in more detail.

Water Resource Management Plans

96. The Environment Agency defines a water resource zone as “the largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall.” There are around 100 water resource zones in England and Wales.

97. In 2008 companies submitted their draft Water Resource Management Plans (draft WRMPs) to Defra. They published these plans and consulted on them. We have used the draft plans for consistency because not all the final plans were available at the time of publication.

98. The plans cover the period to 2034/35. They identify: the projected surplus or deficit in each water resource zone (‘zone’) without any further development of supply/demand options (the ‘baseline’); the options for improving the supply/demand balance; and the company’s preferred programme cumulatively to meet any projected deficits.

99. For each option, the company calculates the Average Incremental Social Cost (AISC) and we used this as our measure of unit cost. It is the unit cost for water produced, measured in pence per cubic metre (p/m^3), taking account of social and environmental costs as well as economic costs. The AISC is calculated by dividing the net present cost by the net present volume of water.

Summary of the methodology

100. Our objective is to compare companies’ plans and a situation where interconnection is optimised and to estimate the potential cost savings.

101. Our methodology is a static analysis of the projected situation in 2034/35. We do not consider the phasing of investment up to this time or the further investment likely to be required thereafter.

102. We carried out the following steps:

Table A1-1 Summary of the methodology

Step 1	**Identifying the surplus or deficit** For each zone, identify the dry year baseline surplus or deficit.
Step 2	**Identifying the incremental supply-side option** For each zone, identify the lowest unit cost ('incremental') supply-side option providing a significant volume.
Step 3	**Selecting the 'trading partner' zone** For each zone that has a baseline deficit (the import zone), identify the neighbouring or nearby 'trading partner' zone likely to meet the deficit at least unit cost (the export zone). Using a map, we then estimate the distance between the centres of the two zones. (For London, in view of the large deficit, we allowed more than one partner.)
Step 4	**Estimating the value of interconnection** We estimate the value of interconnection relative to the company's plan, based on the difference between zones in incremental unit costs, less the unit cost of interconnection. We then calculate the whole-life net present value (NPV) of the interconnection compared to the default (this may be either positive or negative) and sum those that are positive to obtain an estimate (the 'base estimate') of the potential benefits of more interconnection. We assume negative value schemes will not go ahead.
Step 5	**Investigating higher-value opportunities in more detail** For those interconnections with significant positive NPVs, we investigate in more detail all the supply options (where such information is available) in each of the interconnected zones. This provides a more robust NPV estimate of the benefits of those interconnections (the 'best estimate'). We substitute these estimates for those obtained in step 3 and recalculate the sum of positive NPVs. Since this is a mixture of simple (step 3) and more detailed estimates, we call it the 'hybrid' case.
Step 6	**Including a value of water based on scarcity** We repeated step 4 with incremental unit costs that included values of water reflecting scarcity.

Step 1 – Identifying the surplus or deficit

103. The main investment driver is the dry year[38] requirement, although in some cases additional capacity is required to meet peak demands. We therefore recorded the baseline dry year surplus or deficit for each zone from water companies' draft WRMPs.

Step 2 – Identifying the incremental supply-side option

104. To keep the analysis tractable, we initially considered only the 'incremental' option i.e. the one that provides a significant volume at lowest unit cost as measured by the AISC (rather than the 'marginal' option i.e. the highest cost one that has to be used to meet projected demand in 2034/35). We excluded options that provide very small volumes because this would give misleading results. We have therefore exercised a degree of judgement about what volume is significant in relation to any deficit.

105. Resource plans divide options into:

- Customer – Working with customers to reduce consumption; includes metering and tariffs;
- Distribution – Both leakage reduction (effectively managing own demand) and new links within and beyond the zone;
- Production – New / enhanced treatment; and
- Resources – New sources of water.

106. We have only looked at the 'supply side' options of production, resources and any links beyond the zone. We excluded the 'demand side' options of customer management and leakage reduction both to simplify the analysis but also because they often have high unit costs or involve small or uncertain quantities which could distort our results. However, we are not implying that demand side and leakage measures are not important for restoring demand / supply balance.

107. If there is a projected surplus we assumed an AISC of zero. However, variable operating expenditure will still be incurred if additional water is produced for export.

[38] Each company establishes a security of supply criterion, specifying the risk it is prepared to accept of not having enough water to meet all demands in a year e.g. once in 20 years. The corresponding volume is the 'dry year' requirement.

We do not have good information on these costs but assume they are relatively small. For new supplies, resource plans show that the NPV of operating expenditure is typically of the order of half the NPV of capital expenditure, albeit with wide variations. But they do not distinguish 'fixed' operating expenditure for operational staff, site overheads, minor repairs etc from variable operating expenditure i.e. the additional cost of incremental production.

108. If there is a deficit, we rank options in order of increasing AISC and select the AISC of the first significant option as the incremental unit cost. If the company has not identified any options, often because the deficit is small, we assume a relatively high AISC of 100p/m^3.

109. We plotted the incremental unit cost for each zone on the map on page 10 of the main document.

Step 3 – Selecting the 'trading partner' zone

110. For each zone where there was a projected deficit we assumed this would be met by importation and identified the 'trading partner' zone with the best potential for supplying this at low cost. The map helped in this task; often the 'trading partner' zone was the nearest zone with a surplus. We used estimates of the value of interconnection from step 4. Selecting the 'trading partner' zone involved a degree of experimentation.

Step 4 – Estimating the value of interconnection

111. We assume the capacity of the interconnection is the lesser of (a) the deficit in the importing zone and (b) 25% of current water available for use (WAFU) plus the surplus (or minus the deficit) in the exporting zone. Where one zone exports to several, the water available is shared between the importing zones and allocated in descending order of unit value.

112. We estimated the value of interconnection relative to the company's plan, based on the difference between zones in incremental unit costs, less the unit cost of interconnection, both in terms of unit volume (p/m^3) and a whole-life NPV. We call this the base case estimate.

113. The NPV is the value per unit volume multiplied by the pipeline capacity and by the NPV of days' operation (assuming 80% load factor, a 4.5% real discount rate[39]

[39] In line with the Environment Agency's water resource planning guideline (section 11.4.7) and our PR09 final determination.

and an indefinite life). Our 'base case' estimate of the total benefit for England and Wales is the sum of these NPVs where they are positive. We assume negative value schemes will not go ahead.

114. We made the simplifying assumption that the difference in development costs persists on average for the whole of the volume of the deficit in the importing zone. This is on the basis that in deficit zones the options tend to be fewer and higher cost. In step 5 we carried out a more detailed analysis and this showed that this assumption could under-estimate or over-estimate the value of the interconnection but overall tended to be a net under-estimate.

115. We assumed 292 days' operation a year, i.e. a load factor of 292/365 = 80% for the pipeline in particular and for water resources in general. This assumption provides an allowance for outages (around 5%) and for the fairly small variations through the year in water demand (summer to winter variation is of the order of 5 to 10% and annual demand is about 2% higher in a dry year than an average one, mainly due to higher summer demand). Where a supply surplus exists, this provides some flexibility to operate one plant or another, but surpluses should be small relative to demand.

116. We acknowledge that companies may operate particular water resources less, especially where they have high variable (per unit volume) costs, and this operational optimisation represents an opportunity for cost saving compared to the planning scenario. This may apply to pipelines, if significant pumping is required.

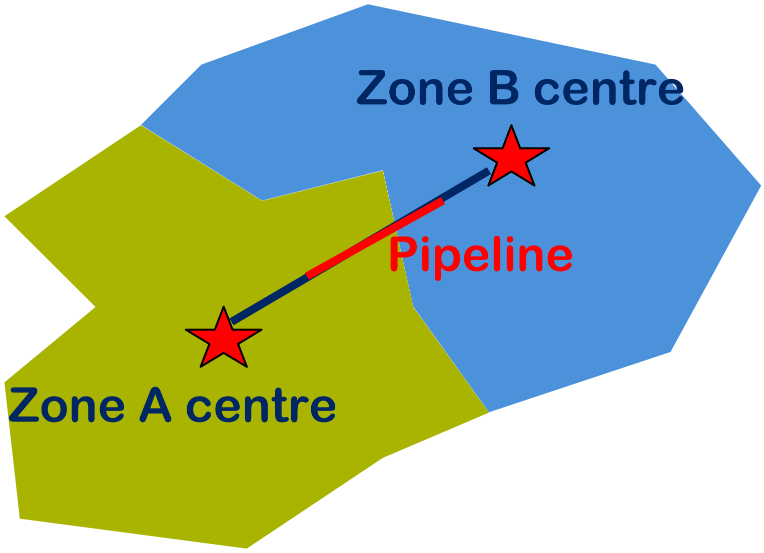
Pipeline cost model

117. We assume zones are linked by a new pipeline. In a particular case there may be other, lower cost options, such as using a river or existing infrastructure; therefore we may be over-estimating the cost.

118. To estimate the length of the pipeline in km, we assume it runs along a straight line from the centre of one zone to the centre of the other. We measured this distance on a map and converted to a distance on the ground.

119. Since a water resource zone is defined as an area in which water can be shared (see paragraph 2 above for full definition), there is already some capability of moving water within the zone. On the other hand, if water is delivered in significant quantity at the border, unless there is an existing link some additional pipeline capacity is likely to be required to convey it to where it is needed. Therefore we assume the notional pipeline only needs to go part of the way from the border to the centre; in the absence of better information we assume it goes half way on average. In effect, the transportation cost is half the cost of a centre-to-centre pipeline. We

considered this to be a plausible assumption given that most zones tend to have large trunk mains within the central part of their region but sometimes not at the edges.



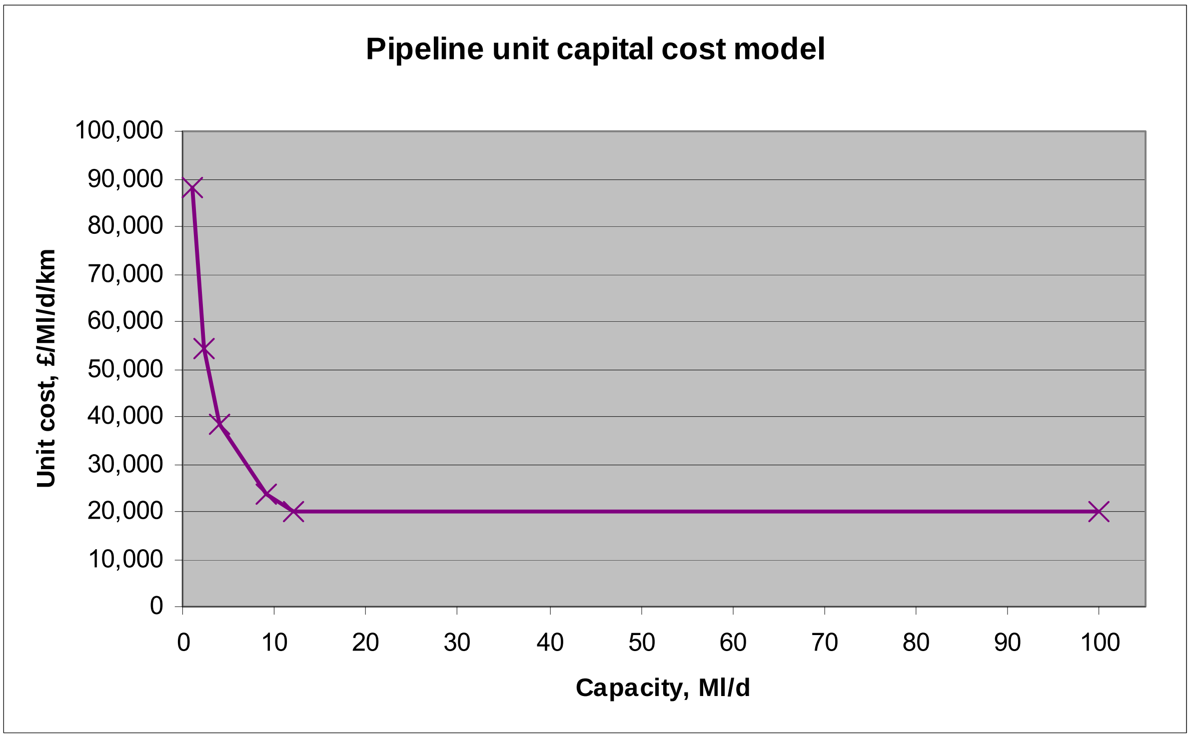
120. If the pipeline has to cross other zones between source and destination, there is likely to be capacity within the intervening zones to move water part of the way across them (and there may be further gains from connecting up these zones). Therefore we continue to assume that the aggregate length of new pipeline connections is half the distance between the centres of the source and destination zones.

121. In estimating the pipeline length we could have taken into account the qualitative assessment of interconnection within the water resource zones carried out by the Cave review team as this would allow us to assess to what extent water could be transported across a zone. However, as this information was qualitative and in theory all water should be transportable across water resource zones we decided building this additional element into our modelling work would make the analysis more complicated and not necessarily improve its accuracy.

122. We developed a pipeline cost model to estimate the cost per unit length of the interconnecting pipes as a function of their capacity in megalitres[40] (Ml) of water per day. We drew on several sources of information including our cost base model, existing internal analysis and estimates of interconnection costs made by water companies.

123. Based on this information we estimate pipeline unit capital costs to be approximately as presented in the diagram below.

[40] A megalitre or Ml is equivalent to 1,000m^3 or 1 million litres of water.



Source: Ofwat

124. These unit costs are high for small capacities because of the fixed costs associated with laying pipes and the economies of scale from larger pipes. We see this particularly in the cost base estimates for pipe diameters below 300mm and capacities below around 10 Ml/d. These economies occur because pipe diameter is an important cost driver, whereas capacity increases with cross-sectional area, proportional to the square of diameter. Also, frictional losses are lower in a large pipe.

125. However very large diameters present additional engineering challenges and we see unit costs decline very slowly beyond 40 Ml/d (around 600mm diameter). Based on the diverse spot figures that we have, £20,000/Ml/d/km is a fair estimate for these pipe sizes. The following paragraphs detail the cost estimate for these larger pipes.

126. In order to reconcile the small and large diameter datasets, we have introduced a breakpoint at approximately 12 Ml/d above which the unit cost is constant and below which it rises steeply in line with the inverse power relationship $(F/12.076)^{-0.6}$, where F is the flow rate.

127. For pipelines the asset life is long and we assume it is indefinite. The annual cost is then the capital cost divided by discount rate. Assuming a real discount rate of 4.5%, the annual cost is £20,000/Ml/d/km * 4.5% = £900/Ml/d/km a year.

128. We estimate the fixed operating costs for maintenance as 1% of the capital cost for the pipeline itself and 2% for pumping stations, to include periodic pump replacement. For a typical scheme this gives overall maintenance costs of around 1.2% of capital expenditure or £240/Ml/d/km a year. We consider these figures conservative ie maintenance may cost less. This adds £240/Ml/d/km to the annual cost, making fixed costs a total of £1,140/Ml/d/km a year.

129. However the AISCs for water resources are expressed in volume terms, so we need to spread the fixed costs over an assumed number of days operation (292 days a year). This means the fixed cost per unit volume is £3.90/Ml/km or 0.39p/m^3/km.

130. The electricity consumption for pumping depends very much on scheme design, particularly the balance between pipeline diameter and pumping effort. In the examples we looked at, we found a consumption of 0.01kWh/m^3/km was typical for larger capacities. We have priced electricity conservatively at 10p/kWh to allow for likely future real rises in electricity prices. Therefore pumping costs are 0.1p/m^3/km.

131. Hence the total cost per unit volume is 0.49p/m^3/km for the larger pipes.

132. For smaller pipelines, capital costs rise rapidly as discussed above and maintenance costs rise at the same rate because they are proportional to capital costs. Pumping costs rise because of greater friction, and we assume these costs rise in line with the fixed costs, considering that the rapid rise in the latter should adequately capture the effect on pumping costs. Hence for flows ‘F’ below 12.076Ml/d we increase the total unit cost by a factor of $(F/12.076)^{-0.6}$.

Step 5 – Investigating higher-value opportunities in greater detail

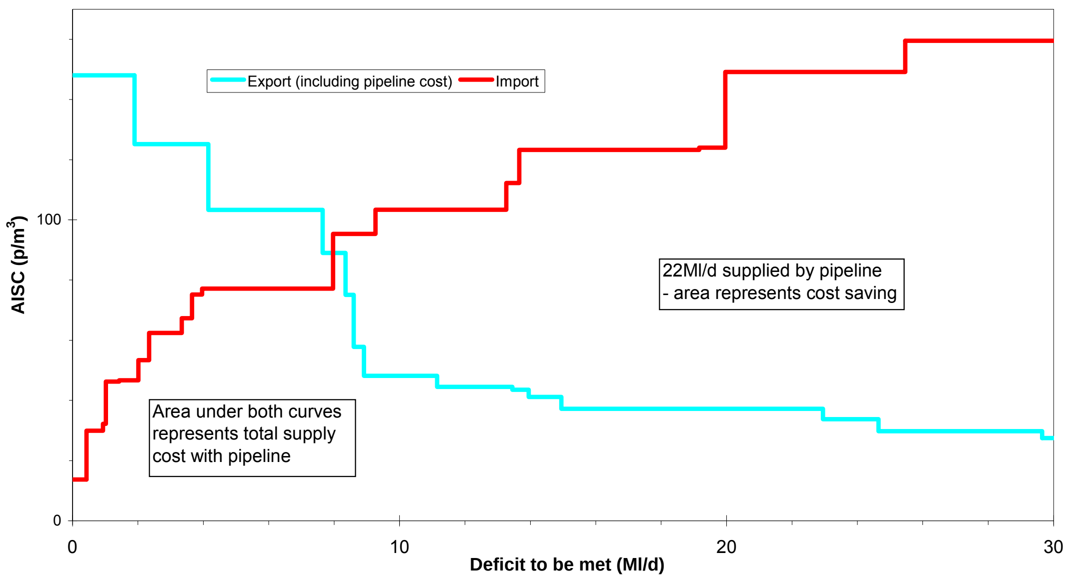
133. We ranked the base case estimates in descending order and investigated the higher value ones in greater detail and, if possible, produced a ‘best estimate’. We did this for all base case estimates above £15m and selected others, covering more than 80% of the aggregate base case estimate.

134. The chart below shows how the ‘best estimate’ is calculated. In this example the projected deficit to be met in 2035 by the importing zone (and any deficit in the exporting zone) is 30 Ml / day. The importing region’s costs of developing water resources are given by the red line. The importing zone will develop its cheapest water supply options first so its options to meet 30Ml/day are ranked from left to right by cost. In this example the importing zone’s first scheme costs about 15p/m^3 and its last scheme required to meet its deficit in 2035 costs 160p/m^3.

135. The blue line on the graph represents the new water supply options open to the importing zone if it purchases water from the exporting zone. The cost of the pipeline is included in the cost of the exporting zone schemes.

136. By flipping round the exporting zone's water supply options and ranking them from highest cost to lowest cost the graph illustrates which schemes the importing zone will use to meet its projected supply deficit in 2035. The importing zone will still develop its cheapest water supply options as part of the programme to meet the deficit (these are the options on the red line to the left of where it crosses the blue line). However, instead of developing its higher cost schemes (the red line to the right of the point where it crosses the blue line) it will import the rest from the exporting zone as the cost is cheaper. In the graph the total saving in resource costs is given by the area under the red line and above the blue line to the right of where the two lines intersect.

Optimising supplies using interconnection



Source: Ofwat example based on information from water companies' draft WRMPs.

137. We are only able to calculate a 'best estimate' in around half the cases. This is because in many zones with a surplus (or a very small deficit) companies have not developed options, since they do not need them to satisfy demand in the zone.

138. For those interconnections where we have not calculated a 'best estimate' we used the results from our 'base case' estimate instead. This gives us our 'hybrid' results which is the most accurate we can be with our current level of information.

Additional pumping

139. In our more detailed work we also considered whether the pipeline was likely to run uphill or downhill and estimated the effect on the pumping head (measured in metres).

140. The work done to lift 1m^3 of water through 1m is 9.8kJ. Assuming the pump efficiency is 70%[41], the energy required is 14kJ or, dividing by 3,600 seconds in an hour, 0.00389kWh/m^3/m. Assuming as before an electricity price of 10p/kWh, the cost is some 0.04p/m^3/m.

141. Based on our internal work we assume the fixed costs of pumping stations is around half the energy cost for 80% load factor and may be less if energy costs have risen faster than construction / equipment costs. But uprating pumping stations that are required in any case will have significantly lower costs. Therefore the unit cost of additional pumping is unlikely to exceed 0.06p/m^3/m pumping head.

142. Many interconnections are level or slightly downhill and no additional pumping is required. The highest additional cost was 7.8p/m^3 corresponding to a 130m rise.

Step 6 – Including a value of water based on scarcity

143. One of the current anomalies of the water sector compared to most other industries is that the raw material, raw water, is hardly traded and has no value attached to it. Ofwat, the Environment Agency, the Cave Review and the Walker Review all consider that revealing a value for water will be important for the efficient use and allocation of scarce water resources.

144. The Environment Agency uses Catchment Abstraction Management Strategies (CAMS) to identify catchment areas where there is over-abstraction, over-licensing, no water available and water available. We assigned arbitrary but plausible values of water in p/m^3 which vary according to the abstraction status of an area. We assumed that the value of water increased significantly once an area was over-abstracted given the environmental damage caused at low flows. It is the differentials between these values that affect the results of the interconnection modelling.

[41] Twort et al (2000) Water Supply, 5th edition, page 552 gives the overall efficiency of electrically driven pumps as about 75% but says it can be significantly worse for small or variable speed pumps.

Table A1-2 EA's assessment of water resource availability status and assumed abstraction price for purpose of assigning a value to abstracted water based on scarcity

Resource availability status	Licence availability	Assumed abstraction price, p/m^3
Water available	Water is likely to be available at all flows including low flows. Restrictions may apply.	0
No water available	No water is available for further licensing at low flows. Water may be available at higher flows with appropriate restrictions.	10
Over-licensed	Current actual abstraction is such that no water is available at low flows. If existing licences were used to their full allocation they could cause unacceptable environmental damage at low flows. Water may be available at high flows, with appropriate restrictions.	20
Over-abstracted	Existing abstraction is causing unacceptable damage to the environment at low flows. Water may still be available at high flows, with appropriate restrictions.	50

Source: EA and Ofwat assumptions

145. The CAMS areas do not coincide with water resource zones (since one reflects river systems and the other pipe networks). We superimposed the water resource zone boundaries on the CAMS surface water and groundwater maps and made a subjective assessment of the resource availability status for each zone. We repeated step 4 (the base estimates) with incremental unit costs that included the resulting values of water.

Annex 2 Full set of results of the interconnection study

146. The table below shows all 31 interconnections we identified as having a positive NPV in our model. These interconnections give an idea of where profitable interconnections might be made. However, each individual interconnection would require a lot more analysis to determine its viability. In addition, a market based approach would be likely to reveal more information and lead to different interconnections being built.

Table A2-1 Interconnections with positive NPVs

Map zone number	Name of zone	Map zone number	Name of zone	Value (£ million over lifetime)
97	Veolia Water Central - Central	94	Thames - Slough Wycombe & Aylesbury (SWA)	91
46	Northumbrian - Essex	98	Veolia Water Central - Northern	85
2	Anglian - East Suffolk and Essex	89	Veolia Water East - Veolia Water East	65
84 east	Southern - Sussex Brighton	90	Thames - Guildford	63
82	Southern - Kent Medway	87	Sutton & East Surrey - East Surrey	59
93	Thames - London	99	Veolia Water Central - Southern	51
50	Veolia Water Southeast - Hills	83	Southern - Kent Thanet	43
7	Anglian - Lincolnshire Fens	12	Anglian - South Humberside	40
57	South East - RZ7	87	Sutton & East Surrey - East Surrey	27
9	Anglian - North Norfolk Coast	1	Anglian - Cambridgeshire and West Suffolk	25
15	Bristol - Bristol Water	105	Wessex - North	24
93	Thames - London	92	Thames - Kennet Valley	15
51, 53 & 55	South East - RZ8	87	Sutton & East Surrey - East Surrey	16
68	Severn Trent - Staffs and East Shropshire	74	South Staffs - South Staffs	15
5	Anglian - Lincoln	12	Anglian - South Humberside	14
11	Anglian - Ruthamford	16	Cambridge - Cambridge	14
52, 54 & 56	South East - RZ6	87	Sutton & East Surrey - East Surrey	11
93	Thames - London	91	Thames - Henley	11
64	SVT - East Midlands	74	South Staffs - South Staffs	9

86	SRN - Sussex North	90	Thames - Guildford	7
48	Northumbrian - Suffolk Northern Central	45	Northumbrian - Suffolk Blyth	7
8	Anglian - Norfolk Rural	1	Anglian - Cambridgeshire and West Suffolk	6
3	Anglian - Fenland	1	Anglian - Cambridgeshire and West Suffolk	4
22	Dŵr Cymru - Bala	24	Dŵr Cymru - Blaenau Ffestiniog	4
67	Severn Trent - Severn	29	Dŵr Cymru - Hereford C.U. Area	3
35	Dŵr Cymru - North Eryri / Ynys Mon	30	Dŵr Cymru - Lleyn / Harlech	2
40	Dŵr Cymru - South Meirionnydd	24	Dŵr Cymru - Blaenau Ffestiniog	2
26	Dŵr Cymru - Clwyd Coastal	21	Dŵr Cymru - Alwen / Dee	2
42	Dŵr Cymru - Tywyn / Aberdyfi	34	Dŵr Cymru - North Ceredigion	2
69	South East - RZ3	87	Sutton & East Surrey - East Surrey	1
47	Northumbrian - Suffolk Hartismere	45	Northumbrian - Suffolk Blyth	0.8

Source: Ofwat calculations based on data in draft WRMPs.

147. Our methodology only looked at interconnections between nearby individual zones. We only considered ‘multi-zone’ connections where several water resources zones with relatively cheap water supply options supply a single water supply zone with relatively expensive supply options in the case of London. We did not consider ‘chain’ connections where there is a chain of displacement from a water resource zone with abundant water supplies to a water resource zone with a large water supply deficit through a series of intermediate zones which switch the direction of the water flows.

148. Considering chain connections would be likely to affect the ranking in the tables above. We would expect schemes that used water from Wales and the west and north of England to supply southern and eastern England through a chain of displacement to be feature in the most profitable schemes.

Annex 3 Evidence on interconnection from other industries

149. We have looked at the evidence on interconnectors from other sectors. The available evidence comes from the energy sector and this annex summarises our main findings.

Predicted benefits of interconnectors

150. Two recent studies look at the predicted benefits of electricity interconnectors between Norway and the Netherlands (NorNed) and between the Irish and UK electricity markets (the East-West Electricity Interconnector called 'EWIC'). These detailed studies set out some of the benefits expected from the interconnectors.

151. The NorNed interconnector was built to arbitrage price differences between the Dutch market (APX) and the Norwegian market (Nordpool). It cost €550 million to build with operating costs of €4 million per year. Some of the main projected benefits were that the interconnector increased the range of electricity sources open to both markets with the Norwegian market being predominantly supplied by hydro power and the Dutch market predominately supplied by fossil fuels. This resulted in short-term cost differences between the markets and allowed productive efficiency gains by each market being able to access the cheapest source of energy at any point in time. It also generated allocative efficiencies as prices were closer to marginal cost.

152. The NorNed interconnector was predicted to lead to security of supply benefits as the interconnector was more reliable than a new generating unit of the same capacity in either country. The link allowed for reduced water storage levels in Norway and lower installed capacity in the Netherlands with consequential reductions in capital costs.

153. A further benefit of the NorNed interconnector was to improve competition within the Dutch energy market. Giesbertz and Mulder (2008)[42] discussed the problem that in the relatively concentrated Dutch electricity market some market players were often 'pivotal' (i.e. had to be in the market for demand to be satisfied) and this pushed the market price up compared to the underlying costs of production. Interconnection, by introducing more players into the market, makes the existing market participants pivotal to a lesser extent or less frequently and the wholesale price will decrease compared to what it would be without the interconnector.

[42] Giesbertz, P. and M. Mulder (2008). "Economics of Interconnection: the Case of the Northwest European Electricity Market,"

154. Matsukawa and Mulder (2009)[43] looked at the benefits to the environment of less carbon dioxide emissions from importing hydropower from Norway into the Netherlands using data from the first 8 months of operation of the NorNed interconnector. They estimated the benefits at circa €60 million each year. This estimate was purely looking at environmental benefits of NorNed.

155. Eirgrid's[44] business case for the Ireland-UK electricity interconnector (EWIC)[45] anticipated that the interconnection would provide a security of supply benefit to Ireland by providing greater diversity of fuel sources. This would also allow Ireland to develop more wind power generation for which base load back up is required which could come through the interconnector. It would also allow for the export of any surplus wind power to the UK at times of high production wind power production. The EWIC would also promote further competition in the Irish electricity market and put downward pressure on prices.

156. The EWIC report cited evidence from Northern Ireland Electricity (NIE)[46] that the largest industrial users in Northern Ireland have seen prices fall by 10% since the commissioning of the Moyle interconnector from Northern Ireland to Scotland[47] and that the capital costs of that interconnector had already been recovered by the income from auctions of the interconnector's capacity. In summary Eirgrid forecast that the interconnector would cost up to €600 million to develop but deliver a total benefit of almost €1 billion to Ireland over its 30 year economic life-time.

Interconnection and price convergence

157. There are also several studies on the effect of interconnection on price convergence between markets. This is one of the main benefits of interconnection as it allows the entire new market to be served at the lowest overall cost. If prices continued to differ between the interconnected zones less efficient plants in the higher cost zone would continue to operate (productive inefficiency) and consumers in the higher cost zone would pay more for their electricity that similar consumers in the lower cost zone (allocative inefficiency).

[43] Matsukawa, I. and M. Mulder (2009) "External costs of interconnection: the case of NorNed"

[44] EirGrid Plc is the state-owned electric power transmission operator in the Republic of Ireland.
[45] Eirgrid Plc (2008) "Business case – the establishment of an East West Electricity Interconnector"
[46] Northern Ireland Electricity Plc (NIE) is the electricity transmission company in Northern Ireland.
[47] This figure is also quote in the NIE press release of 14 February 2002 "Disposal of Moyle Interconnector" http://www.nie.co.uk/media/newsstory.asp?idcode=483

158. Neumann et al (2005)[48] looked at evidence from gas prices on the effect of the UK-Zeebrugge (Belgium) gas interconnector and the Zeebrugge-Bunde (Dutch / German border) interconnector. They found that there was full convergence in prices between the UK and Belgium and that there was significant liquidity around both ends of the interconnectors. However, Neumann et al found that prices had not converged at either end of the Zeebrugge–Bunde link as there was a lack of liquidity at Bunde. This lesson here is that both interconnection and liquid markets at either end of the interconnector are required for prices to convergence and hence for the full efficiency benefits of interconnection to be realised.

159. Cuddington and Wang (2006)[49] examined the effects of the reforms implemented in the US natural gas market by the Federal Energy Regulatory Commission (FERC). The FERC created ‘open access’ to all market participants on a non-discriminatory basis with the aim of fostering greater competition among producers and gas shipper to create a market that was ‘national’ in scope and efficient in allocating resource. Cuddington and Wang looked at daily spot prices at 76 market locations from 1993 to 1997 and found that the East and Central regions of the US formed a highly integrated market with price convergence and quick movements back to converged prices after price shocks as a result of the FERC’s market opening reforms. They also found that the East-Central market was quite segmented from the Western market as there was less convergence of prices.

160. The Australian Energy Regulator (AER)[50] looked at the impact of interconnecting Australia’s state electricity markets through the National Electricity Market (NEM) [51] on price convergence. The AER found that following the construction of interconnectors between the Australian states the NEM now operates as an ‘integrated’ market with price alignment across all regions for around 75 per cent of the time.

161. A notable example of when an interconnection did not lead to price convergence on some occasions was the UK / Belgium gas interconnector that came into operation in October 1998. The interconnector was originally built to take UK gas to the continent (forward flow) but it could also be used to import gas to the UK from the continent (reverse flow). During the winter of 2000-01 gas flowed from the UK to

[48] Neumann, A., Silverstovs, B. and Hirschhausen, C. (2005). Convergence of European Spot Market Prices for Natural Gas? A real- Time Analysis of Market Integration using the Kalman Filter, Working Paper, Chair of Energy Economics and Public Sector Management, Technical University of Dresden, pp. 1-12.
[49] Cuddington, John T. and Zhongmin Wang. (2006) “The Integration of U.S. Natural Gas Spot Markets: Evidence from Daily Price Data,” Journal of Regulatory Economics 29 (2006), 195-210.
[50] Australian Energy Regulator (2007) “State of the energy market 2007” and Australian Energy Regulator (2008) “State of the energy market 2008”.
[51] The NEM linked up Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory (ACT) from December 1998 and Tasmania from 2005.

the continent despite gas prices being higher in the UK market than on the continent. The European Commission investigated[52] whether this uneconomic flow might have been due to cartel-like behaviour. The European Commission found no evidence of competition law infringements, but attributed the uneconomic flow to the continental market being less liberalised than the UK market and rigidities in the rules governing the interconnector. These stopped gas shippers from taking advantage of the price differential.

162. Since 2001 gas has tended to flow from the continent to the UK during the winter. This was due to more flexible interconnector rules and the expansion of reverse flow capacity on the interconnector. However, there are still physical constraints on the network supplying the Belgian end of the interconnector which constrain the flow of gas into the UK through the interconnector. Some market participants also consider that public service obligations in various European countries incentivise gas companies to store their gas early in the winter rather than sell it in case they need to use it later in the winter.

163. The UK-Belgium gas interconnector reinforces the point that functioning markets at each end of the interconnector increase the benefits from the interconnector. It also shows that other parts of the network might need to be strengthened to achieve the full benefits of interconnection.

The effect on prices in the exporting region

164. One issue with interconnection is that it might tend to increase wholesale prices in the exporting company's area. This is a consequence of the price convergence effect of interconnecting markets; prices will tend to fall in the historically higher cost importing region, but may rise in the lower cost exporting region. Consumers as a whole will be better off but there might be distributional consequences.

165. It is worth noting in this context that the impact of interconnection on prices depends on the size of the interconnector relative to the two markets it links up. If an interconnector is small relative to the size of the markets it links then the flows through the interconnector may not be large enough to increase supply sufficiently in the importing zone to push down the wholesale price or to reduce supply in the exporting zone to increase the wholesale price; as a result prices would not fully converge if the capacity of the interconnector is insufficient. The process of price changes might occur over time in discrete steps if it takes time and several

52 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/02/401&format=HTML&aged=0&language=EN&guiLanguage=en

interconnectors to link up the market as seems to have been the case in the US gas market.

166. However, the tendency for prices to rise in the exporting zone is likely to be countered by other effects. First, if the interconnector is used in both directions it is likely to reduce the wholesale price in the net-exporting zone at those times. For example, the exporting zone might incur high production costs for 10% of the time which would be included in wholesale prices and passed on to consumers. However, with the interconnector at such time the exporting zone, even though it is generally the lower cost zone, could import from the usually importing zone. This would allow exporting zone customers to benefit from the interconnector directly. The impact of this effect depends on the extent to which costs over time are correlated in the importing and exporting zone. The flows in the interconnector will determine what proportion of the benefits to consumers accrues in which zone. An empirical example is that when the Queensland and New South Wales electricity markets were interconnected as part of Australia's NEM prices fell in both states. This was in part because the interconnector was used in both directions.

167. Most importantly, the longer-term benefits of interconnection mentioned above will put downward pressure on the wholesale price in the exporting zone. The impact of increased competition in the exporting zone market and the avoided investment due to the security of supply benefits will tend to lower the wholesale price across the whole region. Over time we would expect the benefits of interconnection to outweigh the tendency for interconnection to raise the wholesale price in the exporting zone.

Summary of main findings

168. The evidence on interconnection from the energy sector can be summarised as follows. Interconnection leads to an increase in productive efficiency as a given amount of energy is produced at the least cost by the most efficient plants. Second, there is an allocative efficiency gain as price differences are reduced across a large region and resources are therefore allocated to the right production activities across the region. Third, there is a security of supply benefit from increased interconnection as a lower reserve is required for back up capacity and there is often an increase in the diversity of supply sources available as a result of the interconnector. Fourth, there can be benefits to the environment in the electricity sector from interconnection as areas with excess 'green' energy such as Norway can export it to other markets and less reliable 'green' energy sources such as wind power can be used more often if there is more back up capacity through an interconnector. A fifth lesson is that interconnectors can improve competition in domestic markets as suggested in the Ireland and Netherlands examples.

169. The evidence shows that interconnection and upstream competition are complementary and that interconnectors deliver more benefits where upstream competition is working well in addition to stimulating improvements in the way markets work.

Annex 4 Evidence on the benefits of competition for dynamic efficiency

170. In section C we referred to empirical studies on the relationship between competition and productivity as well as between market reforms and productivity. This annex provides more detail on those studies.

<u>Empirical evidence on the relationship between competition across the economy and productivity</u>

171. The OFT (2007)[53] carried out a comprehensive review on the evidence that competition drives productivity. These are summarised in the table below.

Table A4-1 Effects of competition on productivity

Study	Findings
Haskel (1991)[54]	Used detailed UK panel data on firms in the period 1980-86. He found that high levels of market concentration and market share have an adverse effect on total factor productivity.
Nickell (1996) [55]	Used data from the published account of 700 British manufacturing firms between 1972 and 1986 and found that a 10% increase in price mark-ups resulted in a 1.3 to 1.6 per cent loss in TFP growth.
Disney, Haskel and Heden (2003) [56]	Used the ARD database with 60,000 observations from 143,000 UK manufacturing firms between 1980 and 1992. They found that falls in rents (excess profits) and market share increase both current productivity levels and productivity growth.
Blanchflower and Machin (1995)[57]	Measured competition as reported by participants in the Workplace Industrial Relations Survey. They could not find a positive relationship between labour productivity and competition in the UK but could for Australia. It is worth noting the subjective nature of the measure of competition in this survey.

[53] See footnote above for reference to OFT (2007).
[54] Haskel, J (1991) 'Imperfect Competition, Work Practices and Productivity Growth', Oxford Bulletin of Economics and Statistics, vol 53(3).
[55] Nickell, S.J. (1996), 'Competition and Corporate Performance. *Journal of Political Economy*, Vol. 104.
[56] Disney, R., Haskel, J. and Heden, Y. (2003), Restructuring and Productivity Growth in UK Manufacturing, *Economic Journal*, Vol. 113.

172. Some of the studies above and other studies have looked at evidence for the specific ways in which competition drives productivity: within firm effects, between firm effects and innovation. These were discussed in Box 2 of the main paper.

Empirical evidence on market reforms and productivity

173. The OFT (2007) presented considerable empirical evidence to show that market reforms in network utilities and other non-utility sectors lead to improved productivity performance. We have summarised the most relevant articles from the OFT survey and others we have found in the table below.

Table A4-2 Effects of market liberalisation on productivity

Study	Findings
Wei Li and Lixin Colin Xu (2005) [58]	Competition increased the rate of TFP growth by 33% to 87% in Japanese and world telecoms sectors.
Dassler, Parker and Saal (2001)[59]	TFP performance improved in UK telecommunications after the introduction of full competition. However, the study did not find comparable results for some other countries.
Maher and Wise (2005)[60]	Competition introduced into UK electricity and gas resulted in rates of productivity growth of just over 10% in the 1990s.
Boylaud (2000)[61]	Liberalisation of road freight industry in OECD countries lead to productivity gains.
Olley and Pakes (1996)[62]	Survey of deregulation in US telecommunications found productivity gains.
Gort and Sung (1999)[63]	Found TFP growth rates between 7 and 14 times higher in competitive US telecoms markets than in regional telecoms monopolies during 1985-91.
Nicoletti and Scarpetta (2003)[64]	Aligning the regulatory stance in European countries with the most liberal OECD country for product market regulation would raise TFP growth over ten years by up to 1.1%.

[57] Blanchflower, D and Machin, S (1996) ‘Produce market competition, wages and productivity: international evidence from establishment-level data’, Centre for Economic Performance, Discussion paper no. 286.
[58] Wei Li and Lixin Colin Xu, (2002) ‘The impact of privatisation and competition in the telecommunications sector around the world’, The World Bank, October 2002.
[59] Dassler, T., Parker, D. and Saal, David S. (2001) “Economic performance in European telecommunications, 1978-98: A comparative study” Aston Business School Research Paper 0108.
[60] Maher, M. and Wise, M. (2005), ‘Product Market Competition and Economic Performance in the United Kingdom’, OECD Economics Department Working Papers, No. 433.
[61] Boylaud, O. (2000), ‘Regulatory reform in road freight and retail industry’, OECD Economics Department Working Paper, No. 255.
[62] Olley, S. G. and Pakes, A. (1996), ‘The Dynamics of Productivity in the Telecommunications Equipment Industry’, Econometrica, 64(6).
[63] Gort, M. and Sung, N. (1999), ‘Competition and productivity growth: the case of the US telephone industry’, Economic Inquiry, Vol. 37, No. 4.

Alesina et al (2005)[65]	Find strong effects of deregulation on investment in utilities, transport and communications from 1975 to 1998.
Australian Productivity Commission	Australian competition reforms in the early 1990s lead to reductions in prices in the electricity, rail freight and port sectors.

How market reforms affect innovation

174. There is evidence that market reforms can sometimes lower research and development (R&D) spending and usually lead to a re-orienting of R&D towards more commercial objectives. Jamasb and Pollitt (2008)[66] found that pro-competitive reforms in the electricity sector coincided with a significant decline in energy R&D activities. However, they also found that R&D productivity and innovative output appeared to have improved in line with general improvements in the operating efficiency of the sector resulting from the pro-competitive reforms.

175. Calderini and Garrone (2003)[67] found that the effect of liberalisation on 17 former telecoms monopolies was a decline in publication activity (a proxy for basic research) but a rise in patenting activity (a proxy for applied research). Defeuilley and Furtado (2000)[68] looking at electricity reforms in the UK and USA also found that liberalisation caused R&D spending to decline and that R&D spending was re-oriented towards concrete applications that offered commercial advantage. Sanyal and Cohen (2004)[69] found that different measures of effective competition had different effects on R&D expenditure, some positive and some negative. Markard et al (2004)[70] found in the electricity sector a shift in the focus of R&D from technology-based solutions to customer-oriented product and organisational innovations. Jacquire-Roux and Bourgeois (2002)[71] found that liberalisation led to some reduction

[64] Nicoletti, G. & Scarpetta, S. (2005), 'Product Market Reforms and Employment in OECD Countries', OECD Economics Department Working Papers, 472.
[65] Alberto Alesina, Silvia Ardagna, Giuseppe Nicoletti and Fabio Schiantarelli (2005) "Regulation And Investment," Journal of the European Economic Association, MIT Press, vol. 3(4), pages 791-825, 06.
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[70] Markard, J., Truffer, B., and Imboden, D. M. (2004). The impacts of liberalisation on innovation processes in the electricity sector, *Energy & Environment*, Vol. 15, No. 2, 201-214.
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in R&D spending but led to a modest increase in patenting activity in a large international sample of utilities and a considerable increase for petroleum sector firms.

176. The conclusion from the literature seems to be that whilst there may be a decline in measured R&D spending and basic research there is a reorienting of research towards more commercial applications. This may explain why market liberalisation is associated with a fall in R&D expenditure but also with an increase in commercial innovation and increases in productivity.

Empirical evidence on the amount by which market reforms increase productivity

177. In Ofwat's Review of Competition Part II we referred to a paper by Wei Li and Lixin Colin Xu (2005) who found that the introduction of competition into telecoms sectors increased the rate of TFP growth by 33% to 87%. The OECD has also looked at increases in efficiency resulting from market reforms which are summarised in the table below. The OECD's results are presented as total increases in efficiency rather than increases in productivity growth rates.

Table A4-3 Effects of product market liberalisation on productivity

Authors	Sector and country	Estimate of effect on productivity / efficiency
Wei Li and Lixin Colin Xu (2005) [72]	Telecoms in Japan	33% to 87% increase in TFP growth rates
OECD (1999a)[73]	Air travel in USA	15% increase in efficiency
OECD (1999b)[74]	Telecoms in Mexico	46% increase in efficiency
OECD (2000)[75]	Telecoms in Korea	27% increase in efficiency

[72] 'The impact of privatisation and competition in the telecommunications sector around the world', Wei Li and Lixin Colin Xu, The World Bank, October 2002.
[73] OECD (1999a), Regulatory Reform in the United States, Paris.
[74] OECD (1999b), Regulatory Reform in Mexico, Paris.
[75] OECD (2000), Regulatory Reform in Korea, Paris.

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