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Demand Side Response

A Discussion Paper

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Target audience: Energy suppliers, distribution companies, consumers, aggregators, system operators, academics, and others with an interest in demand side response.

Overview:

The wholesale price of energy, in common with other goods, is cheaper when demand is lower and more expensive when demand is higher. For electricity, demand is typically highest in the early evening on a daily basis, while for gas the variation is more seasonal with demand being higher in winter. This paper, the second in a series of discussion papers, considers the outlook for customers playing a more active role in the energy market by changing the times at which they consume electricity. Specifically, this paper considers how increasing the ability of consumers to be more flexible in their electricity use can contribute to secure and sustainable energy supplies and help to achieve financial and environmental benefits. It also sets out various issues that need consideration to encourage greater demand side response in the electricity sector.

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Context

This paper is the second in a series of ad hoc discussion papers. We published our first discussion paper in July 2009, entitled "Can energy charges encourage energy efficiency?" Discussion papers are different from most of our other publications. They do not set policy positions or announce decisions. Instead, they are intended to present some experimental thinking on emerging subject areas and promote further debate.

The role of demand side response has been highlighted in a number of debates on the future evolution of the energy market. The previous Government's Low Carbon Transition Plan of July 2009 highlighted the need for a more flexible energy system to meet the goal of an 80% reduction in carbon emissions by 2020. In Ofgem's Discovery consultation of February 2010, we said that industrial and commercial consumers are active in demand side response, but participation could be increased and extended to the mass market if short-term price signals are sharpened and barriers are removed. The Energy Networks Strategy Group, in its Smart Grid Roadmap, has highlighted the role for more active network management. Furthermore, in the Energy Market Assessment of March 2010, enabling better demand side response would be pursued in all of the options set out for energy market reform. Finally, the Coalition Government plans to continue with the previous Government's programme to roll-out smart meters to all customers. This creates the potential for domestic and small business customers to play a more active role in the energy market.

Associated Documents

- Can energy charges encourage energy efficiency? Ofgem, 2009
- A smart grid routemap, ENSG, 2010
- Energy Supply Probe- Initial Findings Report, Ofgem 2008
- Energy Supply Probe- Proposed Retail Market Remedies, Ofgem, 2009
- Electricity Distribution Price Control Review Final Proposals, Ofgem, 2009
- Regulating energy networks for the future: RPI-X@20 Emerging Thinking, Ofgem, 2010

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Summary

Demand side response is an important and developing theme to Ofgem's work and consistent with our principal statutory duty to protect the interests of consumers. This discussion paper looks at how changes to the way consumers use electricity could result in both cost and carbon savings and lead to more secure and sustainable energy supplies. We primarily concentrate on electricity usage, although changes to gas usage can also lead to benefits.

In simple terms, demand side response involves electricity users varying demand due to changes in the balance between supply and demand, usually in response to prices. In many markets, supply and demand naturally respond to each other's signals to find a balance. However, electricity is unusual as a product because it cannot be stored cheaply or in great quantities so supply and demand has to balance simultaneously. In most cases, it is easier for centralised and flexible power stations to adjust to maintain this balance rather than the decentralised (and therefore difficult to coordinate) and relatively inflexible customer demand. Therefore, electricity demand side response is not "natural", but it can be both beneficial and necessary in a number of ways.

In our Project Discovery consultation in February, Ofgem identified the vital role that demand side response can play in maintaining secure and sustainable energy supplies. We recognised that large energy users are currently active in providing demand side response but participation could be enhanced, and extended to other consumer segments, if sharper financial incentives were introduced. This would ensure that customers who place a high value on receiving a continuous supply, usually domestic consumers and small businesses, would be able to do so.

In the longer term, however, demand side response could play a different role in a low carbon economy. A low carbon economy would see a fundamental change in both supply and demand. The supply mix would feature a significant increase in renewable generation. Wind, wave and tidal generation is variable in its output, and usually inflexible about the time at which it generates. To aid the transition to a low carbon economy over a similar timeframe, it is anticipated that demand for electricity will increase significantly to power transport and heating. Electric power for transport and heating has the potential to be flexible and, with the aid of smart metering, demand side response has a role to play to encourage it to shift to match supply output. The electricity system will therefore need to adapt to allow supply and demand to have a much more dynamic relationship. However, the primary tool to cope with expanding demand and the strain this will place on sources of supply should be a strong focus on energy efficiency.

Costs and benefits

Electricity demand is usually highest in the early evening and is more pronounced in winter when lighting and, to a lesser extent, heating use is high. This is also when electricity is more expensive.

To assess the impact of demand side response we have undertaken some modelling to estimate the indicative benefits of consumers shifting 5% and 10% of their electricity use in order to flatten peak demand. This analysis shows the following potential impacts, which are indicative only:

- £0.4m to £1.7m daily wholesale cost savings (based on a sample of days);
- £129m to £536m annual avoided capital costs for new generation (based on a sample of days); and
- £14m to £28m annual avoided capital costs for networks.

There are also potential environmental benefits. Provided that carbon is priced appropriately, this level of demand response would immediately lead to a daily reduction in carbon emissions of up to 0.5% (between 800 and 2,550 tCO_2 per day based on the same sample of days), which is equivalent to emissions from about 135,000 households or a town the size of Brighton.

These indicative impacts are likely to be conservative. Looking ahead, the environmental value of demand side response will increase where there is a significant proportion of wind in the generation mix. Demand side response can be used to substitute for carbon-intensive reserve generation which would be used to maintain supplies at times of low wind output. This would also reduce the costs associated with maintaining secure and sustainable energy supplies.

To achieve these benefits, however, there are likely to be associated costs. These include technology and infrastructure costs, as well as costs and inconvenience associated with changing consumption patterns.

Issues to address

The proportion of current demand that can be shifted is relatively small, although some customers, both domestic and industrial, already defer their use of electricity in response to financial signals. However, there are several issues that need to be addressed on both the consumer and industry side if the scope for demand side response is to increase.

Consumers

We have carried out some research with consumers – both domestic and business – to better understand their awareness of usage and attitudes towards making changes to the way they consume electricity. The main issues to address for consumers are:

- addressing the currently **limited financial incentives** to change usage patterns. The majority of standard tariffs do not offer incentive for consumers to shift electricity use away from periods of high demand and high prices. This includes network charges, an element of consumer costs which are not currently structured to incentivise demand side response;

- **improving awareness** for domestic and small business consumers. Most consumers are not aware that wholesale electricity prices vary across the day and year;

- overcoming difficulty in changing consumer behaviour and increasing discretionary demand through **automated response.** Smart meters and smart appliances are an effective means of promoting demand side response; and

- **sharpening short-term price signal** for industrial customers to further encourage those who are willing and able to forgo demand to do so and potentially be rewarded.

Different customers have different needs and the impact of the above actions on vulnerable and low-income customers will need careful consideration. We are mindful that appropriate consumer protection will be required

Industry

The key issues to address for industry are:

- a major barrier to suppliers is the current **balancing and settlement arrangements** for non-industrial (non-half hourly metered) customers because the benefits to a supplier in offering demand side response products are shared among all suppliers;

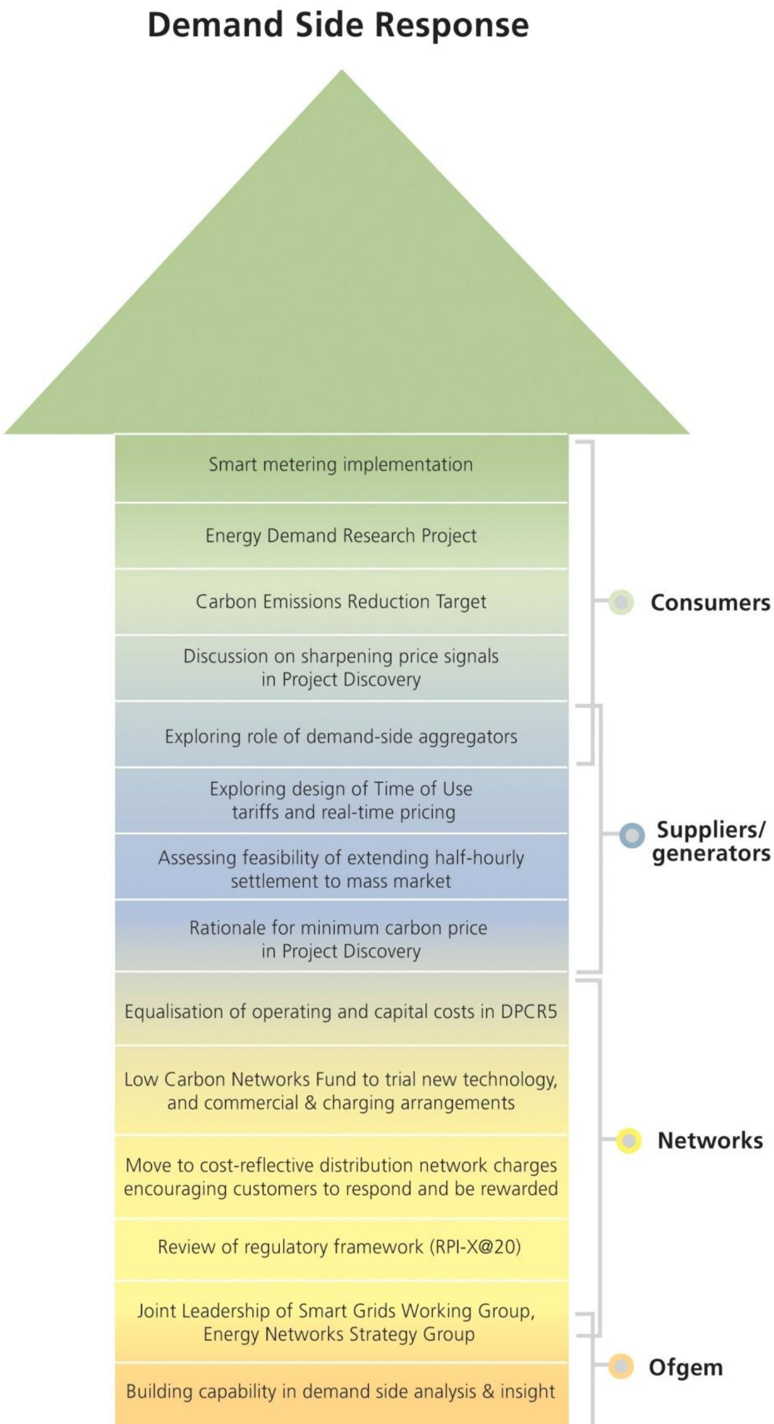
- a more **active role for networks**. As electricity flows at the distribution level become more diverse and complex, the distribution network operator will need to play a more active role in managing the network; and

- demand side response from domestic and smaller businesses needs to be both **firm and aggregated** in order for the system operator to be able to be able to buy it and realise the benefits for the electricity system.

We are addressing a number of the issues set out above, and further initiatives are underway across Ofgem and the supply chain to enable the benefits of demand side response to be realised. These initiatives are illustrated in the following diagram.

We intend to discuss the issues captured in this paper with stakeholders over the next few months, including hosting a workshop this autumn.

Figure: Ofgem initiatives across the supply chain to facilitate demand side response



1. Current demand side response

Chapter Summary

This chapter provides an overview of the current and possible future role of demand side response in the electricity market. It gives an assessment of the flexibility of current electricity demand and examines the various ways in which demand is encouraged to respond to signals across each consumer segment.

Context

1.1. The electricity system must be kept in balance by matching supply and demand within strict technical limits since electricity cannot be stored easily. Electricity demand is difficult to control and varies depending on the time of day, day of the week and the time of year. Centralised and flexible generation technologies are generally used to respond to changes in demand. During peak periods of demand, this generation is, to a greater extent, made up of relatively more expensive and carbon-intensive fossil fuels.

1.2. The Government expects renewable generation to play an important role in the UK's transition to a low carbon economy. To meet the 15% renewable energy target by 2020, renewable generation, principally wind, will need to meet around 30% of electricity demand. The variable nature of wind will bring challenges to the electricity system in terms of its ability to match supply to demand. This will be magnified by the closure of some existing fossil fuel plants used to balance the system and meet peak demand[1]. Both of these challenges will make supply less flexible in meeting demand. The electricity system will need to adapt to allow supply and demand to have a more dynamic relationship.

1.3. Demand side response (DSR) could play a role in this dynamic environment. Ofgem’s Project Discovery consultation[2] discussed options for delivering secure and sustainable energy supplies and includes an assessment of the role DSR could play in maintaining secure and sustainable supplies in the long-term. Specifically, DSR may be able to:

- reduce carbon emissions, energy costs and avoid some investment required in network and generation capacity;

[1] Due to plant reaching the end of its useful life, and EU legislation such as the Large Combustion Plant Directive (LCPD) and the Industrial Emissions Directive (IED).
[2] Project Discovery - Options for delivering secure and sustainable energy supplies, 3 February 2010.

- increase the scope of the electricity system to absorb excess renewable generation;
- improve overall system balancing and efficiency; and
- encourage efficient use of existing generating plant and network capacity.

1.4. Future developments in Great Britain (GB) are expected to facilitate DSR including the Government's plan to have smart meters in place in all households and businesses[3]. Ofgem E-Serve has been managing, on behalf of the Department of Energy and Climate Change (DECC), the first phase of a central programme to design and implement new cross-industry arrangements for the delivery of smart metering[4], with the aim of developing a scoping document by summer 2010. Smart metering will enable customers to receive more accurate and timely information, including stronger price signals. This may influence behaviour of customers by changing consumption in response to these signals. Smart meters are expected to encourage the emergence of innovative products onto the mass market, including those that could facilitate DSR, such as new pricing structures and automated controls for household appliances. The roll-out of smart meters represents a major technological change and a potential for the market to develop in a new way, creating an opportunity to better match demand to supply.

1.5. In the longer-term, electric cars and electric heating are expected to become more prevalent as part of the Government's strategy to reduce emissions from the heat and transport sectors. These developments are likely to increase electricity consumption overall and alter electricity consumption profiles. Demand from electric cars and electric heating, which have the facility to store energy, could be relatively flexible and could therefore shift in response to supply conditions. However, with respect to electric cars, this will largely depend on the type of charging infrastructure that is adopted.

1.6. In order to integrate an increasing proportion of renewable and distributed generation and accommodate increasing demand from heat and transport, the electricity system will need to be able to intelligently integrate the actions of all users connected to it, including generators, consumers and those that generate and consume electricity. The development of a smart grid will facilitate this integration by providing improved information and allowing automation (e.g. electric cars recharging automatically during periods of low prices). This will allow consumers to manage their electricity use. Ofgem, the Government and industry have worked together through the Electricity Networks Strategy Group to address issues that

[3] Press Release - 2 December 2009 - UK energy system gets smart: http://www.decc.gov.uk/en/content/cms/news/pn139/pn139.aspx
[4] Please see the following for further details: http://www.ofgem.gov.uk/e-serve/sm/Pages/sm.aspx

affect the electricity network's transition to a low carbon future, including a vision for a UK smart grid[5].

What is DSR?

In the broadest sense, DSR involves electricity consumers varying demand due to changes in the balance between supply and demand, usually in response to prices. This may result in a change to the time the electricity is used and/or a reduction in the electricity use.

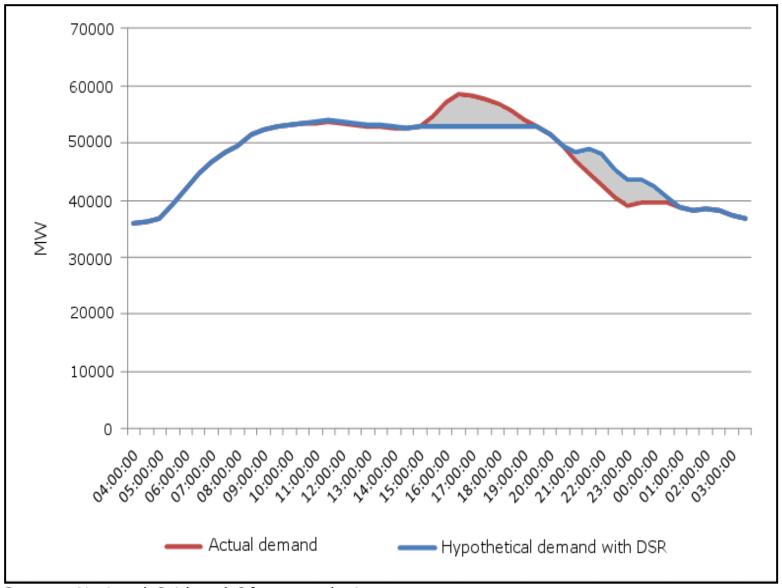
DSR can take the form of consumers shifting their electricity demand from periods of peak demand and typically high prices to periods of low demand and typically lower prices. Over time, this can result in a permanent flattening of peak demand. Peak periods in a day are typically early evening and, to a lesser extent, early morning.

Figure 1.1 shows actual demand for a typical winter's day in GB and a hypothetical demand profile with DSR (i.e. peak demand shifted to earlier and later in the day). The shaded area shows where demand has changed. Figure 1.2 shows demand profiles for a day in each season. Peak demand is most pronounced in winter and, to a lesser extent, in autumn and spring as expected.

DSR can also be used in response to system balancing requirements. This can occur if total electricity demanded in GB is greater than total available supply at any given moment, or if the reliability of the electricity system is under stress. For example, at times when there is an unusually high demand for electricity or a large generation plant has shut down for emergency repairs.

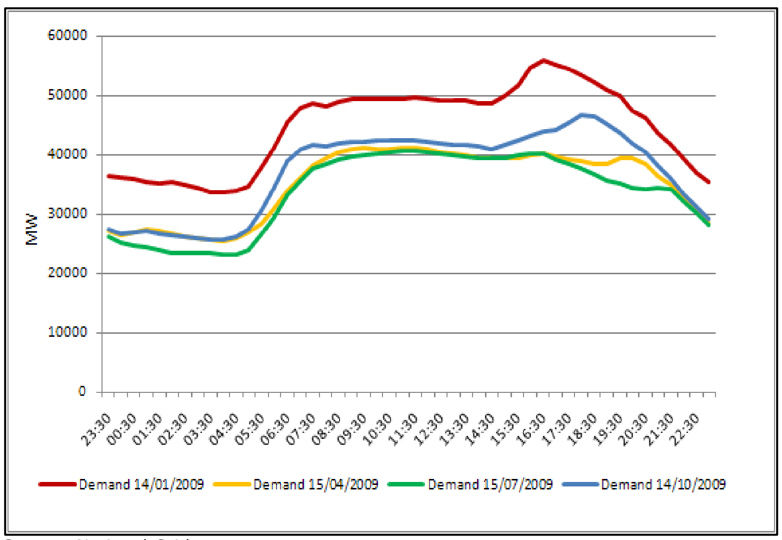
DSR reduces the need for peaking generation plants which typically run for short periods each day to meet peak periods of electricity demand.

Figure 1.1: Actual and Hypothetical Demand with DSR



Source: National Grid and Ofgem analysis

Figure 1.2: Daily Demand Profiles



Source: National Grid

[5] Energy Networks Strategy Group, A Smart Grid Roadmap

Scope

1.7. In this paper, we explore what DSR may be able to achieve across different consumer segments (domestic, small and medium enterprise or SME and industrial and commercial or I&C), and how to unlock this potential prior to the integration of renewables and the wide-spread electrification of transport and heating.

1.8. As noted above, DSR can be related to shifting or reducing electricity consumption. Although reducing demand has many benefits, the primary focus of this paper is on shifting electricity use as this is less well-understood and less documented. In addition, this paper principally focuses on the electricity sector. DSR is an important issue in the gas sector (as evidenced in early 2010[6)] but there is more limited scope particularly among domestic gas consumers to respond to price signals since cooking and heating are both largely inflexible and essential uses of gas. Additionally, gas heating is expected to decline in future due to the electrification of this sector.

1.9. The rest of this paper discusses the following areas:

- flexibility of current electricity demand profiles and existing ways of stimulating DSR in GB within each consumer sector (I&C, SME and domestic);
- potential benefits and costs of encouraging customers to shift electricity use; and
- consumer and industry-led issues that require consideration to encourage greater DSR.

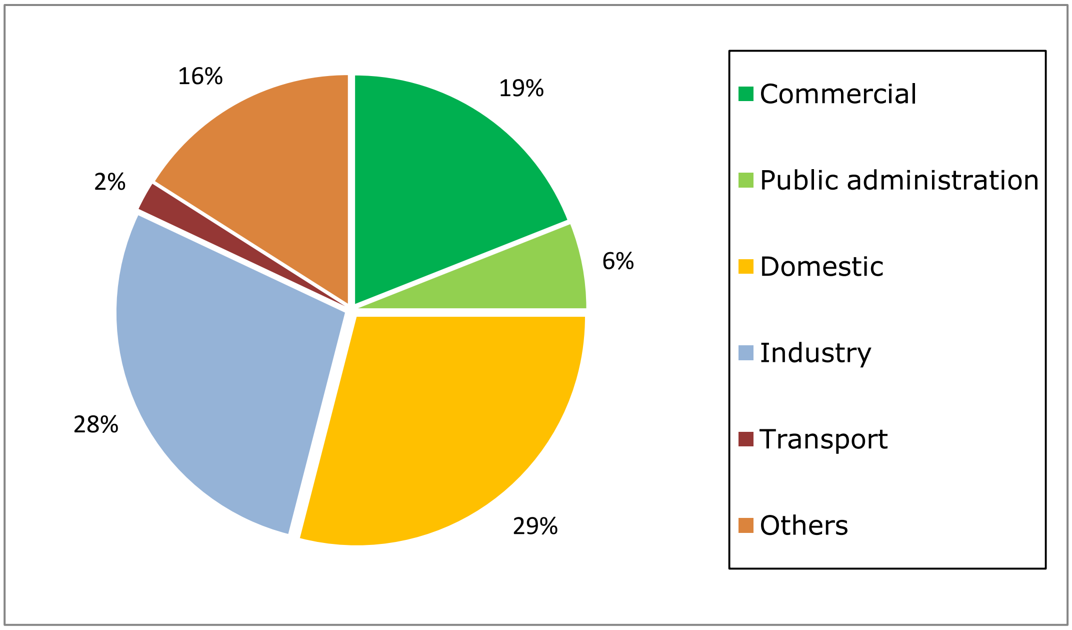
Assessment of the flexibility of electricity demand

1.10. Electricity use is usually highest in the early evening on a weekday in the winter and, to a lesser extent, in the autumn and spring, as illustrated in Figures 1.1 and 1.2, when domestic demand overlaps with commercial and industrial demand. Later in the evening (once regular business hours close), half of electricity demand comes from domestic consumers[7]. Figure 1.3 presents electricity demand by sector. Domestic, commercial and industrial demand comprises the largest share of total electricity demand, suggesting that energy management strategies, including DSR, should be targeted to these groups. However, the take-up of DSR will depend on how flexible this demand is. In this section, we assess this flexibility; that is, how easily electricity demand can be time-shifted by consumers.

[6] Please see 'Demand Side Working Group Meeting, 9 February 2010', page 2 to 3. http://www.ofgem.gov.uk/Markets/WhlMkts/CustandIndustry/DemSideWG/Documents1/DSWG%20Febuary%20Minutes.pdf

[7] Ofgem's own analysis as part of Project Discovery

Figure 1.3: Electricity demand by sector, 2008



Source: DUKES 2009

1.11. Household activities requiring electricity use by domestic consumers include cooking meals, using consumer electronics, running appliances etc. Of these activities, in general, running wet appliances (e.g. dishwashers, washing machines and tumble dryers) outside of peak periods of electricity demand is likely to result in the least disruption to households and require the least amount of change to lifestyles. The proportion of wet appliances as a percent of total electricity consumption by household domestic appliance is about 15%.

1.12. Electricity consumption activities by SME and commercial consumers include catering, computing, lighting, cooling and ventilation, etc. A combination of different forms of electricity consumption may be flexible to time-shifting by these consumer segments. Activities most likely to be amenable to DSR include some catering (in the form of wet appliance use) and some cooling and ventilation.

1.13. For industrial customers, again, a combination of electricity consumption activities may be flexible to DSR, including drying, refrigeration and electricity space heating. Typically, demand from individual industrial customers will be large at any given time. Please see Appendix 1 for a breakdown of electricity consumption activities within each consumer group.

1.14. For our assessment of benefits and costs in Chapter 2, we use a rough estimate of total flexible demand at peak periods to be between 5% and 10%. To come to these figures, we have used a combination of sources, set out in Chapter 2 and in more detail in Appendix 2. It is important to note that there is no consensus within industry on the level of flexible demand. However, it is a commonly held view that, in future, electricity demand is likely to increase, particularly from domestic consumers, due to the electrification of the heat and transport sectors[8]. A significant proportion of this increased demand is likely to come from electric vehicles and electric heating which could be relatively flexible to shift to meet available supply.

Current demand side response in Great Britain

1.15. In practice, there are many DSR actions that consumers can take. These range from responding to price signals given by particular tariff structures to purchasing technologies which can automate DSR. The methods to facilitate DSR can be broadly classified into three types of products:

- shifting use in response to different types of tariffs, typically for domestic and smaller business consumers. These include time of use (TOU) tariffs, critical peak pricing (CPP) and real-time or dynamic pricing. Please see Appendix 5 for definitions of these terms;
- contracts, typically for I&C consumers, to curtail load (at pre-agreed times or in response to changing conditions on the electricity network); and
- automated devices including 'smart' appliances which respond to either changing conditions on the electricity network or a price signal.

1.16. The next sections review the GB experience of stimulating DSR within each consumer segment - domestic, SME and I&C.

Domestic consumers

1.17. Currently, the majority of domestic consumers in GB have little or no incentive to shift consumption away from peak periods as the price of their electricity does not vary with when they use it. The bulk of tariffs charge consumers for their energy based on total consumption levels, regardless of what time of day they use electricity. However, there are currently some arrangements, including time of use (TOU) tariffs such as Economy 7, Economy 10 and Dynamic Teleswitching, where consumers are charged different rates depending on when they use electricity.

[8] Project Discovery projections to 2025 for electricity demand from the heat and road transport sectors is between 4 TWh and 14.5 TWh for heat and between 8.3 TWh and 27.7 TWh for road transport. Current assumed electricity demand is 0 TWh from both heat and road transport. These figures are based on data from the Committee on Climate Change's October 2009 report 'Meeting the Carbon budgets, the need for a step change' (page 27), DECC's 2009 'The UK Renewable Energy Strategy' (page 42) and the associated impact assessment for renewable heat (page 12).

Tariffs

1.18. Currently, the peak and off-peak periods, and associated prices, in most TOU tariffs in GB are fixed in advanced (i.e. static TOU tariffs). TOU were primarily developed to support customers who are able to shift a significant share of their electricity consumption to off-peak time periods. This often includes those who use electricity to heat space or water, for example where a customer heats their home with night-time electric storage heaters[9]. Some forms of TOU tariffs are more prevalent in certain areas across the country, particularly where consumers are not connected to the gas network.

1.19. All major suppliers offer Economy 7 tariffs, which offer cheaper electricity at night but slightly more expensive rates during the day. This basic form of DSR shifts electricity use away from peak periods, and is often attractive to customers with night-time electric storage heaters, or other usage patterns that allow them to shift consumption away from daytime hours. Aside from electric heat and hot water, Economy 7 tariffs encourage consumers to use other household appliances overnight, such as washing machines, dishwashers and tumble dryers. In 2008, uptake of Economy 7 was about 20%[10].

1.20. Some suppliers also offer tariffs with three different time periods known as Economy 10 tariffs. These are similar to Economy 7 but may offer a middle rate time slot in addition to the peak and off-peak rates. An example of this is EDF Energy's new Eco 20:20 tariff[11].

1.21. Around 1 million customers who are on TOU tariffs have Dynamic Teleswitching functionality on their multi-rate electricity meters[12]. Dynamic Teleswitching enables the supplier or local Distribution Network Operator (DNO) to remotely "switch" a consumer's electricity supply through radio signals. This functionality allows suppliers to vary the time at which electricity is supplied to electric storage heaters under Economy 7. It also allows DNOs to manage constraints on the network and prevent overloading. Dynamic Teleswitching is a technology that enables DSR and is a precursor to more widespread automation that could be introduced.

[9] English House Condition Survey, ODPM 2006
[10] BERR Impact Assessment of Smart Metering Roll out for Domestic Consumers and Small Business, page 55
[11] See www2.savetodaysavetomorrow.com/Eco_20-20.html
[12] Ofgem's own analysis, 2008

Trials

1.22. The Energy Demand Research Project (EDRP)[13] is a major study funded jointly by industry and DECC and managed by Ofgem. There are around 59,000 households taking part in a number of activities designed to test demand management, including issues such as more frequent billing and information, smart meters, visual display units and community engagement. One part of the trial involves a range of interventions which identify peak usage or high cost periods via tariffs and time of use statements. The EDRP trial is on-going and further analysis will be available when the trial is complete, with the final report due in early 2011.

1.23. A number of suppliers are planning to trial new multi-rate TOU tariffs from 2010. Some are looking at Critical Peak Pricing (CPP) tariffs which are a form of dynamic TOU tariffs; the peak periods and associated prices are not fixed in advance as in static TOU tariffs, rather they are communicated to customers a short time before they begin.

Automated devices

1.24. Dynamic-demand control devices switch appliances on and off in response to changes in the balance between supply and demand on the electricity grid or in response to prices. These devices can be either retrofitted to existing appliances or installed when appliances are manufactured (i.e. smart appliances). The devices are best suited to appliances, such as refrigerators, air conditioners and hot water heaters, which run on cycles (i.e. switch on for a period then switch off). Dynamic-demand control devices have not yet entered the mass market.

1.25. Early this year, RLtec, RWE npower and Indesit rolled out a trial of fridges fitted with dynamic demand control devices[14]. Up to 3,000 RWE npower customers were supplied with such a refrigerator, which automatically modify power consumption in response to changes in frequency[15] on the grid without affecting the refrigerator's performance. The trial contributes to RWE npower's obligations under the Carbon Emissions Reduction Target (CERT).

SME customers

1.26. The SME sector is made up of a diverse group of consumers covering all industrial sectors, and energy consumption patterns can vary considerably depending

[13] The latest progress report can be found at: http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=14&refer=Sustainability/EDRP
[14] Please see for further details: http://www.npowermediacentre.com/content/detail.aspx?ReleaseID=3052&NewsAreaID=2
[15] Frequency is the balance between supply and demand which needs to be maintained at 50 hertz.

on, among other things, the size and type of business. Some can exhibit similar levels of energy consumption to that of a household, while others have significantly higher levels of consumption.

1.27. DSR arrangements for SME consumers with relatively high consumption levels are often bespoke, and limited information is readily available in the public domain. For other SME customers, products are typically restricted to TOU tariffs and automated devices similar to those offered in the domestic sector.

1.28. Historically, DSR products often suffered from low uptake for a variety of reasons. SME customers may consider energy bills to be a relatively small component of business costs. They are also likely to be primarily focussed on core business operations and therefore do not necessarily have sufficient resources or incentives to properly consider DSR. Even if the concept of DSR is known, some SME consumers may have limited flexibility to adapt to business practices without disrupting core activities. Anecdotal evidence suggests that, for some SME consumers, the benefits of changing working patterns, for example by working night shifts, are currently seen to be too weak to offset the cost involved in doing so. However, this would change if the incentive were sufficient.

I&C customers

1.29. In general, I&C consumers participate in DSR more actively than other consumer segments. One reason for this may be that energy bills represent a larger proportion of their costs and a greater absolute value, which can help to justify investment in alternative energy sources such as on-site backup generation.

1.30. Demand from individual I&C customers are likely to be large in comparison to other consumer segments. Thus, another reason why there may be more activity within this consumer segment is that large interruptible or manageable loads are of greater use to the system operator than many small loads, because they are easier to manage and more reliable. Finally, the supply of the majority of large users is metered on an actual basis every half-hour and, depending on the type of contract an I&C consumer has agreed with their supplier, they may have a variable rate contract that reflects the price of electricity in real-time, providing these customers with an incentive to shift demand.

Interruptible contracts

1.31. I&C customers can provide DSR by contracting directly with the transmission system operator or their energy supplier. Interruptible contracts are a way to help maintain reliability of the electricity system by instructing large consumers with these contracts to limit the amount of energy they use when the system is tight. In exchange for this, consumers who have agreed to interruptible contracts generally receive a reduction in the levies charged to use the transmission system and/or an overall reduction in their energy bills. There are a number of forms these contracts can take including frequency response and reserve services. Frequency response means switching off or reducing production levels if the balance between supply and demand on the national electricity system (i.e. frequency) drops below a preset level. The provision of reserve services entails decreasing pre-agreed levels of demand in response to instructions by the system operator. Reserve service contracts are triggered in response to demand and supply conditions on the national electricity system, for example where there are outages of generation or network facilities. There are variants of each type of interruptible contract in terms of how quickly a consumer needs to respond and how long it needs to sustain the response, giving consumers the flexibility to match their response capability to the contract.

1.32. Some suppliers are currently trialling load management services targeted at large energy intensive users with a view to expanding them to less intensive energy users if the trials are successful.

Triad Management

1.33. The triad system is an instrument used to manage peak load. Triads are the three half-hour periods in a financial year with the highest demand on the electricity transmission system. Suppliers are charged higher rates if its customers demand electricity during these periods and these penalties are passed onto these customers. If a consumer can reduce consumption during these periods then it avoids the penalties and lowers its electricity bill. The triad system encourages consumers to manage their electricity use during these high demand periods and helps the electricity system operator to maintain supply. Suppliers offer services to notify large users when a triad period is expected to occur.

Summary of current demand side response

1.34. In general, products specifically designed to encourage DSR are currently restricted to interruptible contracts for larger business consumers and TOU tariffs for domestic and, to a lesser extent, small business consumers.

1.35. At the domestic level, households tend to participate in DSR through TOU tariffs, many of which provide incentives for consumers to shift consumption (e.g. for electric water or space heating) via lower tariff charges during typically off-peak periods during a day. A smaller number of domestic consumers participate in DSR in a more dynamic way by responding to TOU devices through dynamic teleswitching. These tariffs and technologies were first developed to support customers who could shift a significant portion of their electricity consumption to off-peak periods. There is limited incentive for the majority of customers on standard flat rate tariffs to participate in DSR and help smooth overall system demand.

1.36. Furthermore, the majority of existing machines and appliances do not have the capabilities to allow businesses and households to manage DSR in an automated way. However, trials are underway where the feasibility of new tariffs and technologies are being tested. From our research, there does not appear to be very much DSR activity within the SME sector, but available information in this area is limited.

1.37. There are currently mechanisms in place, such as interruptible contracts, which reward predominantly larger consumers who agree to avoid electricity usage at particular times, or on demand by the system operator. Furthermore, the triad system encourages demand reduction at peak periods within a year. Both of these arrangements give large users the opportunity to help the electricity system match demand to supply conditions in exchange for a financial benefit.

2. Benefits and costs

Chapter Summary

This chapter examines the potential benefits and costs associated with shifting demand away from peak periods, including changes in carbon emissions, wholesale cost savings and avoided plant and network investment. It also qualitatively discusses potential improvements in security of supply. The chapter then considers the potential costs associated with DSR.

2.1. DSR has the potential to lead to a more efficient and sustainable energy supply by facilitating a more optimal use of the resources required to meet demand. Increasing DSR has the potential to directly benefit both consumers actively participating in it and the system at large. As discussed previously, industrial consumers as well as some domestic consumers, and to a lesser extent, small businesses have actively engaged in DSR; however, there may be scope for increasing the levels of DSR from all consumer groups by sharpening price signals.

2.2. This chapter presents analysis we have undertaken to assess the impact of encouraging consumers, equipped with enabling technologies and tariffs that encourage DSR, to defer electricity use at peak times to other times in the day. These peak periods commonly occur in the early evening and are more pronounced in the winter, and to a lesser extent autumn and spring, when heating and lighting use increase (see Figures 1.1 and 1.2). During peak periods, generation plant that is more expensive to run, and in some cases more carbon-intensive, is used to meet demand. Our estimates of specific benefits from DSR are indicative and are likely to be conservative. They include:

- **wholesale and capital cost savings:** There are short-term gains to be realised in terms of reduced wholesale costs by displacing higher cost (peak) generation with lower cost (off-peak) generation. These cost savings are expected to trickle down to consumers through lower electricity bills. We have calculated daily wholesale cost savings to be between £0.4 million and £1.7 million, depending on the level of demand that is shifted and the particular day examined. Over the course of a year, we estimate that savings in generation investment could be between £129m and £536m, and savings in network investment could be between £14m and £28m;

- **carbon emission savings:** As long as carbon is priced appropriately (and all else being equal in terms of commodity prices), DSR can lead to a reduction in carbon emissions by displacing higher emitting (peak) generation. We have estimated these daily savings to be between 800 tCO_2 and 2,550 tCO_2, depending on the particular day examined. This represents a daily carbon reduction savings rate of between 0.16% and 0.50%, which is equivalent to emissions from about 135,000 households or a town the size of Brighton; and

- **facilitate variable generation:** As the share of variable generation increases in the generation mix, DSR can facilitate more variable generation by replacing some of the higher cost, and in some cases more carbon-intensive, peaking plant that would otherwise be needed to maintain secure and sustainable supplies at times of low variable generation output[16]. We have not attempted to quantify this benefit but have qualitatively discussed implications to security of supply.

2.3. Table 2.1 presents a summary of the benefits we have quantified. Our modelling has demonstrated that DSR can lead to financial benefits by deferring network investment, reducing the need to build new plants and facilitating wholesale cost savings. In addition, DSR can lead to an immediate reduction in carbon emissions as long as carbon is priced appropriately. However, to achieve the benefits of increased DSR there are likely to be associated costs, including technology and infrastructure costs, as well as the costs and inconvenience of changing consumption patterns. These are discussed in the section on costs below.

Table 2.1: Summary of Quantified Benefits

	Shift 10% peak load	Shift 5% peak load
Daily wholesale cost savings	£0.7m to £1.7m	£0.4m to £0.8m
Annual capital cost savings	£265m to £536m	£129m to £261m
Annual network investment savings	£28m	£14m
Daily carbon emission savings (base case), tCO_2	-850 tCO_2 to 2,200 tCO_2	-650 tCO_2 to 1,350 tCO_2
Daily carbon emission savings (base case), £	-£12,000 to £31,000	£-9,000 to £19,000
Daily carbon emission savings (gas price decrease, carbon price increase), tCO_2	800 tCO_2 to 2,550 tCO_2	n/a
Daily carbon emission savings (gas price decrease, carbon price increase), £	£11,200 to £35,700	n/a

Assumptions

2.4. We have applied a number of assumptions to estimate the benefits of deferring peak demand to other periods in the day, including the following[17]:

- enabling technologies to facilitate DSR, such as smart meters, are available;

[16] DSR can lead to a more efficient use of resources needed to meet firm demand; however, it is noted that the expected dampening of short term price signals may impact long term peaking plant investment.
[17] See Appendix 2 for further details.

- tariffs that encourage DSR, including TOU, CPP and real-time pricing, are also available for all customers;
- no net change in electricity demand as a result of DSR[18]; and
- potential for around 5 to 10% of total peak demand to be shifted within day[19]. Appendix 3 sets out our assumptions on these figures in detail[20].

Benefits

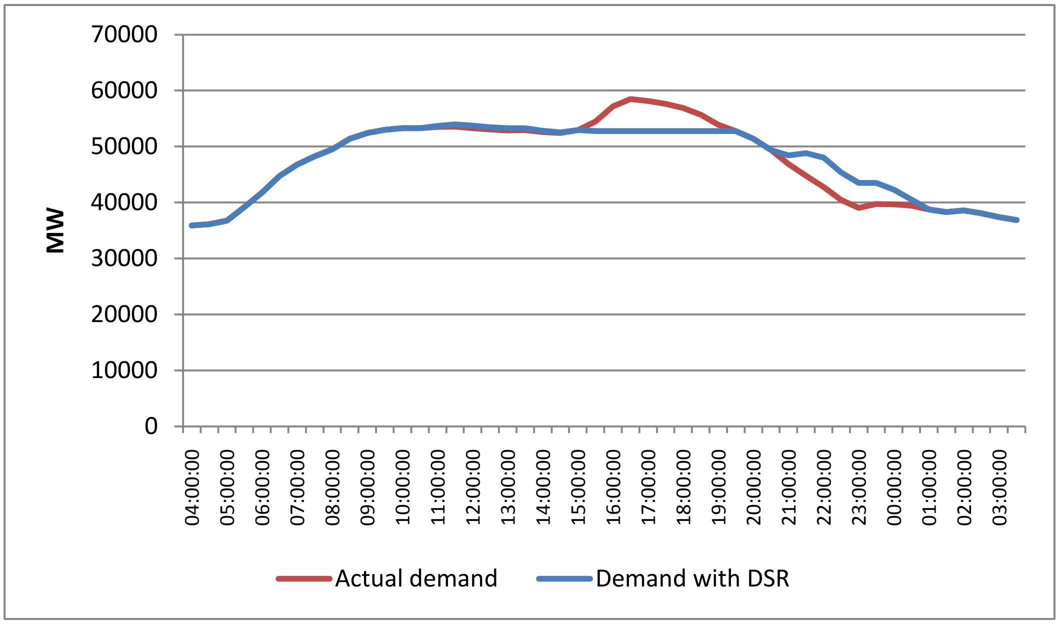
2.5. In this section, we have calculated wholesale cost savings, impact on carbon emissions and avoided capital costs, based on the assumptions listed in the above section. Our estimates are indicative only and are likely to be conservative. We have qualitatively discussed implications of DSR on security of supply.

Daily wholesale cost savings

2.6. Figure 2.1 illustrates actual demand and demand with DSR (assuming 10% of total peak demand is shifted to earlier and later in the day). The demand profile with DSR is noticeably flatter[21].

[18] We have not attempted to quantify the benefits of energy efficiency as part of our analysis. It is not clear how much electricity usage would be reduced as a result of signals to shift demand away from peak periods.
[19] Note that in DECC's impact assessment of a GB-wide smart meter roll out for the domestic sector, December 2009, it assumed a 5% load shift from a 20% uptake of TOU tariffs.
[20] As discussed in Chapter 1, no consensus within industry about the level of DSR can be assumed: these figures represent a rough approximation based on the range of available information.
[21] We have based our analysis of a 'within-day' demand shift on the 24-hour period 4am to 4am.

Figure 2.1: Actual demand and demand with 10% DSR, 7 January 2010



Source: NG, Ofgem analysis

2.7. To estimate the change in wholesale costs, we have used demand profiles for two winter days (7 January 2010 and 14 January 2009) and an autumn day (14 October 2009[22]), assuming a 5% and 10% shift in demand. For each of these days, we have analysed the following to calculate the wholesale cost savings:

- **Short Run Marginal Cost Saving (SRMC):** the difference between the SRMC of the generation plant 'displaced' by DSR and the 'replacement' generation plant. The 'replacement' (off-peak) plant is expected to have a lower SRMC than the 'displaced' (peak) plant. This is because we assume generation plants used to meet demand run in ascending order of SRMC; and

- **capital cost savings:** the potential capital cost savings associated with DSR being able to displace the need to invest in new generation plants to meet peak demand.

2.8. Our methodology regarding SRMC is explained further in Appendix 2. Our estimates of the SRMC and capital cost savings for each of the three days, along with

[22] This is a 'shoulder day', which refers to a day in which the difference between high demand periods and low demand periods are less pronounced but demand profiles are not as flat as the lowest demand periods, commonly in the summer.

the total daily wholesale cost savings, are presented in Tables 2.2 and 2.3. The total wholesale cost savings per day is between £0.4 million and £1.7 million, depending on the day analysed and the level of demand that is shifted. At least a portion of these savings would be expected to trickle down to consumers through lower electricity bills, as competitive forces will drive suppliers to pass on savings to its customers.

Table 2.2: Estimated daily wholesale cost savings across different days, 10% shift of peak demand

Day	Peak demand shifted	Daily capital cost saving[23]	SRMC saving	Total daily wholesale cost saving
	GW	£m	£m	£m
07/01/2010	5.7	0.9-1.5	0.2	1.1-1.7
14/01/2009	5.5	0.9-1.4	0.2	1.1-1.6
14/10/2009	5.4	0.7-1.2	0.01	0.7-1.2

Source: Ofgem analysis (using 2009 SRMC)

Table 2.3: Estimated daily wholesale cost savings across different days, 5% shift of peak demand

Day	Peak Demand Shifted	Daily capital cost saving	SRMC saving	Total daily wholesale cost saving
	GW	£m	£m	£m
07/01/2010	2.8	0.4-0.7	0.02	0.5-0.7
14/01/2009	2.7	0.4-0.7	0.1	0.5-0.8
14/10/2009	2.2	0.4-0.6	0.01	0.4-0.6

Source: Ofgem analysis (using 2009 SRMC)

2.9. These daily estimates are not applicable all year round. Potential wholesale cost savings in the winter months, and to a lesser extent in the autumn and spring months, are larger than they would be in the summer months, because peaks in the demand profile are more pronounced during these periods. Given the difficulties in estimation, we have not attempted to extrapolate these potential daily savings to produce an annual figure.

2.10. However, as we have considered capital cost savings, resulting from a reduction in new peaking plant investment, to be evenly spread across the year, it is possible to produce an annual estimate of this portion of the total wholesale cost savings; that is, the capital cost saving resulting from a reduction in new peaking plant investment. Tables 2.4 and 2.5 present our estimates of the annual potential

[23] Our estimates of the capital cost savings vary depending on whether OCGT or CCGT is the assumed peaking plant that is displaced by DSR. Taken from the Discovery model, our estimated annuitized capital costs are £93.73/kW/yr for CCGT plant, and £57.69/kW/yr for OCGT plant. We note that OCGT may be a more direct substitute for DSR however we have included a range to reflect uncertainty.

capital cost savings from an assumed DSR of 10% and 5% respectively. These estimates represent the long term investment cost savings due to DSR displacing some peaking plant generation.

Table 2.4: Annual capital cost savings from DSR displacing new plant investment, 10% shift of peak demand

Peak demand days	Peak demand shifted (10%)	Annual capital cost saving[24]
	GW	£m
07/01/2010	5.7	330 - 540
14/01/2009	5.5	320 - 510
14/10/2009	4.6	270 - 430

Source: Ofgem analysis

Table 2.5: Annual capital cost savings from DSR displacing new plant investment, 5% shift of peak demand

Peak demand days	Peak demand shifted (~5%)	Annual capital cost saving
	GW	£m
07/01/2010	2.8	160 - 260
14/01/2009	2.7	160 - 250
14/10/2009	2.3	130 - 210

Source: Ofgem analysis

2.11. As we have based our analysis on just three sample days, these figures should be taken as indicative only. In addition, as wholesale prices are likely to capture the price of European Union Allowances (EUAs) as well as investment costs, there may be some degree of double-counting between the wholesale cost savings, carbon emission savings and investment savings. Our analysis of potential carbon emission savings is set out below.

Daily carbon emission savings

2.12. In this section, we examine the impact on carbon emissions of shifting 5% and 10% of demand within-day. Depending upon the carbon intensity of the 'replacement' (off-peak) generation relative to that of the 'displaced' (peak) generation, there may be a net increase or decrease in carbon emissions as a result

[24] Our estimates of the annual capital cost savings vary depending on whether OCGT or CCGT is the assumed peaking plant that is displaced by DSR. Taken from the Discovery model, our estimated annuitized capital costs are £93.73/kW/yr for CCGT plant, and £57.69/kW/yr for OCGT plant. We note that OCGT may be a more direct substitute for DSR however we have included a range to reflect uncertainty.

of DSR. However, provided that carbon is priced appropriately (and all else being equal in terms of commodity prices), DSR can lead to a reduction in carbon emissions by displacing higher emitting (peak) generation.

2.13. To estimate the daily change in carbon emissions as a result of a 5% and 10% shift in demand, we have used the same days as in the previous section: 7 January 2010; 14 January 2009; and 14 October 2009. We have used the Project Discovery Model[25] to produce a generation mix associated with each of these demand profiles[26].

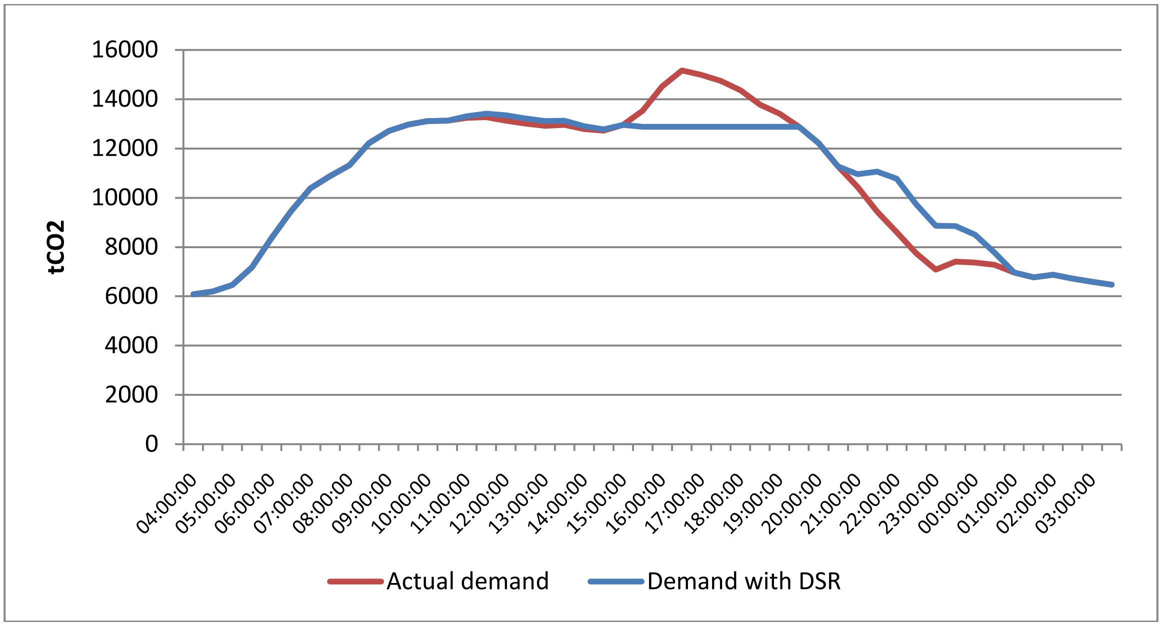
2.14. For 7 January 2010, we estimate a (hypothetical) marginal net increase in carbon emissions of around 850 tonnes (relative to daily emissions before DSR of 514,000 tonnes). Based on an assumed traded price of £14/tonne CO2[27], this increase in carbon could be valued at around £12,000. Our analysis is illustrated in Figure 2.2 below, which shows a carbon saving in the peak period from which demand is shifted, but a carbon increase in the off-peak period.

[25] The Project Discovery Model examines scenarios and stress tests for the GB energy sector over the next 10 to 15 years. The Discovery Model produces a merit-order generation mix for a given set of inputs, including (but not limited to) the level and profile of demand, commodity prices and plant-specific efficiency factors. Our analysis in this section is based upon 2009 SRMC data.

[26] It is important to note, however, that the half-hourly generation mix produced by the Discovery Model for the actual demand profile does not perfectly coincide with reality, as it does not model within-day contractual arrangements in place, on-the-day plant availability and system constraints, provision of reserve and voltage control non-energy services, etc. See Appendix 2 for further details on our generation mix assumptions.

[27] 'Updated short-term traded carbon values for UK public policy appraisal', June 2010, Decc

Figure 2.2: Estimated carbon emissions, actual demand and demand with DSR, 7 January 2010



Source: Ofgem analysis (using 2009 SRMC)

2.15. We have replicated this analysis for the remaining days, assuming within-day shifts in demand of 10% and 5%, respectively. Tables 2.6 and 2.7 present our estimates.

Table 2.6: Estimated daily savings in carbon emissions due to DSR, 10% shift of peak demand

Date	Emission savings	Carbon value
	tCO2/day	£
7/1/2010	-850	-11,900
14/1/2009	1,150	16,100
14/10/2009	2,200	30,800

Source: Ofgem analysis (using 2009 SRMC)

Table 2.7: Estimated daily savings in carbon emissions due to DSR, 5% shift of peak demand

Date	Emission savings	Carbon value
	tCO2/day	£
7/1/2010	450	6,300
14/1/2009	-650	-9,100
14/10/2009	1,350	18,900

Source: Ofgem analysis (using 2009 SRMC)

2.16. As the examples above show, on some days there could be a net saving in carbon emissions from DSR, and on other days there could be a net increase. The change in carbon emissions resulting from a within-day shift in demand will depend on the difference in carbon intensity between the 'replacement' and 'displaced' generation. In turn, this will depend upon (among other factors):

- the level of commodity prices;
- the level of the carbon price;
- the level of demand and the profile across the day;
- the generation which is contracted to run on the day; and
- the level of wind output at different times of the day.

2.17. The relative prices of gas, coal and carbon are particularly significant as they are key determinants of the generation mix, and therefore the type (and carbon intensity) of generation scheduled to run during the peak and off-peak periods[28].

2.18. Using the same assumptions as above, we have examined the impact of changing commodity and carbon prices on carbon emission savings as a result of a 10% shift of demand. Using the 7 January 2010 demand profile, we have considered four additional scenarios to estimate a carbon impact from DSR:

- gas prices decrease by 5%;
- gas prices decrease by 10%;
- carbon prices increase by 10%; and
- carbon prices increase by 20%.

2.19. In each of these four scenarios, we estimate a net saving in carbon emissions from DSR, compared to a net increase in emissions in a number of our base scenarios. Table 2.8 shows the results of our modelling.

[28] For example, if there is a material difference between clean dark and clean spark spreads (a measure of the profitability of coal and gas plant respectively, accounting for assumed plant efficiency, commodity prices and carbon prices), we may expect to observe a reduction in carbon emissions from DSR, as the peak generation displaced by DSR is replaced by less carbon intensive generation of the same fuel type. However, if there is not a material difference between clean dark and clean spark spreads (and as a consequence the generation stack is mixed), the outcome from DSR in terms of carbon emissions is somewhat ambiguous, as relatively higher emitting (but cheaper) coal plant may displace gas plant.

Table 2.8: Impact of changing relative commodity prices on carbon emissions, 7 January 2010, 10% shift in peak demand

	Base Scenario	Gas price -5%	Gas Price -10%	Carbon Price +10%	Carbon Price +20%
Carbon Savings (t/CO2)	-850	2550	2250	800	1900
Carbon Savings (£)	-£11,900	£35,700	£31,500	£11,200	£26,600

Source: Ofgem analysis

2.20. Reducing the price of gas or increasing the price of carbon is more likely to restrict coal plant to run during periods of peak demand, rather than at periods where demand is shifted to. This is because the profitability of running a gas plant will increase relative to that of running a coal plant.

2.21. In periods where peak demand is shifted to, the type of 'replacement' plant used to meet this demand is somewhat ambiguous. This is because where a gas plant is running at or near maximum capacity, some of the most efficient coal plant may be required to meet the additional demand in this period. This explains the somewhat counterintuitive impact observed above, whereby moving from a 5% to a 10% reduction in gas price results in a smaller carbon saving. Despite this effect, we would generally expect a net carbon saving where the profitability of running a gas plant is increased relative to that of a coal plant, whether this is a consequence of relatively higher carbon prices or relatively lower gas prices.

2.22. The analysis above considers changes on a single day, rather than a permanent flattening of the peak. In 2020, we may expect less ambiguous results if DSR permanently displaces fossil-fuel based generation used to meet peak demand and helps to maximise use of variable wind generation output. In its suite of options, the February Discovery paper included rationale for setting a minimum carbon price in order to promote low carbon investment. If such a price were sufficiently strong, it should ensure that, with all else being equal, the most carbon-intensive generation would be displaced by a flatter peak through DSR.

2.23. It is important to note that even if there is a net saving in carbon emissions when DSR is used to flatten peak demand, overall carbon emissions in the short-term will not decrease in the EU. Carbon emissions associated with electricity generation are captured within the EU Emissions Trading Scheme (ETS). Therefore, although increased DSR may allow GB to meet its emissions cap at lower cost, any emission savings as a result of DSR will be transferred to another sector, possibly in another Member State, as the ETS emissions cap will be unchanged. However, overall emissions in GB will decrease and GB could benefit from selling surplus EU Allowances (EUAs). In the future, if DSR is an effective abatement measure, it may allow a tighter cap to be agreed. Additionally, DSR displaces the need to build new peaking plants which could have associated positive environmental benefits.

2.24. In addition to CO2 savings, there may be localised benefits in the form of avoided nitrogen oxide (NOx) and sulphur dioxide (SO2) emissions as a result of using DSR as an alternative to peaking plant generation, but again this depends on the generation mix.

Avoided network investment

2.25. As noted above, DSR can be used as an alternative to peaking plant generation. In some regions, this may reduce the need for load-related investment in the electricity distribution network, in the long-run; provided that network operators have assurance that DSR at peak periods is reliable. Table 2.9 shows investment expenditure allowed by Ofgem for all electricity distribution network operators in GB in the most recent price controls- Distribution Price Control Review 5 (DPCR5).

2.26. We would expect that the level of avoided network investment as a result of DSR across the distribution network could be in the order of millions of pounds per year, if there is a sufficient take up of DSR by electricity consumers. These figures are presented in rows 2 and 3 in Table 2.9[29]. These figures relate to general reinforcement only as DSR is expected to displace this type of network investment and not other regulated investment activities such as demand connections, diversions and fault levels. Although DSR is expected to displace capital expenditure for connections of generation plants, this is an unregulated activity and so is not included in the figures below. Thus, savings in distribution network investment may be greater. We would also expect some investment savings arising from the transmission network.

Table 2.9: Load-related capital expenditure for distribution network

Distribution Network (2007-08 prices)	
Annual average general reinforcement investment (2010-15)	£275m
Potential annual savings with a 10% reduction in peak demand	£27.5m
Potential annual savings with a 5% reduction in peak demand	£13.8m

Source: DPCR5, Ofgem

2.27. There are various studies in which network investment savings have been estimated as a result of DSR. In particular, a study conducted by the Brattle Group[30] calculated a reduction in transmission and distribution costs across the EU at

[29] To arrive at these figures, we have assumed a one-to-one relationship between a reduction in peak demand and network investment. In reality, the relationship is exponential so the figures in our table may be understated.
[30] Unlocking the 53 billion savings from smart metering in the EU, October 2009

between €536 million and €107 million per year based on a high peak demand reduction (10%) scenario and a low peak demand reduction (2%) scenario respectively. A study conducted jointly between Imperial College London and the Energy Networks Association[31] estimated avoided distribution reinforcement costs at the GB level due to future real-time distribution network control, which incorporates real-time demand response facilitated by smart metering technology. These savings were estimated at between £0.5 billion and £10 billion over the next 20 years, and vary due to different penetration levels of electric vehicles and heat pumps.

2.28. In addition to avoided network and generating plant investment, there may be benefits associated with operating the system more efficiently (since congestion would be reduced) and improving the use of existing generation and network capacity[32].

Security of supply

2.29. Increasing DSR could contribute to maintaining secure and sustainable supplies by reducing the amount of peaking plant needed to meet demand in the short term. However, as increased DSR becomes an input into generators' investment decisions, generation capacity margins are likely to fall accordingly as DSR will displace peaking generation investment. Therefore, once the potential for DSR is exhausted, its contribution to security of supply is likely to remain constant.

2.30. DSR is likely to have a greater impact on security of supply where real-time pricing tariffs encourage demand to be shifted or reduced in response to market signals to help balance the system or overcome constraints. However, again, this would also feed into investment decisions for new infrastructure and may again displace new generation.

2.31. As variable renewable generation increases its share of the generation mix, DSR is likely to become increasingly valuable as it could displace plant otherwise needed to generate during periods of low wind output (as well as high demand). This will ultimately benefit consumers by helping to promote secure and sustainable energy supplies and reduce the costs the industry, and consumers, face to deliver secure and sustainable supplies.

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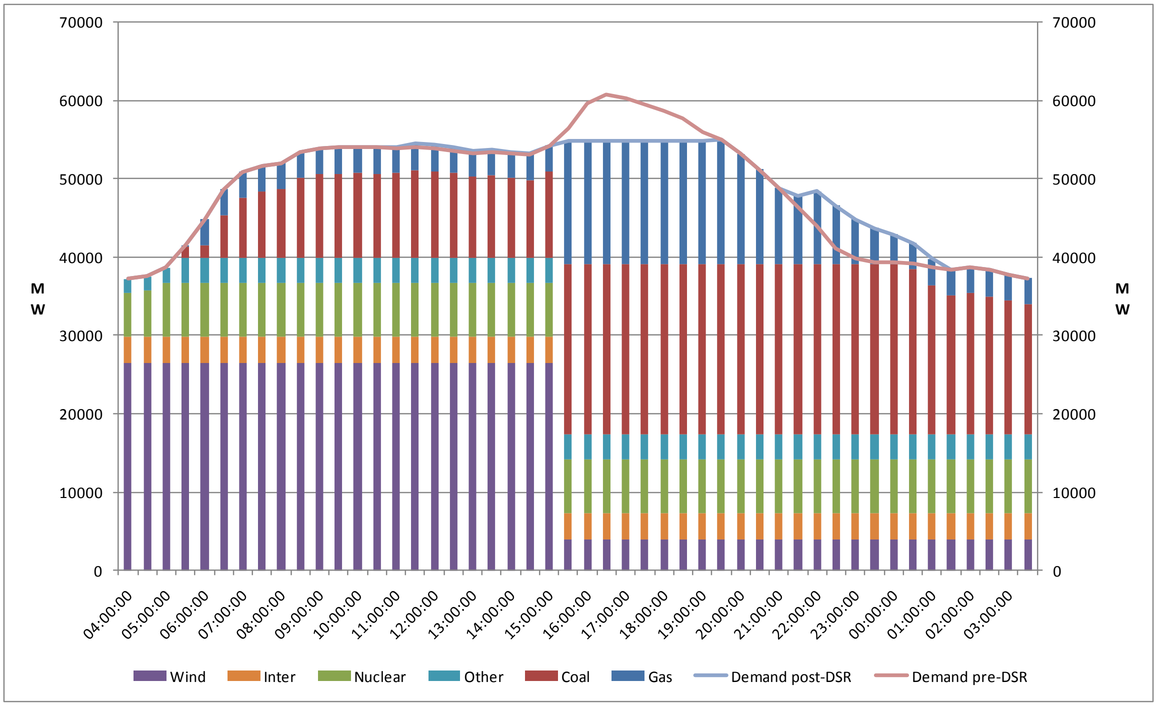
[31] Benefits of Advanced Smart Metering for Demand Response Based Control of Distribution Networks: Summary Report

[32] Demand side management: Benefits and challenges, Goran Strbac

2.32. We have examined a hypothetical winter day in 2020, in which wind output drops suddenly during the peak period[33]. Figure 2.3 illustrates the changing generation mix under such a scenario.

Figure 2.3: DSR in a potential 2020 generation mix – managing wind variability



Source: Ofgem analysis

2.33. As Figure 2.3 illustrates, when wind output drops, more flexible plant such as Combined Cycle Gas Turbine (CCGT) and coal would be expected to run in response to high wholesale prices. If the demand side had the means to respond to these high wholesale prices it could displace a portion of the required peaking plant, thus reducing the costs of maintaining secure and sustainable supplies.

Costs

2.34. This section discusses some of the costs associated with shifting demand from peak periods to off-peak periods within day. Many of these costs are one-off and

[33] Our starting point is the Project Discovery scenario entitled 'Green Transition', which is characterised by rapid economic recovery and a significant expansion in investment in green measures.

upfront. They include technology and infrastructure costs as well as the costs and inconvenience associated with changing consumption patterns.

Technology and infrastructure

2.35. Consumers' premises or places of business may need to be set up in order to participate in DSR. The cost of smart electric meters for 77% of SME electricity customers is the same as it is for domestic customers, £58 (including real time display unit)[34]. The remaining 23% of SME electricity customers require an advanced meter which is necessary for customers with higher energy use. This advanced meter costs £262 (including real time display unit)[35]. These costs may be paid up-front by customers or passed through by the supplier to all of its customers.

2.36. The estimated total cost of the smart meter roll out will range between £8.19 billion and £9.86 billion[36] in the domestic sector and between £558 million and £580 million[37] in the SME sector. These costs will occur anyway regardless of a customer participating in DSR as the smart meter roll out programme has been mandated.

2.37. A range of static and dynamic tariffs that encourage DSR can be accommodated within the current settlement system arrangements. However, if very short and frequent settlement periods are required, the settlement system for domestic and some SME customers may need to be modified so that smart meters could capture this data. A change to the settlement system can cost up to around £1 million depending on the modification required[38]. Again, these costs will arise regardless of a customer participating in DSR.

2.38. Costs directly attributable to customers participating in DSR include upgrading to smart appliances or retrofitting existing time-flexible appliances with dynamic demand control devices. Smart appliances or dynamic demand control devices are relatively new technologies but if they are rolled-out to the mass market they are

[34] DECC (2009) 'Impact assessment of a GB-wide smart meter roll out for the domestic sector', page 22. These figures may be revised in a forthcoming update to the Impact Assessment.
[35] DECC (2009) 'Impact Assessment of smart / advanced meters roll out to small and medium businesses', page 12. These figures may be revised in a forthcoming update to the Impact Assessment.
[36] DECC (2009) 'Impact assessment of a GB-wide smart meter roll out for the domestic sector', pages 2 and 5. These figures may be revised in a forthcoming update to the Impact Assessment.
[37] DECC (2009) 'Impact Assessment of smart / advanced meters roll out to small and medium businesses', pages 2 and 3. These figures may be revised in a forthcoming update to the Impact Assessment.
[38] Please see Modification Report submitted to Authority 11 July 2008 for Modification Proposal P217 Revised Tagging Process and Calculation of Cash Out Prices Elexon, page 5 to 6: http://www.elexon.co.uk/changeimplementation/findachange/modproposal_details.aspx?propid=237

likely to add about £5 to the production cost of an appliance[39]. These technology costs are decreasing and may over time become increasingly affordable to the majority of consumers.

2.39. In addition, suppliers may incur costs related to changes in their billing systems with the introduction of new tariffs. Overall, the Government's impact assessments shows a positive net benefit for smart metering due to expected savings for suppliers from, for example, avoided meter readings and reduced theft[40].

2.40. Finally, distribution network operators will incur costs to facilitate DSR including incremental operational costs. They will also incur capital costs associated with re-designing and building parts of their networks to allow DSR to facilitate an increasing proportion of variable and distributed generation on their networks.

Costs and inconvenience of changing consumption patterns

2.41. Costs associated with changing consumption patterns are an issue particularly relevant to businesses. Companies that want to participate in DSR but have inflexible business operations may need to put in place new arrangements such as changing their regular working hours. This may result in costs being incurred such as revising work schedules and paying overtime wages to keep staff available until later in the evening or to finish earlier in the day.

2.42. The inconvenience of participating in DSR, and therefore changing consumption patterns, includes the time involved in switching to a new tariff (e.g. TOU or real time) or researching other types of DSR products. Ofgem's Energy Supply Probe Initial Findings Report revealed that a majority of customers consider the level of expected savings from switching tariffs to be too low and not worth the hassle of switching tariffs in general. Many people stated they are too busy to think about switching[41]. Since the Probe, Ofgem has made a number of changes to seek to improve the information available to customers and reduce the risk of miss-selling[42]. However, a level of customer inertia is likely to remain.

2.43. In addition, inconvenience associated with changing electricity demand patterns involves varying the times at which household activities are carried out, such as using appliances and electronic devices and cooking meals or carrying out other household chores outside of peak periods of electricity demand. However, once automated devices become widespread and mainstream, the hassle associated with

[39] BNXS41: Dynamic demand control of domestic appliances, Market Transformation Programme
[40] For example, see page 26 to 28 of DECC (2009) 'Impact assessment of a GB-wide smart meter roll out for the domestic sector'.
[41] 'Energy Supply Probe Initial Findings Report', October 2008, page 57.
[42] 'Energy Supply Probe: Proposed Retail Market Remedies', August 2009

changing electricity consumption should dissipate. This is discussed in greater detail in Chapter 3.

3. Issues

Chapter Summary

This chapter sets out key issues to address in order to stimulate more DSR. The issues are informed by both our own primary consumer research and the published results of international DSR trials.

Research

3.1. In December and January, we commissioned some consumer research to help us explore consumers' attitudes to, and awareness of, DSR. This included some initial research among domestic consumers in the form of an omnibus survey[43], conducted by Ipsos MORI on behalf of Ofgem, as well as discussions with Ofgem's Consumer First Panel[44]. In both the MORI omnibus survey and the panel discussions, respondents were asked how likely they would be to change their usage of certain household devices and activities if the cost of energy varied during the day. Further, in the Consumer First Panel discussions it was explained to participants that moving consumption away from high periods of demand could reduce costs. They were asked to discuss what consumers could do to participate in shifting usage to smooth demand throughout the day. A full summary of the results of this research is set out in Appendix 3.

3.2. Additionally, in January we held a workshop to discuss key issues around expanding the scope of DSR in the short to medium term in the domestic, SME and I&C sectors. Participants included large and small business consumers, industry experts, academics and consumer and environmental groups. A summary of the workshop can be found in Appendix 3.

3.3. Finally, our research included a review of activity in other countries[45] to determine whether there are any lessons that can be drawn out and applied to GB. In particular, we have reviewed various methods used to facilitate DSR internationally and what customer feedback has been where available. Specific case studies within each consumer segment and a list of lessons learned can be found in Appendix 4.

[43] Survey of the population of Great Britain including 1,961 quota controlled face-to-face interviews in the period 11-21 December 2009 using computer aided personal interviewing.
[44] This is made up of 100 everyday domestic customers across 5 different locations.
[45] Including Australia, France, Ireland, New Zealand, Norway, Spain, Sweden and United States.

Findings

3.4. Based on the research outlined above, we discuss below a number of consumer and industry related issues which need consideration in order to realise greater DSR. The issues include:

- awareness and financial incentives;
- changing consumer behaviour;
- limits to discretionary demand;
- technology;
- weak short-term price signals;
- suppliers' incentives;
- passive nature of the electricity distribution network; and
- aggregation.

Consumer related issues

Issue 1: Awareness and financial incentives

3.5. The majority of domestic and small business consumers pay for their electricity through tariffs that do not vary charges by the time of use. Perhaps unsurprisingly then, the Consumer First Panel discussions revealed that most domestic consumers are not conscious that the wholesale price of electricity varies within the day according to demand and the amount of supply available to meet it. Once this was explained to the Panel, the response was that more visibility of the variation in energy prices, including real-time price signals, would encourage consumers to engage in DSR. We also learned through the Panel that consumers could not immediately understand what the benefits of deferring peak electricity consumption could be. Panellists suggested that more awareness of the benefits of using energy at different times of the day would help to change behaviour. However, the consumer view was that, ultimately, a financial incentive was required to motivate a change in behaviour.

3.6. As part of our international review we looked at various trials involving DSR. In the majority of the trials targeted at domestic consumers there were clear benefits, including savings on electricity bills (between 7% and 10%) and a reduction in peak demand (by at least 13%). There were also high rates of satisfaction among participants and some stated they would continue with the product after the trial ended. We also noted that there was a correlation between targeted price signals and peak load reduction. A summary table of the trials can be found in Appendix 4 along with an overview of common features.

Awareness

3.7. The concept of peak pricing is fairly common in other sectors (e.g. telecommunication, transport). Even in domestic energy consumption, Economy 7 tariffs which offer cheaper overnight rates are long-established. This suggests that awareness, while an issue, is not insurmountable provided attractive products are available and are well marketed as has been the case in other sectors. However, in future many DSR actions are likely to be automated which may dissipate the need for consumer awareness.

3.8. Price comparison websites, which provide information to customers, have a role in helping customers make informed decisions. It will be important, as tariffs develop, that comparison websites continue to display information that is accurate, easy to understand and comparable by all consumers. Consumer Focus is responsible for accrediting internet price comparison services which meet the Consumer Focus Confidence Code[46]. We are happy to work with Consumer Focus to discuss how best to present tariffs which facilitate DSR.

3.9. While different kinds of tariffs may offer attractive savings it will be important to consider the potential impact these tariffs may have on vulnerable and low-income customers, and put measures in place that will offer them appropriate protections. This sentiment was expressed at our workshop in January 2010 and in a paper published in March 2010 by Sustainability First entitled 'Smart Tariffs and Household Demand Response'[47]. In addition, at the Consumer First Panel, panellists expressed concern for vulnerable consumers who may be most attracted to the cost savings in such tariffs, but who may also be at risk from deferring usage when it is needed.

Incentives

3.10. Apart from TOU tariffs, there are few financial incentives for domestic and small business consumers to change their demand patterns because they do not receive relevant price signals within their tariff structure and the true cost of each unit of electricity consumed is not visible.

3.11. In the long run, it is expected that smart meters will facilitate the marketing and uptake of new tariffs, which can provide financial incentives to encourage DSR. There are issues which would need to be resolved in order to fully harness this (discussed below) but if there is value in domestic and small business users providing DSR before smart meters are rolled out, then there are other areas that can be considered.

3.12. One of the key lessons from our international review is that some DSR can take place without smart meters and result in consumer benefits. For example, through static TOU tariffs, including the consideration of how the differentials between peak

[46] The Consumer Focus Confidence Code: A Voluntary Code of Practise for Online Domestic Price Comparison Services: http://www.consumerfocus.org.uk/assets/1/files/2009/11/154_20081017141314_e_@@_Consumer_Focus_Confidence_Code.pdf

[47] Please find at: http://www.sustainabilityfirst.org.uk/publications/smart_tariffs_2010.htm

and off-peak prices motivate behaviour. Another example is looking at how network charges could be reflected to consumers to motivate behaviour.

3.13. In a previous Consumer Panel we conducted, we found that there was an element of resistance to TOU tariffs[48]. Despite this, some suppliers are testing and marketing new TOU tariffs (e.g. Eco:2020), which require meters that can capture multiple rates. The way customers interact with TOU tariffs is important. Sharpening price signals within these tariffs by creating larger differentials between the pre-fixed rate blocks may encourage greater shifts of energy use to off-peak periods. From discussions with industry, the Department for Business, Enterprise and Regulatory Reform found that the price difference between peak and off-peak periods of 700% to 1,000% might be needed to provide enough incentive to switch[49]. However, this is not the only way of encouraging load shifting. For example, before privatisation of the energy sector in GB, three area boards successfully increased uptake of their Economy 7 tariffs by equalising peak rates with rates under their standard tariffs (with a slightly higher standing charge). The consequence of this was that there was an increase in the uptake of Economy 7 tariffs by customers without storage heating. This example demonstrates that there may be a case for reward-only incentives which encourage demand shifting.

3.14. Another option to encourage consumers to participate in DSR is to make specific charges within the supply chain more cost-reflective (e.g. transmission and distribution network charges)[50]. Customers would receive economically efficient incentives to reduce consumption at times of high network load, and their charges would vary according to when they use electricity.

3.15. On 1 April 2010 Ofgem introduced a new, cost-reflective, charging methodology for users of the lower voltage distribution networks including non-half hourly metered households and small businesses[51]. The vast majority of households do not currently use half hourly meters, so remain unaffected by this change which is aimed at the commercial sector. Business customers need to be aware of when the periods of low and high network demand occur to change consumption patterns and

[48] 'Ofgem Consumer First Panel: Research Findings from the Third Events, October 2009', page 40.
[49] 'IA of Smart metering Roll Out for Domestic Consumers and for Small Businesses', BERR, April 2008, page 55.
[50] As at August 2009, transmission and distribution network costs make-up 18% of an average electricity domestic bill. See for details: http://www.ofgem.gov.uk/Media/FactSheets/Documents1/updatedhouseholdbills09.pdf
[51] Examples of how these methodologies achieve cost-reflectivity include creating time-of-day unit rates such that units consumed during times of high network load are more expensive and units consumed during periods of low network load are cheaper; and recognising the economic benefits that distributed generators provide to the network and crediting them for it.

participate in DSR[52]. However, for customers to reap any benefits, suppliers would need to pass on any cost savings to customers participating in DSR.

3.16. Any new type of pricing structure based on actual usage may expose consumers to greater price volatility and would require changes to the current way network companies charge suppliers (on behalf of customers) for use of their networks. This may be desirable for the purposes of facilitating DSR. However, it could be problematic for consumers, particularly vulnerable consumers, if they have limited visibility of what prices are at a given time and/or have limited ability to participate. Making such tariffs voluntary is not necessarily socially equitable. In particular, TOU tariffs are likely to unfairly impact people who are at home during the day. This includes many of the more vulnerable customers such as older pensioners, the sick, disabled and carers.

3.17. Other approaches could include separate or special use of system tariffs for customers with white goods that link to reducing power usage during times of peak demand on DNOs' networks.

Issue 2: Changing consumer behaviour

3.18. There are barriers beyond a lack of awareness and an absence of financial incentives for domestic consumers. Consumers on our panel noted that shifting consumption would require changes to their lifestyle. The level of financial incentive to motivate a lifestyle change is therefore a relevant consideration.

3.19. The majority of consumers who participated in the DSR trials we reviewed experienced bill savings. Around 10 to 20% of respondents to the MORI omnibus survey indicated that they would be 'very likely' to postpone electricity use of certain household activities from peak periods of demand to later in the evening if given the right incentives, and about 20 to 30% said they would be 'fairly likely'[53].

3.20. The MORI survey and Consumer First Panel showed that consumers are more willing to shift consumption of certain activities than others. The most feasible changes include:

- **using some appliances after midnight:** some consumers already do this (e.g. washing machines) because it fits within their lifestyle or they believe it will save them money. This is consistent with our assessment in Chapter 1 of the type of consumption activity that is most likely to be flexible for domestic consumers to

[52] This information may be provided through smart meters but, in the interim, customers could take note of the time periods relating to high and low network load, which is contained within each DNO's published use of system charges methodology.
[53] Ipsos MORI, 'Energy Issues 2009: Survey of British public opinion', page 22.

shift. However, many consumers have lifestyles or living arrangements that makes using appliances after midnight unattractive (such as those living in flats or terraced houses where the noise of appliances would disturb their neighbours and/or those in small properties where the noise cannot be contained); and

- **heating water at night:** this appealed particularly to people who had hot water tanks and immersion heaters that could be used on timers.

3.21. Consumers unsurprisingly felt that changes like cooking at different times were not feasible. The majority also considered the use of electric storage heating to be inferior to central heating and were therefore unlikely to seriously consider it. Customers were also hesitant about automated controls for appliances. This finding is in line with the feedback given as part of the international trials we have reviewed, where some participants were initially hesitant about giving up control of electric appliances to suppliers but this concern was reduced after they had some experience of the arrangement.

3.22. As energy bills are expected to rise for all customers, including domestic and SME, they may represent a larger proportion of their total spending in the future[54]. Against a background of rising fuel bills and the potential for further increases in the coming decade, greater levels of demand management, including DSR, is one way to help mitigate these rises. However, in order to do so, consumers need a good understanding of their usage and how and when they can shift discretionary demand. Smart metering technology and appropriate price signals will have a key role to play in facilitating this.

3.23. Larger SME customers are required to participate in the CRC Energy Efficiency Scheme, and are also required to display energy certificates and energy performance certificates on their premises. Consequently, they have an incentive to manage and reduce their energy consumption, with DSR one option among many. However, smaller SMEs do not have equivalent incentives.

3.24. Furthermore, enabling technologies and automated devices are likely to become widespread over time, and this may help to overcome the issue of changing consumer behaviours.

Issue 3: Limits to discretionary demand

3.25. Even if consumers are willing to change electricity demand patterns, there may be limits to how much of it is flexible, as discussed in Chapter 1. Usage, and therefore flexibility, is affected by factors such as working patterns and the composition of a household and these can vary considerably. However, the longer-

[54] As part of the Project Discovery scenario analysis, Ofgem estimated that customer bills will rise on average by 13-26% over the period 2010-20.

term outlook suggests that demand is likely to become increasingly flexible for a number of reasons. Smarter technology may well unlock much of the existing potential flexibility (discussed in Issue 8 below). Additionally, both electric cars and (to a lesser extent) electric heating are projected to become more prevalent. Were this to be the case it would lead to a significant growth in electricity demand. However, such demand would be more flexible since these consumption activities have the potential to store energy. They could therefore consume electricity away from times of peak demand, or even in response to times of peak wind output (thereby helping to keep the system in balance).

3.26. Smaller non-domestic consumers are also very diverse in their energy demand needs. However, we found little available data on SME consumers' energy management and little evidence of engagement on DSR by them. The extent to which a SME consumer can participate in DSR depends on several factors including hours of operations, how much scope there is to change them and the financial impact of changing consumption patterns. It may also be difficult to change behaviour among SME consumers for a range of reasons. Some of these, which we gathered from anecdotal conversations with SME representatives, are listed below:

- SMEs will be primarily focussed on core business operations;
- fuel bills may not represent a significant proportion of overall costs;
- SMEs may not have the resources to devote to energy management; and/or
- they may have inflexible energy consumption patterns.

Issue 4: Technology

3.27. Technologies such as smart meters and smart appliances (appliances that can interact with a smart meter and operate automatically or respond to changing conditions on the electricity network) currently have a very low level of market penetration. However, alongside the mandated rollout of smart meters, smart appliances are forecast to grow significantly in popularity. Smart appliances can play an important role in facilitating DSR. Studies have shown[55] that the more sophisticated and automated enabling technology is, the stronger the demand response. Indeed, automation was a common feature among the successful international trials we reviewed. Installing automated devices requires a one-off behaviour change which will have lasting results. Automation also bypasses other barriers such as suppliers' concerns over how certain or 'firm' a customer's load is and changing consumer behaviour. However, some consumers may resist new technologies or consider the costs to be too high.

3.28. One example of a relatively new technology is a dynamic demand control device which can be installed into new appliances or retro-fitted into existing ones. As discussed in Chapter 1, these devices work on appliances that are time-flexible.

[55] 'Unlocking the €53 Billion Savings from Smart Meters in the EU', The Brattle Group

That is, appliances which run in cycles and therefore do not need to be turned on continuously such as refrigerators and air conditioning units. Dynamic demand control devices respond to demand and supply conditions on the electricity system. The device can sense when the balance between demand and supply (or frequency) is below a preset level (50 hertz), at which point the appliance is turned off. The appliance is then switched back on once the balance between demand and supply is restored to the minimum required level. However, for such devices to have a significant impact on keeping the system in balance, millions need to be active. There are currently some small scale trials in operation. These devices are allowable measures under the CERT scheme (which Ofgem administers) and it is under these auspices, and EDRP, that the trials are taking place.

Issue 5: Weak short-term price signals

3.29. In the February Discovery publication[56], one of the key issues raised is that short term price signals, during periods of stress on the electricity system, may not fully reflect the value that customers place on security of supply. Specifically, it is possible that some customers could have their supply limited before short term prices have reached the maximum value that they would pay to maintain a continuous supply. One of the consequences of weak short-term price signals is that incentives to develop DSR are reduced.

3.30. One of the options presented in the Discovery document was to sharpen short term price signals to encourage industrial customers who are willing to defer or forgo demand to do so and potentially be rewarded. A number of measures could be adopted to sharpen short term price signals, including: making the allocation of costs associated with back-up generation used to balance supply and demand, on a particular day, more reflective of system tightness; and ensuring that when measures are deployed under extreme conditions, this is reflected in the price.

Industry related issues

Issue 6: Suppliers' incentives to offer products

3.31. There are a limited number of products available to encourage DSR, particularly among domestic consumers and small businesses. In our workshop in January 2010, it was identified that a barrier to suppliers is the current balancing and settlement arrangements for domestic consumers and small businesses. Participants claimed that there was little or no incentive for suppliers to offer tariffs that encouraged load shifting. Specifically, the view presented at the workshop was that when an individual supplier offers products to its smaller customers to shift

[56] 'Project Discovery: Options for delivering secure and sustainable energy supplies', 3 February 2010, page 19

consumption, from periods of high demand and high prices to periods of low demand and low prices, all suppliers share in this benefit.

3.32. Settlement for most small customers is based on average profiles not actual half-hourly consumption data as it is for larger users. However, the balancing and settlement arrangements include a mechanism for adjusting the average profiles to reflect the metered (actual) consumption patterns of groups of customers (using so-called 'Standard Settlement Configurations'). Thus, a wide range of TOU tariffs could be introduced within the current non-half-hourly market settlement arrangements, and greater flexibility will be enabled through the roll-out of smart metering technology. Furthermore, a range of dynamic tariffs could also be offered without the meter point having to move to the half-hourly market, subject to small changes to the Balancing and Settlement Code. The changes required to the Balancing and Settlement Code can be proposed by industry. However, the view expressed by some participants at the workshop was that suppliers have not raised any modification proposals in this area as it is either too complicated or costly, or there are practical barriers. Greater changes to settlement would be needed if, for example, the number of different time profiles was to exceed 10,000 or the settlement periods were very short or frequent (approaching the half-hour settlement period).

3.33. Smart meters offer the opportunity to use more recent data as a base for the standard profiles used in the non-half-hourly market. As such, Elexon has set up a Profiling and Settlement Review Group to assess the implications and to decide what changes need to be made[57]. Smart meters also offer suppliers the opportunity to settle non-half hourly customers accurately on a half-hourly basis and therefore offer tariffs that encourage customers to shift consumption. Therefore, as part of the Profiling and Settlement Review, Elexon recently launched a consultation to better understand how the half-hourly market is likely to grow and whether the current Balancing and Settlement arrangements need to be changed[58]. In the recent Project Discovery publication, it was noted that as part of Ofgem's ongoing work it is exploring specific market design issues related to balancing and settlement. This may include examining the potential for half-hourly (or shorter interval) settlement for residential customers to be introduced[59].

3.34. Another barrier to suppliers which was also identified at our workshop is that there is too much uncertainty over whether or not a consumer will reduce demand when required. When contracting its position in the balancing and settlement system, a supplier would take into account DSR. Some suppliers argue the risk associated

[57] The terms of reference for this working group can be found at: http://www.elexon.co.uk/documents/bsc_panel,_committees_and_groups/svg_meeting_2010_-_109_-_papers/svg109_07_v1.0.pdf
[58] 'Profiling and Settlement Review Supplier Consultation', 30 April 2010: http://www.elexon.co.uk/consultations/closed/default.aspx#consultation8
[59] 'Project Discovery: Options for delivering secure and sustainable energy supplies', 3 February 2010, page 35

with a customer not responding is too high and there could be further impacts in terms of the supplier's ability to deliver energy to other customers. Other barriers for suppliers in terms of offering DSR products are related to commercial investment decisions. Suppliers may be unwilling to invest in new billing and customer service systems, which may be required, for example, with the introduction of further static TOU tariffs particularly if smart meters render them redundant.

Issue 7: Passive nature of the electricity distribution network

3.35. The distribution network currently has relatively straightforward one-directional flows of electricity, and it is built with sufficient network capacity to accommodate peak flows[60]. Consequently, there has been no need for distribution network operators (DNOs) to actively manage their networks. However, in future this may change as both electricity demand and variable and distributed generation increase, making electricity flows at the distribution level more diverse and complex.

3.36. In order to meet these future developments, DNOs are expected to take on a more active role similar to the transmission system operator (TSO). This may include activities to ensure demand and supply of electricity on the network is balanced by increasing generation flows (e.g. distributed generation) or decreasing demand flows through DSR. As discussed in Chapter 2, one of the benefits of DSR is avoided network investment, giving DNOs a clear financial incentive to actively manage distribution networks by facilitating DSR.

3.37. We have taken steps to encourage DNOs to assume a more active role in managing flows of energy on their networks, including thinking about the role they could play in facilitating DSR. In the latest distribution price control (2010 to 2015) review[61], we included initiatives that were intended to equalise incentives between investing in new assets or investigating the potential to pursue operational solutions. The purpose of this change is to encourage DNOs to consider the relative merits associated with operational solutions such as DSR. Alongside this, we also established the Low Carbon Networks Fund. The Fund will allow up to £500 million of support to projects sponsored by the DNOs to trial new technologies or commercial arrangements to facilitate, among other things, DSR, local generation and energy efficiency. The objective of the projects is to aid understanding of how DNOs can contribute towards security of supply at value for money in the transition to a low carbon electricity system.

3.38. More broadly, we are currently undertaking a review of the regulatory framework that applies to the gas and electricity transmission and distribution networks in our RPI-X@20 project. As part of this review, we have set out that the network companies should play a full role in facilitating the transition to a sustainable

[60] 'The role of future energy networks', Frontier Economics, page 37
[61] See Distribution Price Control Review 5 Final Proposals

energy sector and delivering value for money for existing and future consumers. To effectively deliver against these objectives, it will require a mindset change on the part of the network companies. In our Emerging Thinking consultation document[62], we set out that the network companies should become more responsive to new technologies and approaches to ensure that they are not perceived to be a barrier to the emergence of innovative solutions. This includes technologies such as smart metering and the operational practises that would underpin the delivery of benefits from this technology. More generally, in Emerging Thinking we set out that the network companies should be encouraged to consider the longer term implications of their decisions in identifying the best value solutions. To facilitate this, they should consider a wider range of delivery options, including innovative operational solutions such as DSR. We set out that, in exploring these types of options, the network companies should also seek to work with others to develop integrated solutions that could help to deliver value for money for existing and future consumers. In our Emerging Thinking consultation document, we proposed to reward network companies that respond proactively to these types of demands.

Issue 8: Aggregation

3.39. In situations where networks are under stress, balancing the system can require a response which is both large and located in a specific part of the network. Typically, response is provided either by generation units ramping up or down their output or (where sudden shortages exist) by large demand units (e.g. I&C customers) ramping down their demand. DSR by small consumers who are dispersed and uncoordinated is therefore of little use in such situations where an immediate and coordinated response is required.

3.40. One of the common messages from our workshop was that aggregated DSR from all consumer groups can provide a valuable service. There are already aggregators who bid DSR on behalf of their customers in GB, and activity in this area seems to be increasing. The focus to date, however, has been on larger consumers.

3.41. In an international context, there are examples of aggregators who offer aggregation services to all classes of users to sell DSR. Aside from specialist aggregators, theoretically other parties such as suppliers, DNOs or Energy Service Companies (ESCOs) could also undertake this role. While utilising existing relationships and roles would have advantages, there might be a number of conflicts of interests which would need to be considered.

3.42. There are several issues that need to be explored to assess the feasibility of aggregating DSR from domestic and small business customers, including:

- the feasibility of this business model in the GB market;

[62] Regulating energy networks for the future: RPI-X@20 Emerging Thinking

- consumer protection with regard to delivery agents;
- contractual or legal barriers that might prevent aggregation services (e.g. issues surrounding the ability of a party, other than a supplier, aggregating DSR from individual consumers); and
- the impact on industry players (such as the impact on a supplier's revenue stream from a third party to which it has no contractual relationship).

Next steps

3.43. DSR is an important and developing theme to Ofgem's work, and is consistent with our primary duty to protect the interests of consumers. We are addressing a number of the issues set out above and further initiatives are underway to enable the benefits of DSR to be realised. In addition to working with the Government to ensure the smooth roll-out of smart meters, promoting DSR is embedded across our key work areas. Our current work areas that relate to DSR are listed below, and summarised in Figure 3.1:

- **Energy Demand Research Project**: participants in the trials are taking part in a number of activities designed to test DSR;

- Under the **Carbon Emissions Reduction Target**, which we administer, dynamic demand control devices are allowable measures;

- In its suite of options, **Project Discovery** included discussion on measures to **sharpen short-term price signals** and set out rationale for a **minimum carbon price** to encourage greater investment in low carbon technologies;

- As part of our ongoing work we are **exploring the potential for half-hourly settlement for domestic customers to be introduced, the design of TOU tariffs and real-time pricing and the role of demand-side aggregators**;

- **Equalisation of operating and capital costs**: in the final proposals for the latest distribution price control (DPCR5), incentives for operating and capital costs were equalised. These changes should assist in encouraging DNOs to invest in non-network solutions such as DSR;

- **Low Carbon Networks Fund:** the objective of the Fund is to stimulate innovation on the networks and encourage DNOs to trial new technologies to facilitate DSR and energy efficiency. It is likely that many of the projects will yield valuable data on DSR. Under the RPI-X@2020 project, we are proposing to build on this Fund to allow non-network parties to lead on projects and to extend the Fund across each of the four energy network sectors (i.e. electricity distribution, electricity transmission, gas distribution and gas transmission);

- On 1 April 2010, we introduced a new, **cost-reflective charging methodology** for users of the lower voltage distribution network (e.g. households and small businesses). On 1 April 2011, we will introduce a cost-reflective methodology for users of the higher voltage distribution network (e.g. large manufacturing sites)[63]. This should assist in encouraging these consumers to participate in DSR as they would be rewarded for doing so;

- Ofgem recently approved the implementation by the DNOs of a **common distribution charging methodology** (CDCM) as of April 2010. It covers all domestic and the majority of business customers. The CDCM was implemented with more accessible governance arrangements that allow DNOs and other stakeholders (e.g. suppliers and their customers) the ability to modify the CDCM, for example, to allow the DNOs to charge its customers, who reduce demand at peak periods, commensurately;

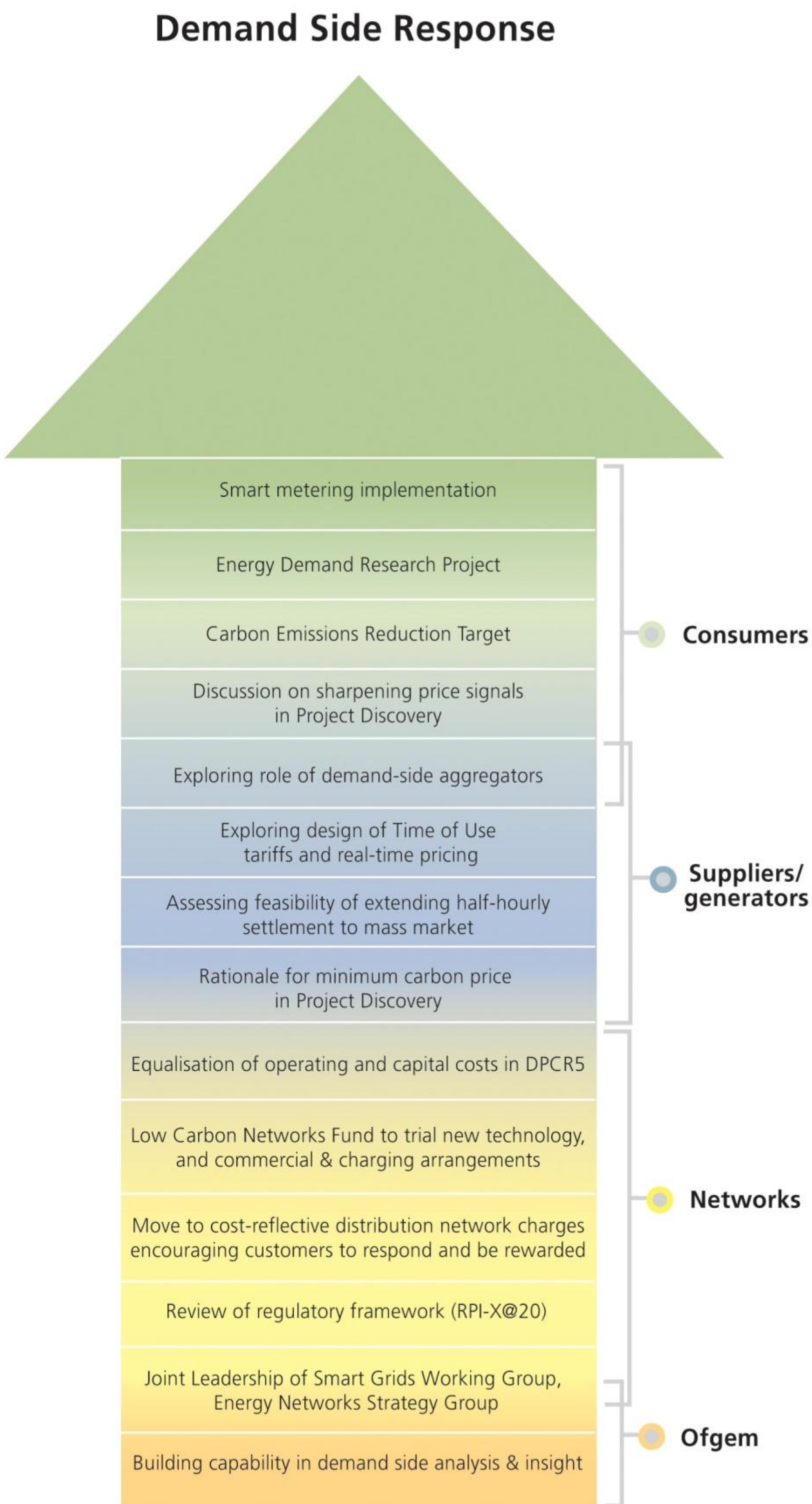
- Ofgem is conducting a **review of the regulatory framework (RPI-X@20)** that applies to the gas and electricity transmission and distribution networks;

- **Energy Networks Strategy Group's Smart Grids Working Group:** this Group is chaired by Ofgem and DECC which has produced a high level vision of what the UK smart grid might look like, the challenges it would help address and a route map for delivery of this vision; and

- As part of the new Sustainable Development Division, Ofgem is creating **expertise in demand side analysis and insight**.

[63] Examples of how these methodologies achieve cost-reflectivity include:
•creating time-of-day unit rates such that units consumed during times of high network load are more expensive and units consumed during periods of low network load are cheaper; and
•recognising the economic benefits that distributed generators provide to the network and crediting them for it.

Figure 3.1: Ofgem initiatives across the supply chain to facilitate demand side response



3.44. We intend to discuss the issues captured in this paper with stakeholders over the next few months, including hosting a workshop in autumn. While not a consultation, if you have any feedback or views on any aspect of this paper or would like to attend the stakeholder workshop, please contact Sabreena Juneja (sabreena.juneja@ofgem.gov.uk).

Appendices

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Appendix 1 - Uses of electricity by consumer group

Table 1- Electricity consumption by household domestic appliances, 2008

Appliance	% of total consumption
Lighting (e.g. light bulbs)	20%
Cold appliances (fridge-freezer, chest freezer, refrigerator, upright freezer)	17%
Wet appliances (washing machine, washer-dryer, dishwasher, tumble dryer)	16%
Consumer electronics (TV, DVD, etc)	24%
Home computing (desktops, laptops, printers, etc)	7%
Cooking (electric oven, electric hob, microwave, kettle)	15%

Source: DECC Energy Consumption in the UK, Domestic data tables, 2009 Update

Table 2- Electricity consumption by service sector[64], 2007

Electricity consumption activity	% of total consumption
Catering	14%
Computing	5%
Cooling and ventilation	9%
Hot water	3%
Heating	15%
Lighting	40%
Other	13%

Source: DECC Energy Consumption in the UK, Service sector data tables, 2009 update

[64] Includes commercial offices, communication and transport, education, government, health, hotel and catering, retail, sport and leisure and other.

Table 3- Industrial electricity consumption by end-use, 2007

Electricity consumption activity	% of total consumption
High temperature process	12%
Low temperature process	17%
Drying/separation	6%
Motors	34%
Compressed air	10%
Lighting	3%
Refrigeration	5%
Space heating	8%
Other	5%

Source: DECC Energy Consumption in the UK, Industrial data tables, 2009 update

Appendix 2 – Methodology and assumptions for quantifying carbon emissions and wholesale cost savings

1.1. This appendix presents some of the detailed assumptions which underpin our analysis in Chapter 2. It includes the following:

- demand assumptions;
- generation mix assumptions; and
- an explanation of wholesale cost savings from DSR.

Demand Assumptions

1.2. Table A2.1 contains our within-day demand assumptions, assuming that 10 per cent of daily peak demand is shifted across all customer groups, where the period between 15:30 and 19:30 is the peak.

Table A2.1: 10% shift of total daily peak demand[65]

Customer	% peak demand	DSR potential	% peak demand with DSR	Time period	
				From	To
Interruptible I&C	3.8%		3.8%		
Firm I&C	16.0%	-5.0%	15.2%	15:30-19:30	11:00-15:00
SME	30.2%	-5.0%	28.7%	15:30-19:30	21:00-01:00
Domestic	50.0%	-5% to -15.0%	42.5% to 47.5%	15:30-19:30	21:00-01:00
Total	100.0%		90.2% to 95.2%		

1.3. The estimates in Table A2.1 have been generated as follows:

- for domestic customers, we have assumed that between 5 and 15% of peak demand could be shifted from the peak period to later in the evening. As discussed in Chapter 1, the upper limit represents a rough approximation of the

[65] Based on a combination of sources, including: our assessment in Chapter 1; Ofgem Project Discovery; Global Insight; and "Estimation of Industrial Buyers Potential Demand Response to Short Periods of High Gas and Electricity Prices" (2005 California DSR trials).

level of domestic demand that is flexible to DSR. We have used a range of information to inform our estimates, in particular the report by Global Insight[66];

- for SME customers, we have assumed that 5% of peak demand could be shifted from the peak period to later in the evening. We have assumed a similar demand profile to that of domestic customers, but with lower potential for DSR given that, intuitively, SME demand is likely to be less flexible[67]; and

- for firm I&C customers[68], we have assumed that 5% of peak demand could be shifted from the peak period to earlier in the business day. As DSR from large industrial customers with enabling technology is assumed to be reflected in the demand data already, this 5% estimate relates to the additional potential DSR from commercial customers only[69].

1.4. Our modelling exercise across a number of sample winter and autumn days takes these demand assumptions as static (i.e. they do not vary according to price or other factors). It is also worth noting that for the purposes of this report, no work on elasticity of demand based on price or other factors has been studied, and no such figures are included in the quantitative analysis.

Generation Mix Assumptions

1.5. In order to quantify the impact of DSR on both carbon emissions and wholesale costs, we have used the Project Discovery model to produce a generation mix to correspond to each of the days examined. The following key assumptions have been adopted:

- for the three days analysed in 2009/10, we have used 2009 short run marginal costs (SRMC), based on actual average commodity and carbon prices for the 2009 calendar year. For the 2020 estimate, we have used the 2020 forecast SRMC estimates under our 'Green Transition' scenario as part of the Project Discovery Model;

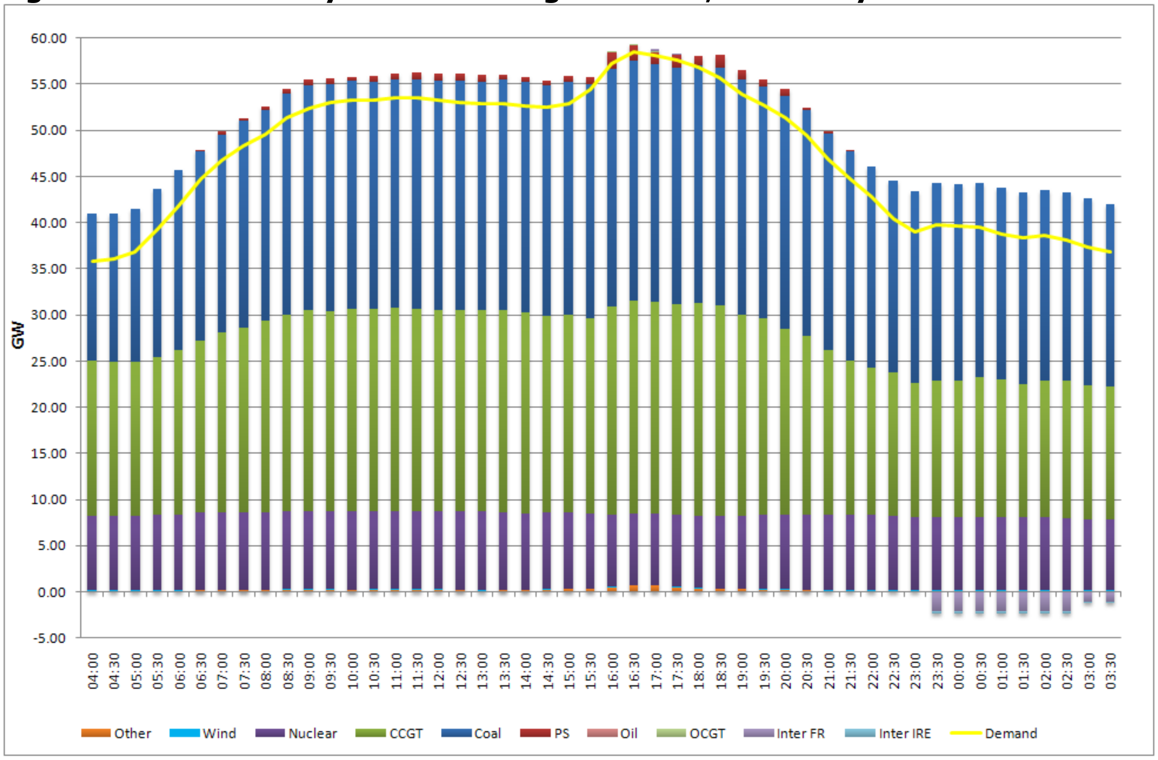
- all plants are despatched in order of their SRMC; and

- peak de-rated capacity has been used for single day analysis but we have relaxed this assumption for the 2020 analysis illustrating changes in wind output.

[66] IHS Global Insight (2009) 'Demand Side Market Participation Report'. We note that there is no consensus within industry about the level of DSR that can be assumed.
[67] There is limited information available regarding the potential for DSR among SMEs.
[68] Firm I&C customers do not have contractual provisions that allow the system operator to take direct action that results in interruptions to their electricity supply to correct for supply-demand imbalances.
[69] Our estimates for commercial customers have been informed by our analysis in Chapter 2 regarding existing levels of demand and the results of the California trials of 2003-05, in which these customers reduced their peak demand by between 4.8 and 13%.

1.6. DSR flattens the demand profile which could be expected to change the generation mix across the day, and in turn, the carbon intensity of the electricity produced in the affected periods. As Figure A2.1 illustrates, using actual data for 7 January 2010, the generation mix changes throughout the day in response to changes in demand.

Figure A2.1: Electricity demand and generation, 7 January 2010



Source: National Grid and BM reports

1.7. For example, on this particular day, relative to the off-peak periods, at the peak period (15:30 - 19:30), there is not only more Combined Cycle Gas Turbine (CCGT) and coal plant running, but peaking plant such as pumped storage and Open Cycle Gas Turbine (OCGT) also ran to meet demand. As the generation mix changes over the course of the day, so too does the associated carbon intensity of that generation.

Assumptions specific to carbon impact analysis

1.8. We have assumed a value of £14 per tonne of CO_2 to value the daily change in carbon emissions brought about by DSR[70]. Our carbon intensity assumptions by fuel type (before plant efficiency adjustments) are contained in Table A.2.2.

Table A2.2: Carbon Intensity Assumptions

Fuel type	**Carbon intensity (tCO_2/MWh)**
Biomass	0
Coal (without CCS)	0.34
Coal (with CCS)	0.03
Fuel oil	0.28
Gas	0.18
Gas oil	0.36
Pumped storage	0.48
Nuclear	0

Source: Ofgem Project Discovery

1.9. The following assumptions apply to the estimates in Table A2.3:

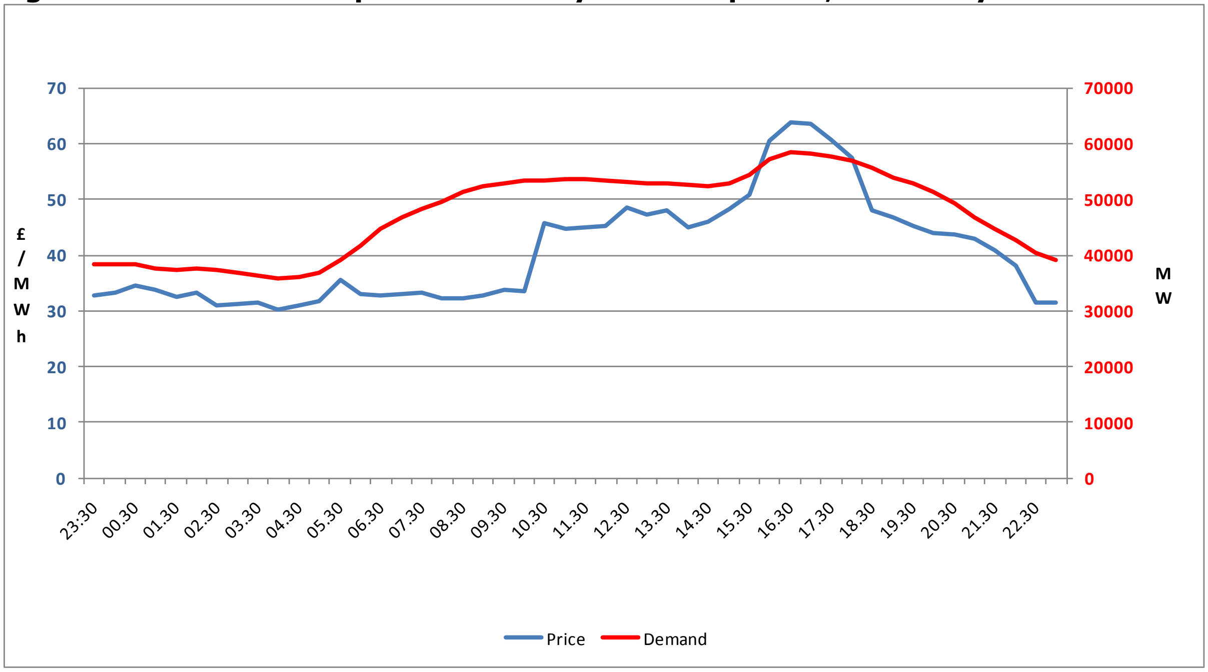
- absolute amount of carbon in fuel relative to energy from fuel;
- coal (with CCS): assumed that once fully fitted, 90% of emissions will be abated using CCS; and
- pumped storage: assumed that CCGT supplies energy at the margin for overnight pumping, and pumped storage plant efficiency of 70%.

An explanation of wholesale cost savings from DSR

1.10. Electricity generation plant tends to run in ascending order of its SRMC. As a consequence, in peak periods where demand is higher, wholesale electricity prices tend to be higher. An example is provided in Figure A2.2 below, for 7 January 2010, a day of particularly high demand in GB.

[70] 'Updated short-term traded carbon values for UK public policy appraisal', June 2010, Decc

Figure A2.2: Wholesale prices and daily demand profile, 7 January 2010

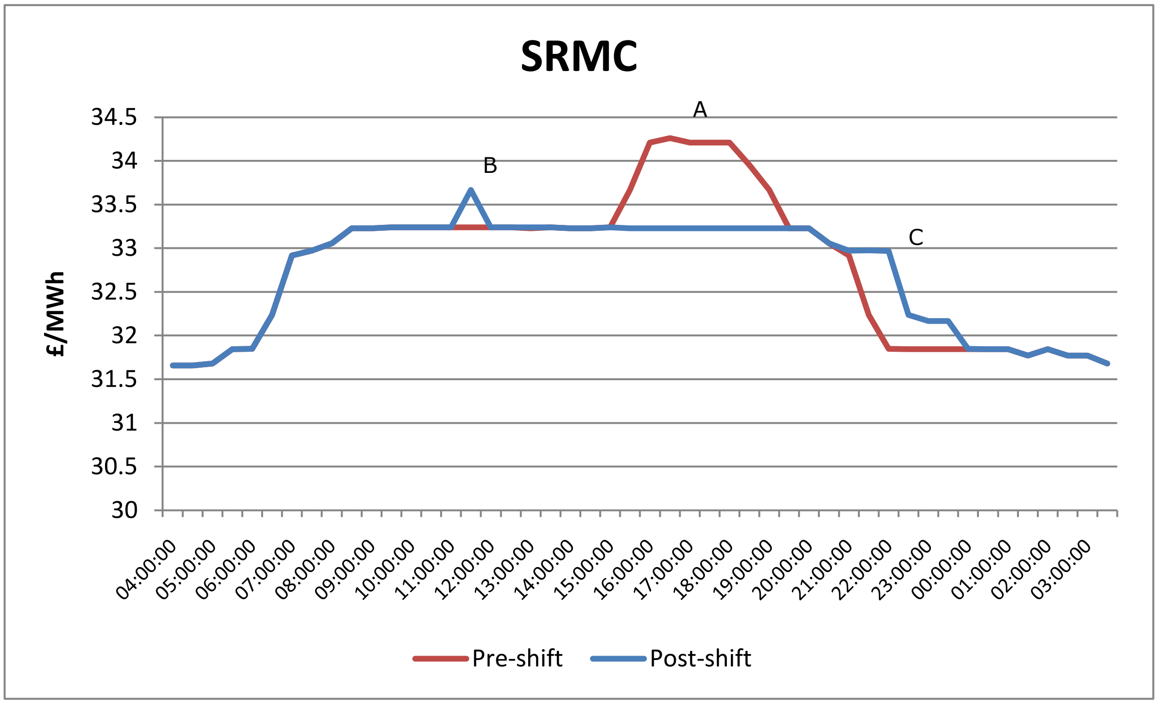


Source: APX, National Grid

1.11. Shifting demand away from these peak periods should reduce the necessity to dispatch generation plant with a higher SRMC. Those plants responding to higher demand in the periods demand was shifted to would have a lower SRMC than those displaced from the peak period; thus, it is anticipated that total wholesale electricity costs across the day would be reduced.

1.12. To estimate the change in wholesale costs we have used the same "pre-shift" and "post-shift" demand profiles as were used for our carbon impact calculations. Using the Project Discovery model and 2009 SRMC data, we identify the difference in the SRMCs of the plant that would be generating for each period for the two demand profiles, assuming plant is dispatched in SRMC order. Figure A2.3 below demonstrates the change in SRMC on 7 January 2009.

Figure A2.3: 7 January 2009 – Wholesale cost savings resulting from differences in SRMC of despatched plant



1.13. The areas between the 'Pre-shift' and 'Post-shift' lines (A, B and C) demonstrate the differences in SRMC of despatched plant in each period. Area A, where Pre-shift demand and hence SRMC is above Post-shift, shows cost savings from demand shifting away from peak periods. Areas where Post-shift SRMC is above Pre-shift SRMC (B and C) represent an increase in costs in the periods that demand is shifted to. As area A is larger than B+C the net effect is a reduction in wholesale generating costs.

1.14. The ability of certain plant to provide certain peaking services or manage constraints will mean that plant is commonly despatched out of SRMC order in certain periods. As the model used despatches plant in SRMC order, some of this more expensive plant is not despatched by the model. This should mean that our estimates are conservative of the potential benefits of DSR on short run costs.

1.15. Furthermore, if the DSR were dynamic and able to respond to price signals, some of this expensive plant could be displaced providing further cost savings. Such dynamic responsiveness is likely to become increasingly valuable as variable renewable plant increases its share of the generation mix; however this is not modelled here.

Appendix 3 – Summary of consumer research

Consumer First Panel

1.1. This section summarises domestic deliberative research regarding consumers' views of demand side response using the Consumer First Panel. It was undertaken in January 2010 by Opinion Leader.

1.2. The Ofgem 'Consumer First' Panel is a diverse group of 100 domestic energy consumers. It was formed to be the 'voice of the consumer' and to help Ofgem ensure policy developments are consumer focused. It meets 3 or 4 times per year to discuss topical issues. The Panel is in its second year and draws its members from 5 locations across Great Britain, including Aberdeen, Aberystwyth, Bradford, Bristol and London. The Panellists are recruited to be broadly representative of domestic energy consumers.

1.3. Panellists generally saw that the behaviour changes consumers may be asked to take on as being somewhat unfeasible. In particular:

- there was scepticism around using technology which automatically switches appliances off at times of high demand as they were concerned they would have no control;
- cooking food at different times was not considered possible as they regarded meal times as fixed; and
- having an interruptible supply was not appealing for most and there was some concern this would appeal to vulnerable consumers who might suffer negative effects from interruptions.

1.4. Using appliances and heating water at night were seen as most reasonable, although some felt they could not use appliances at night due to noise.

1.5. Panellists were provided with a graph showing typical daily electricity usage and it was explained that smoothing the demand peaks at differing times of the day could help to reduce the cost of the system. The discussion considered what consumers could do to help smooth this line and what the role of the consumer could be. Many were unaware of the peaks and troughs of energy usage during a typical day and it was felt that a higher level of awareness of both this and the benefits of using energy at different times of the day could help to change behaviour.

1.6. Panellists did not immediately think about using energy at different times of day. They tended to think of overall energy usage as being important and could not immediately understand why shifting usage from evenings to night would make a difference. This concept was hard for Panellists to grasp as it required them to think about breaking their current habits and adopting new ones, and overall Panellists seemed to feel it was unlikely they would adopt these new habits.

1.7. The introduction of financial incentives, such as cost savings for shifting usage, was seen to be essential for encouraging these behaviour changes. This reinforced findings from the previous Panel meeting where it was identified that cost is a major factor in affecting change in behaviour.

1.8. Panellists felt that some responsibility lay with manufacturers to build appliances which make it easy for people to use electricity during antisocial hours e.g. washing machines with a timer function. However, it was also felt that upgrading equipment may require significant expenditure, and so may be a barrier to people switching to using electricity at night.

1.9. The most feasible changes to behaviour for Panellists were:

- **using appliances after midnight:** some Panellists do this already out of habit. For example, using washing machines at night fits with their routine, and others think they would if they could save money. However, there was resistance from some Panellists living in flats as they felt the noise of appliances would disturb themselves and neighbours. There were also some mixed messages identified in Aberdeen surrounding the safety of using appliances after midnight;
- **heating water at night:** most Panellists favoured this idea, especially if they had hot water tanks and immersion heaters set by timers. Most thought that this would be appealing if the money they saved outweighed what they spent on using their boilers.

1.10. Other changes which seemed less feasible to Panellists were:

- **cooking at different times of day:** for most Panellists meal times are fixed, especially for those with children and those in full time employment, although some older Panellists thought cooking at different times of day might be possible;
- **using storage heaters:** some Panellists were aware of these, but the majority saw these as inferior to central heating and so would not favour their use in the future;
- **use of technology that would automatically switch off appliances** (e.g. fridge, freezer etc): if electricity supplies are stressed – most Panellists were suspicious of this technology as they were unsure of the impact this might have on their appliances, e.g. would their freezer defrost? A small number of Panellists felt that this type of control would be acceptable as they would not notice it and would simply forget about it after a while. Panellists were however more open to having more information on their energy usage, and some spontaneously mentioned smart meters. They felt that this would help them to make choices for themselves about their energy usage based on the price at that time of day, and would encourage them to switch things off themselves; and
- **interruptible supply:** – the idea of an interruptible supply did not appeal to most Panellists. Some simply did not like the idea of limited power, even if these interruptions were planned, and those with young families said that this would not be a viable option for them. Some younger Panellists and older Panellists felt they might consider this for a reduced cost as they could arrange to be out at the time their power went off. Some did identify concern about this development in tariffs. They felt it might appeal to the most vulnerable consumers, who would be

attracted by the lower cost implications, but who might be most affected by power cuts, e.g. pensioners, young families.

Omnibus survey

1.11. This section summarises domestic quantitative research regarding consumers' propensity to undertake energy saving measures. It was undertaken in December 2009 by Ipsos MORI.

1.12. This research is based on data from a nationally representative omnibus (CAPIBUS) survey of the population of Great Britain aged 15 and over. Ipsos MORI conducted 1,961 quota controlled face-to-face interviews in the period 11 to 21 December 2009 using computer-aided personal interviewing in 174 systematically-selected sampling points (more than on a standard week due to bad weather – fieldwork period was also extended). The data is weighted to the known demographic profile of the population.

1.13. All information collected on CAPIBUS is weighted to correct for any minor deficiencies or bias in the sample. CAPIBUS uses a 'rim weighting' system which weights to NRS (National Readership Surveys) defined profiles for age, social grade, region, tenure, ethnicity and working status - within sex.

1.14. The research found that there is considerable interest in some of the proposed energy saving measures. However, none of the measures received an overwhelming majority acceptance, and some are unpopular. The highest likelihood of adoption is for heating water and using appliances at different times of the day to current practice. A little less popular but, on balance, likely rather than unlikely to be adopted is the use of technology for automatic switching of appliances to match costs of energy. There is more resistance to varying the times of completing household tasks; the proportion likely to adopt this measure is balanced by the proportion of those who are not. On the other hand, it is generally thought to be unlikely that there will be greater use of electric storage heaters.

1.15. The table below shows the range of responses to the survey categorised by age, social grade and region.

Table A3.1: Likelihood of changing usage of household activities and devices if energy is cheaper at certain times of the day

Likelihood of choosing options

		Age			Social Grade				Std Region		
	Total	15-34	35-64	65+	AB	C1	C2	DE	Eng	Sco	Wales
Base: All respondents	1961 %	610 %	883 %	468 %	389 %	647 %	418 %	507 %	1671 %	149 %	141 %
Heat your water at different times of the day											
Very/fairly likely	56	55	55	59	62	56	52	52	57	44	54
Very fairly unlikely	25	20	27	27	28	26	24	20	23	43	23
Use certain appliances after midnight											
Very/fairly likely	51	49	55	43	59	53	49	40	53	33	46
Very fairly unlikely	33	30	30	46	33	32	34	35	31	61	30
Install technology to automatically switch off appliances when prices are high											
Very/fairly likely	47	50	47	40	50	47	50	40	48	43	39
Very fairly unlikely	31	24	31	44	36	32	26	30	30	45	37
Carry out chores or cook meals in cheaper periods (eg after 7pm)											
Very/fairly likely	41	47	39	35	41	43	40	37	42	25	39
Very fairly unlikely	40	30	43	52	47	38	39	37	38	62	48
Use electric storage heaters											
Very/fairly likely	35	47	30	28	29	39	32	38	36	25	33
Very fairly unlikely	47	28	54	60	59	43	50	35	45	62	51

Source: Ipsos MORI

1.16. Of the five energy-saving measures explored, the option of heating water at different times of the day attracts the highest likelihood of adoption. This is followed by using appliances (dishwashers, washing machines etc) after midnight. Both of these options are thought 'very/fairly likely' to be adopted by a (small) majority of the population. Slightly less popular is the concept of technology that would automatically switch off appliances when prices are high, though this still attracts more respondents rating it as 'likely' than 'unlikely'. The public are evenly split on carrying out household tasks including cooking during cheaper periods. Least popular is the use of electric storage heaters – 47% rate this as 'very/fairly unlikely' while only 35% sees it as 'likely'.

1.17. The overall figures do mask some significant variations in the likelihood of different demographic groups adopting each measure. Heating water at different times of the day is popular with a majority in all age groups, and marginally more with those aged 65 and over. However, the 15 to 34 age group shows wide internal variation, with 15 to 24s much less likely to adopt the measure than the 25 to 34s (48% 'very/fairly likely' compared to 63%) There is some relationship to social grade, with AB groups more likely to adopt this behaviour than the C2DE groups. There is also a regional dimension: interest is concentrated in England, with some in Wales. Scotland is much less likely to adopt this behaviour. Overall, on the prospect of heating water at different times of the day, the pattern of answers by demographics is very similar, with the youngest age group, social grade DE and those in Scotland least likely to adopt the measure.

1.18. Just under half are likely to adopt automatic switching of appliances. Interest is notably lower among social group DE compared to other social groups. In terms of age, likelihood of adoption is notably higher in the 15 to 34 age group (50% 'very/fairly' likely'), with lower interest among the 65 and over group. In contrast to the overall positive balance, those in Scotland are more unlikely than likely to adopt the technology (45%' unlikely', compared to 43% 'likely'). Likelihood in Wales is even lower, though not significantly so, and it just outweighs the proportion unlikely to adopt the behaviour.

1.19. Carrying out household tasks at alternative times is of most interest again to the 15 to 34 age group, older people being significantly less likely to adopt this measure, especially the 65 and over group. There is little difference on this, however, by social grade. Those in Scotland are least likely to adopt this measure.

1.20. Interest in using storage heaters does not follow the same kind of pattern as the most popular measures. People aged 35 and over are unlikely to adopt storage heaters while, in contrast, those under 35 are likely to be interested. Similarly, in terms of social group, ABC1C2 grades are unlikely to adopt storage heaters, while the DE social group show less tendency to say they are "unlikely" to adopt the measure, though their positive enthusiasm is still not great. Enthusiasm for storage heaters is greatest in England and lowest in Scotland, where 62% are unlikely to adopt the measure.

Consumer workshop

1.21. In January of this year, we held a workshop to discuss the key issues related to increasing DSR in the short to medium term. Participants included large and small consumers, industry experts, academics, and consumer and environmental groups.

1.22. From the perspective of large users, if the conditions are right they will participate in DSR as long as it does not interfere with their core business operations. Several attendees considered the available discretionary load quoted in some literature as too high and it is more likely to be 1GW for large users. Supplier offerings to large users are mainly related to those required by National Grid (i.e. interruptible contracts), but there is growing activity among aggregators who bring together electricity consumers who agree to reduce consumption at peak periods. Aggregators then sell this unused electricity typically to the system operator.

1.23. Some attendees considered that the reason for limited product offerings by suppliers is that there is too much uncertainty over whether or not a consumer will reduce demand when required, and this could impact the suppliers' ability to provide supply to its other customers. Furthermore, lessons can be learned (and applied to the electricity sector) from the gas sector where arrangements for interruptions are seen by some as too complicated and transaction costs too high.

1.24. The general industry view is that, when an individual supplier offers products to its customers to shift consumption, from periods of high demand and higher prices to periods of low demand and lower prices, all suppliers share in this benefit. Several attendees stated that this is a result of the current settlement for small customers being based on average profiles, not actual half-hourly consumption as it is for larger users.

1.25. With respect to domestic and small businesses, some attendees considered that some DSR innovation is possible before smart meter roll-out but avoiding complexity in design is important and considering protections for vulnerable and low income consumers will be vital. At the workshop, common messages from all stakeholders included the following:

- aggregation of DSR actions among small and large users is needed if we want to achieve DSR potential;
- more information is needed on responsiveness and consumption patterns, particularly on SME consumers;
- consumers are not homogenous even within each sector, so there will be a need to tailor products to suit individual needs;
- avoiding complexity is important, especially for consumers; and
- benefits need to be shared and incentives need to be set across the entire supply-chain.

Appendix 4 – International research and lessons learned

1.1. In this section, we discuss the international experience with DSR, particularly the various methods used to facilitate DSR and what customer feedback has been where available. By examining the trials and products available in other countries, we can gain insight from instances where consumers have demonstrated an ability and willingness to shift and reduce demand from peak periods and determine whether any lessons can be applied to GB. A table at the end of this appendix outlines the international trials we investigated.

Domestic Consumers

1.2. Some countries have successfully implemented innovative tariffs that use visual display units and smart meters or electronic alerts (website, email or text messages) to provide a strong price signal to households to reduce demand at peak periods. For example, in France, there are around 350,000 domestic and 100,000 non-domestic consumers signed up to a CPP tariff which provides day-ahead price information to consumers via internet, text or in-home visual display units. The tariff has daily peak and off peak pricing periods and day of the year pricing[71]. The trials prior to roll-out of this CPP tariff revealed that, on average, customers did respond to higher pricing by lowering usage at peak periods and the majority of customers were satisfied with the programme and made savings on their electricity bills.

1.3. Even if suppliers offer innovative tariffs to stimulate DSR, it does not necessarily follow that consumers will take them up. The market structure plays an important role. For example, in most of the US, there is no retail competition in electricity supply. Therefore, the regulator is able to set specific tariffs (such as dynamic tariffs) as a default. In contrast, in the UK, where there is full retail competition, consumers would need to actively choose to switch to a tariff that facilitates DSR. The state of Texas most resembles the UK in terms of market structure and adoption rates in Texas for dynamic pricing have been among the lowest in the US.

1.4. According to the Brattle Group, studies show that about 80% of customers would remain on dynamic pricing if it were set as the default tariff and only about 20% would choose one voluntarily[72]. However, these figures need to be considered in context; for example, costs involved with switching tariffs may play a role in a consumer's decision to opt in or out.

1.5. In the face of frequent supply shortages, some countries have implemented direct control systems to remotely switch off appliances during peak periods. For

[71] The year is divided into: blue days (low rate); white days (medium rate); and red days (high rate).
[72] 'Unlocking the €53 Billion Savings from Smart Meters in the EU', The Brattle Group, page 5.

example, from 2005 South Africa implemented a radio switch programme for electric water heaters to help overcome severe electricity shortages. The programme connects radio-controlled units to electric water heaters, allowing them to be switched on and off by remote control. This has helped the network maintain supply at times when the system is under stress. In South Africa, there is also a power alert system programme, whereby viewers of particular television stations are alerted when the electricity network is under significant stress and can follow on-screen instructions to facilitate electricity reduction (e.g. switching off unnecessary appliances), thereby maintaining supply.

1.6. Many DSR products are designed specifically to take advantage of the scope that air conditioning or electric heating offers to DSR. For example, California experiences hot summers. In anticipation of an energy supply emergency, technologies fitted to air conditioners to reduce energy demand from the unit are available to both domestic and SME consumers. The technologies are remotely activated by the utility company and do not affect performance of the unit. The devices can also be set to automatically reduce load once a threshold electricity price is reached allowing consumers to benefit through lower bills.

SME Consumers

1.7. Dynamic pricing has been successful in the SME sector in the US. An example of this is California's CPP tariff, also offered to I&C consumers. The aim of the programme is to reduce peak load through price incentives to SMEs with a demand of around 20 to 200kW. The CPP tariff features higher prices for 6 or 7 hours during up to 12 critical peak period days each year, and lower prices during non-critical peak period days. After successful trials, during which around 200 customers achieved a peak load reduction of about 0.02% 8.3MW, three Californian utility providers have continued to offer this product, which comes with a 12 month 'no worse off' price guarantee.

I&C Consumers

1.8. As in GB, load management by the I&C sector can provide the network companies and system operators with guaranteed and substantial load reductions when necessary and the consumer with an additional revenue stream.

1.9. An example of contracted load reduction is that offered to large businesses by Pacific Gas & Electric (PGE) in the US to reduce electricity demand by at least 100kW. It offers a monthly financial incentive[73] to its customers for committing to reduce power to a minimum pre-selected level, the so-called 'Firm Service Level', when requested. Customers are notified of the event thirty minutes in advance and are required to reduce their monthly peak demand by 15%, which should be no less

[73] PGE pays customers between $8/kW to $9/kW per month.

than 100 kW. Failing to reduce load by the required level of demand on request can lead to penalties[74].

Lessons Learned from International Experience

1.10. Below we have included a table which summarises international trials of DSR, including those discussed above. In the majority of these trials, load reduction during periods of peak demand and high prices was achieved, consumers made savings and there were high satisfaction rates. For example, in the domestic trials (involving about 364,000 participants), participants:

- saved on average 7 to 10% on their electricity bills;
- had high rates of satisfaction and some stated they would continue with the DSR product after the trial closed. However, initially some of these consumers were hesitant as they considered too much control of their usage may be given to suppliers; and
- reduced demand during peak periods and high prices by at least 13% .

1.11. Some of the common features of these successful trials include conveying information through convenient methods (e.g. texts, internet) and automation.

1.12. The international review shows that interventions in DSR often have a location or event specific impetus; however, this does not prevent some DSR case studies from having the potential to work in a variety of situations. For example, automated control developed in a warm climate to avoid summer peaks caused by air conditioning may also work in colder climates to reduce winter peaks by shifting electric heating and other devices, but further analysis on this would be needed.

1.13. There are a number of specific lessons we can learn from our international review, including the following:

- smart meters are likely to play an important role going forward, but some DSR can take place without smart meters. Many of the examples discussed do not require smart meters but still elicited a response and resulted in consumer benefits;
- products are generally developed around activities where there is maximum scope for DSR. Many DSR trials and products have been specifically designed to reduce and shift load from air conditioning units or electric heaters, which are widespread in the countries we have examined. The use of air conditioners in GB is low compared to the US but it is increasing. The majority of heating in GB is gas not electric, but this may change in the future;

[74] $6/kWh per month

- products have been developed in the face of frequent supply shortages. South Africa has designed a number of automatic load control technologies to help the network cope with frequent supply shortages; and
- regardless of the number of products available, consumers are more likely to participate in tariffs when they are required to opt-out. In areas where there is no retail competition in electricity supply, behaviour-changing tariffs can be introduced by setting them as the default tariff.

Product Name & Type	Description	Results	Customer Feedback
DOMESTIC			
EDF's Tempo trial for domestic and non-domestic consumers in France. Conducted between 1989 and 1995. The trial resulted in a product but is now only available to existing consumers.	Daily peak and off peak pricing periods and day-of-the year pricing. Days divided into: blue days (low rate); white days (medium rate); and red days (high rate). Customers informed in advance of colour of next day via text, internet or in-home visual display unit.	On average, daily consumption was reduced by 15% on white days compared to blue days and by 45% on red days compared to blue days.	Trial participants saved 10% on average on electricity bills and 90% were satisfied.
Sweden's direct load control programme, Jönköping Energi. Carried out in winter 2003-04, and 50 customers participated.	Electric heaters were controlled in exchange for reduced tariff rates.	Load reduced on five occasions by 67%. This represented an average controllable load reduction of 4-5 kW per household.	No customers complained about the heating following the control.
Elforsk Market Design, Price initiatives, Sweden. Conducted in winter 2003-04, and involved 93 households.	Higher price for a maximum of 40 hours during the year. Customers informed a day ahead via text or email. Two Swedish energy companies promised customers 1000-1400 SEK (Kronor) of annual savings during the course of the trial if they cut usage during peak price periods.	Load reduction on average by 50% at times of high electricity prices.	Participants were generally willing to reduce electricity consumption during periods of high prices. Participants were willing to continue using this tariff after the end of the trial and to finance some equipment-related cost themselves.

Product Name & Type	Description	Results	Customer Feedback
DOMESTIC			
SINTEF Energy Research, Norway Carried out between 2001 and 2004, and involved 11,000 participants.	Direct load control of water heaters combined with TOU tariffs, two way communication and automated meter reading.	Overall peak load was reduced by 3.2 MW and about 0.5 kWh per household during peak periods.	
Energy partners load control programme, Houston. Carried out between 1991 and 1992, and 185 customers participated.	Direct remote control of air conditioner units combined with financial incentive. 30 minutes control cycles, where air conditioner is remotely turned off and on for 15 minute periods.	Load was reduced by 1.46kW per household on average. Potential of 3.85kW load reduction on a peak temperature day for a continuous load shed (air conditioning switched off for the entire 30 min cycle period).	Monthly surveys revealed 89% would participate in an ongoing direct load control.
California Automated Demand Response System (ADRS) Pilot – peak load reduction. Conducted between July 2004 and December 2005, and 175 households participated.	TOU tariffs, automated climate control system and web-based programming.	High consumption households achieved load reduction between 1.4kW and 1.84kW.	

Product Name & Type	Description	Results	Customer Feedback
DOMESTIC			
California Statewide Pricing Pilot – peak load reduction. Carried out in 2003-05. 630 commercial and small industrial customers and 1861 domestic customers participated.	Direct load control of air conditioning units, combined with CPP tariffs and smart thermostats.	Domestic - average reduction on critical peak period days was between 13% and 27%. Commercial – between 4.83% and 13%. Industrial customers – between 5% and 9.5%.	Most participants have chosen to continue with the tariff even when asked to pay for the metering.
Customer Choice & Control pilot, Laredo, Texas. Carried out in 1994-1995 and involved 600 homes.	Control of air conditioning units, water heaters and tumble dryers, combined with a four tier TOU tariff.	Peak demand reduction by about 2kW per household. Customers saved on average 7-10% on electricity bills.	
SME			
California's critical peak pricing for SMEs and I&Cs. Conducted in 2003-04, later become a product. 206 customers participated.	Peak load reduction combined with a CPP tariff. The tariff featured higher prices for 6 or 7 hours during each CPP day (max. 12 days each year), and lower prices during non-critical peak periods.	Peak load reduction of 0.02%. Average savings ranged from a few percent to 20% depending on event.	84% responded that they were either somewhat or very likely to take actions for future events, 4% of participants reported they were not at all likely to take action and 7% were somewhat unlikely.

Product Name & Type	Description	Results	Customer Feedback
SME			
ORION Network DSM Program, New Zealand. Conducted in 1990-2008, and about 185,000 homes and businesses participated. Currently a product offered to all market segments.	Direct load control of water heaters and TOU tariffs. Control period lasted for at least 30 minutes. Orion provided a 10 minute advance warning via ripple, text or email.	Peak load reduction of 19%. Orion estimated network investment savings of about NZD 12 million per year for distribution and NZD 6 million per year for transmission.	
I&C			
Market design demonstration load control project, Sweden. Trial conducted between 2003 and 2005, and six large industry customers participated.	Customers reduced load during the notified period of high electricity prices and received payments for doing so.	Relatively large customers reduced their demand on average by 1MW each.	Each company had very positive opinions about future possibilities to control demand over 1-2 hours period of temporarily high spot prices.
Winter Peak Demand Reduction Scheme, Ireland Trial was conducted in 2003 and 2004, and 186 I&C customers participated.	Load reduction between 5-7pm on business days by using on-site generation.	The load reduction achieved was fairly reliable on a daily basis. Achieved 1.85% load reduction on the winter peak load of 4320MW.	Participants who could reduce their consumption to the committed levels earned nearly EUR20,000 each over the four winter months. 25% of participants failed to reduce entirely.

Product Name & Type	Description	Results	Customer Feedback
I&C			
Castle Hill Demand management project, Australia Trial carried out between 2003 and 200, and 6 commercial and small industrial customers participated.	Peak load reduction using direct load control, standby generation, energy efficiency, power factor correction.	Reduction of peak Load of 33 MW. Energy savings of 3,800 MWh.	Avoided cost of AUD 320,000 for a year's deferral of the planned substation.

Appendix 5 - Glossary

Aggregator

Bring together electricity consumers who agree to reduce consumption at peak periods. The aggregator then sells this unused electricity typically to the system operator.

Balancing and Settlement Code (BSC)

The BSC contains the rules and governance arrangements for the electricity balancing and settlement in Great Britain. All licensed electricity suppliers must be party to it. The energy balancing aspect allows parties to make submissions to National Grid to either buy or sell electricity into/out of the market at close to real time in order to keep the system from moving too far out of phase. The settlement aspect relates to monitoring and metering the actual positions of generators and suppliers (and interconnectors) against their contracted positions and settling imbalances when actual delivery or offtake does not match contractual positions.

CRC Energy Efficiency Scheme

The CRC Energy Efficiency Scheme (formerly known as the Carbon Reduction Commitment) is the UK's mandatory climate change and energy saving scheme. It has been designed to raise awareness in large organisations, especially at senior level, and encourage changes in behaviour and infrastructure.

CCGT

Combined Cycle Gas Turbine: A type of generation plant where the waste heat from gas generation is used to make steam to generate additional electricity, thereby increasing its efficiency. Most new gas power plants in Europe are of this type.

CCS

Carbon Capture and Storage: A process whereby carbon dioxide is captured from power plants, and stored away from the atmosphere in a deep geological formation.

CERT

Carbon Emissions Reduction Target: CERT requires gas and electricity suppliers to achieve targets for a reduction in carbon emissions generated by the domestic sector.

CHP

Combined Heat and Power: A technology where electricity is generated at or near the place where it is used, with the heat produced being used for space heating, water heating or industrial steam loads. This potentially leads to much higher efficiency than conventional generation.

CPP

Critical Peak Pricing: Different tariff rates apply in different periods of the day and on different days of the week or year. Consumption in these periods is recorded on different registers in the meter. The days and times of applicability are not pre-defined but declared shortly before real time, subject to guarantees that the higher cost periods will have a maximum duration.

Distributed Generation

Distributed generation is also known as embedded or dispersed generation. It is an electricity generating plant connected to a distribution network rather than the transmission network.

Distribution Network Operator (DNO)

A DNO is a company operates the electricity distribution network which includes all parts of the network from 132kV down to 230V in England and Wales. In Scotland 132kV is considered to be a part of transmission rather than distribution so their operation is not included in the DNOs' activities. There are 14 DNOs in the UK which are owned by seven different groups.

Dynamic pricing

See real-time pricing

Electricity Distribution Network

Electricity distribution networks are the low voltage electricity wires carrying electricity from the transmission systems, and some generators that are connected to the distribution networks, to industrial, commercial and domestic users.

Electricity Transmission Network

Electricity transmission networks are the high voltage electricity wires carrying electricity from generators to the electricity distribution networks.

Elexon

Elexon is the Balancing and Settlement Code Company (BSCCo) for Great Britain. It procures, manages and operates the services and systems which enable the balancing and imbalance settlement of the wholesale electricity market and retail competition in electricity supply.

EU ETS

European Union Emission Trading Scheme: The EU-wide greenhouse gas emissions trading scheme, under which governments must set emission limits for all large emitters of carbon dioxide in their country.

Flexible plant

A flexible power generation plant is one which is able to alter its level of output easily in response to changes in market conditions.

Frequency

Frequency is the balance between supply and demand which needs to be maintained at 50 hertz.

Fuel poor

Households who need to spend more than 10% of their annual income on fuel to maintain an adequately heated home.

Generation Capacity

The maximum power that can be produced by a generation plant.

Generation capacity margin

The difference between installed generation capacity and average cold spell peak demand (normally expressed as a percentage of average cold spell peak demand).

GW

Gigawatt: a unit of energy equivalent to one billion watts.

IED

Industrial Emissions Directive: An EU Directive on industrial emissions which will replace the LCPD and lead to higher constraints on power station emissions.

LCPD

Large Combustion Plant Directive. This is a European Union Directive which aims to reduce emissions from large combustion plant. GB power plants must either comply with the LCPD through installing emission abatement equipment or 'opt-out' of the directive. An existing plant that chooses to 'opt-out' is restricted in its operation and must close by the end of 2015.

OGCT

Open Cycle Gas Turbine: A less efficient type of gas generation plant where the waste heat from generation is not used to generate additional electricity.

Pumped Storage

Pumped storage is a type of hydroelectric power generation where energy is stored in the form of water pumped from a lower elevation to a higher elevation. During periods of high electrical demand, the stored water is released through turbines.

Real-Time Pricing

Dynamic time of day pricing whereby the customer receives frequent signals on the cost of consuming electricity at that time.

Smart Appliance

An appliance that can alter the way in which it uses energy either in response to changes in the balance between supply and demand or in response to prices.

Smart Grid

A smart grid allows system and distribution network operators to balance supply and demand on their networks using new technology.

Smart Meter

A smart meter is an advanced meter which identifies consumption in more detail than a conventional meter. It is capable of two-way communication by transmitting meter readings and sending data remotely to suppliers and end-users.

Time-of-Use (TOU) tariffs

Under a time-of-use tariff, a supplier varies its charges based on when energy is used (e.g. day/night; peak/off-peak; or by season). Such tariffs can be dynamic (changes in real time) or static (changes at pre-set periods).

Appendix 6 – The Authority's Powers and Duties

1.1. Ofgem is the Office of Gas and Electricity Markets which supports the Gas and Electricity Markets Authority ("the Authority"), the regulator of the gas and electricity industries in Great Britain. This appendix summarises the primary powers and duties of the Authority. It is not comprehensive and is not a substitute to reference to the relevant legal instruments (including, but not limited to, those referred to below).

1.2. The Authority's powers and duties are largely provided for in statute (such as the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998, the Enterprise Act 2002 and the Energy Acts of 2004, 2008 and 2010) as well as arising from directly effective European Community legislation.

1.3. References to the Gas Act and the Electricity Act in this appendix are to Part 1 of those Acts[75]. Duties and functions relating to gas are set out in the Gas Act and those relating to electricity are set out in the Electricity Act. This appendix must be read accordingly[76].

1.4. The Authority's principal objective is to protect the interests of existing and future consumers in relation to gas conveyed through pipes and electricity conveyed by distribution or transmission systems. The interests of such consumers are their interests taken as a whole, including their interests in the reduction of greenhouse gases and in the security of the supply of gas and electricity to them.

1.5. The Authority is generally required to carry out its functions in the manner it considers is best calculated to further the principal objective, wherever appropriate by promoting effective competition between persons engaged in, or commercial activities connected with,

- the shipping, transportation or supply of gas conveyed through pipes;
- the generation, transmission, distribution or supply of electricity;
- the provision or use of electricity interconnectors.

1.6. Before deciding to carry out its functions in a particular manner with a view to promoting competition, the Authority will have to consider the extent to which the interests of consumers would be protected by that manner of carrying out those functions and whether there is any other manner (whether or not it would promote competition) in which the Authority could carry out those functions which would better protect those interests.

[75] Entitled "Gas Supply" and "Electricity Supply" respectively.
[76] However, in exercising a function under the Electricity Act the Authority may have regard to the interests of consumers in relation to gas conveyed through pipes and vice versa in the case of it exercising a function under the Gas Act.

1.7. In performing these duties, the Authority must have regard to:

- the need to secure that, so far as it is economical to meet them, all reasonable demands in Great Britain for gas conveyed through pipes are met;
- the need to secure that all reasonable demands for electricity are met;
- the need to secure that licence holders are able to finance the activities which are the subject of obligations on them[77]; and
- the need to contribute to the achievement of sustainable development.

1.8. In performing these duties, the Authority must have regard to the interests of individuals who are disabled or chronically sick, of pensionable age, with low incomes, or residing in rural areas[78].

1.9. Subject to the above, the Authority is required to carry out the functions referred to in the manner which it considers is best calculated to:

- promote efficiency and economy on the part of those licensed[79] under the relevant Act and the efficient use of gas conveyed through pipes and electricity conveyed by distribution systems or transmission systems;
- protect the public from dangers arising from the conveyance of gas through pipes or the use of gas conveyed through pipes and from the generation, transmission, distribution or supply of electricity; and
- secure a diverse and viable long-term energy supply,

and shall, in carrying out those functions, have regard to the effect on the environment.

1.10. In carrying out these functions the Authority must also have regard to:

- the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed and any other principles that appear to it to represent the best regulatory practice; and
- certain statutory guidance on social and environmental matters issued by the Secretary of State.

1.11. The Authority may, in carrying out a function under the Gas Act and the Electricity Act, have regard to any interests of consumers in relation to communications services and electronic communications apparatus or to water or sewerage services (within the meaning of the Water Industry Act 1991), which are affected by the carrying out of that function.

[77] Under the Gas Act and the Utilities Act, in the case of Gas Act functions, or the Electricity Act, the Utilities Act and certain parts of the Energy Acts in the case of Electricity Act functions.
[78] The Authority may have regard to other descriptions of consumers.
[79] Or persons authorised by exemptions to carry on any activity.

1.12. The Authority has powers under the Competition Act to investigate suspected anti-competitive activity and take action for breaches of the prohibitions in the legislation in respect of the gas and electricity sectors in Great Britain and is a designated National Competition Authority under the EC Modernisation Regulation[80] and therefore part of the European Competition Network. The Authority also has concurrent powers with the Office of Fair Trading in respect of market investigation references to the Competition Commission.

[80] Council Regulation (EC) 1/2003.

Appendix 7 - References

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