E3G

Driving lower energy bills and security of supply

The case for demand side electricity market reform

E3G

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Executive summary

Against the background of rising energy prices driven by volatile fossil fuel costs and investment requirements for new generation, activating the demand side of the power market will be essential in order to reduce consumer bills even if electricity unit costs increase. The UK Government has recognised that reform of the electricity market is needed in order to attract sufficient levels of investment in energy infrastructure whilst maintaining current standards for security of supply, delivering the low carbon transition and keeping costs down. It is critical that new market structures and institutional arrangements result in the best value for investments across the electricity system. The best way for this to be achieved is for demand side resources (including demand management, demand response and distributed generation – referred to as D3) to be empowered to compete as low cost alternatives to supply side investment.

New technologies and opportunities

The range and potential of demand side options has been transformed by the revolution in information and communication technologies. Innovative new smart grid, micro-generation, storage and energy management technologies offer a wide range of benefits, from cost savings and new consumer products to carbon reductions and increased security of supply. A range of new business models have emerged for deployment of these technologies. However, demand side resources have been largely excluded from current market arrangements in the UK. To date, demand management and response programs have been limited to a few of the largest industrial and commercial consumers, and distributed generation capacity remains far below its potential. By contrast, demand side resources play an active role in a number of US power markets, with proven results. Evidence collected by the Regulatory Assistance Project shows that inclusion of D3 resources within the New England capacity market saved customers as much as USD $280 million.

Reduced system cost and lower bills

Demand side measures have a clear potential to reduce power system costs and consumer bills. Department of Energy and Climate Change (DECC) evaluation of demand response trials targeted at domestic consumers found clear benefits including savings on electricity bills of 7 percent - 10 percent. According to estimates from the UK energy regulator Ofgem, demand response could yield up to £11.9 billion in savings over the next decade, including £1.5 billion to £6.2 billion in avoided wholesale electricity costs, £1.3 billion to £5.4 billion in avoided capital costs for new generation, and £140 million to £280 million in avoided capital costs for networks. Embedding approximately one quarter of UK peak demand on local grids through decentralised generation would deliver economic benefits of roughly £13 billion over the same period.

Risk management and integration of renewables

The demand side can play an integral role in allowing the UK to cost effectively meet its low carbon infrastructure challenge by facilitating the integration of renewables into the electricity grid and improving energy efficiency. Demand response technologies deliver essential flexibility that allows variable outputs from renewable generation to be accommodated. For example, pilots of critical peak pricing tariffs in California have led to a drop in peak demand of 27 – 44 percent, avoiding the need for high cost back up generation. The reductions in overall energy demand enabled through D3 technologies will also make the UK's 15 percent renewable energy target by 2020 easier and cheaper to achieve.

The overall regulation and policy framework must be able to support financing for both centralised and decentralised renewable systems. China has made 70 percent of its clean energy investments over the last 5 years in a centralised wind system, as opposed to Germany which has made 80 percent of its investments in decentralised solar power. Given the uncertainty between centralised and decentralised pathways, there is value to keeping options open. Activating the demand side of the market can provide a critical part of an overall risk management strategy for the power sector.

Current proposals will not deliver

The current electricity market reform proposals largely overlook D3 resources and risk locking out potential cost effective investments. Demand side incentives are bolted onto a capacity payment mechanism primarily designed to bring forward supply side investment. As currently framed, security of supply objectives are also biased towards buying more generation capacity rather than achieving system-wide security. The current Green Deal proposals are only likely to deliver energy efficiency investments in heat, leaving a significant gap in support for power improvements.

Unless a more fundamental re-evaluation of the role of the demand side within the electricity market reform package is undertaken, market arrangements will remain biased against demand side participation, and opportunities to increase power system performance and drive down cost will be missed. Demand side measures must be prioritised now – if workable arrangements for activating the demand side of the market are not incorporated in the current electricity market reform process, the opportunity could be lost for a decade.

Objectives and principles for market reform

The Government's forthcoming electricity market reform white paper must clearly set out the objective of *fair and equivalent treatment of demand side resources, with the aim of securing best value investment across the power system*. The EMR package must be designed to:

> Minimise system costs through deployment of all demand side investments that are cost effective compared to supply side alternatives

- Create new, competitive customer-facing markets and improve competition in the electricity market
- Create a set of real options for large scale deployment of distributed energy resources
- Support innovation in new technologies and business models
- Reduce the risks related to the integration of low carbon generation in the system
- Reinforce other UK carbon reduction policies, for example by providing a complementary flow of finance into the Green Deal

Institutional implications

Delivering these aims requires:

- Expert purchasing facilities to procure any available demand side resources when they are cheaper than supply side alternatives, as it will be necessary to proactively identify the opportunity and devise the commercial arrangement that will attract the necessary investment. To ensure transparency and accountability this facility should be an independent, arms-length body operating under a clear mandate.
- An amended mandate for the System Operator to act as the agency incentivised to purchase the demand response services that will reduce the costs of maintaining security of supply. The separate low carbon purchasing agency would then focus on procuring demand side services that will reduce the overall costs of the low carbon transition.

Functions

Finally, some initial conclusions can be drawn regarding the sharing of functions between Government and the delivery agencies.

Government must:

- Define the appropriate minimum security standard that must be maintained throughout the low carbon transition based on the advice from Ofgem
- Set minimum levels of low carbon resources (both supply and demand side) for the next [10] years based on a strategy to cost effectively meet overall carbon reduction targets, and define the process for updating this objective
- Set minimum levels of individual technologies (both supply and demand side) for the next [10] years to drive innovation and manage delivery risks, and define the process for updating these targets
- Establish the statutory and governance framework for the new delivery institutions

The System Operator and low carbon purchasing agencies must:

- Identify the range and extent of the products and services required to deliver the security standard, low carbon and technology objectives, and develop a procurement strategy for endorsement by Ofgem
- Proactively seek out demand side providers and develop new commercial arrangements that will bring forward the necessary investment. These arrangements must define how the services interact with the spot and balancing market arrangements and must be endorsed by Ofgem
- Perform a monitoring and evaluation role by having the capability for measuring and auditing delivery
- Demonstrate the business case to Ofgem where investments in network infrastructure are required to realise demand side services (the so-called 'smart grid' functionality).

A new world: why the demand side matters

Against the context of rising energy prices driven by volatile fossil fuel costs and investment requirements for new generation, activating the demand side of the power market will be essential in order to reduce consumer bills even if electricity unit costs increase. Demand side resources in the UK electricity industry (including demand management, demand response and distributed generation) also hold tremendous potential for enhancing security of supply, improving energy efficiency and providing the flexibility that will allow low carbon supply side technologies to become cost effective. An active demand side represents an opportunity for new competitive markets in a vast array of customer facing products and services, the introduction of which will result in greater technological innovation and improved retail choice for energy consumers.

Ensuring these potential benefits are actually realised presents a significant challenge for policymakers. Whereas the supply side is mature and investment is supported by current market arrangements the demand side has never been fully recognised or exploited by UK energy policy. The demand side is diffuse and made up of a diverse set of SMEs with unique business models and highly specialised products and services. Because revenues will be spread across a large group of market participants the demand side lacks a strong and cohesive constituency able to make the case for the reforms needed to stimulate market growth. The integration of demand side resources, while more cost effective than bringing new generation online, is also a more difficult undertaking given historical experience with the operation of the electrical grid and the complexity involved in adding many new assets and controls to the system.

The existence of these barriers means that to date demand management and response programs have been limited to the largest industrial and commercial consumers, and distributed generation capacity remains far below its potential. The System Operator (National Grid) contracts just 200 MW of interruptible industrial demand from large consumers as well as a limited amount of frequency control demand. Installed energy storage – another demand response resource – makes up 3 GW of capacity, most of which is pumped storage from hydro power. Distributed generation (DG) including combined heat and power (CHP), wind and small scale hydro and biomass currently accounts for roughly 10 percent (8 GW) of UK capacity.

While the design and implementation of the necessary reforms will be challenging, the current process on electricity market reform is a crucial opportunity to ensure that new regulatory and market arrangements capture the wide range of cost, reliability and security benefits that the demand side holds.

Definition and description of D3

The demand side of the electricity market includes three types of activities, referred to here as D3. While each is often considered in isolation it is useful to think of them collectively, as the ability to integrate all three components is essential in capturing the overall value of demand. Together they encompass a range of technologies, policies, and management systems including improvements in energy efficiency, demand response and distributed generation. The three types of activities can be defined as follows[1]:

> **Demand management (DM)**: the reduction of energy use on a long-term basis. This can be accomplished by the use of a range of technologies including low energy lighting, insulation, efficient industrial processes, and management techniques such as monitoring and targeting. Demand management is also referred to as "energy efficiency", or "energy productivity".

> **Demand response (DR):** A short term change in energy demand in response to the use of incentives or price signals. This can be achieved through a range of technologies including the use of stand-by generators, switching off load, frequency response and energy storage. DR can be used to both reduce peak demand and to shift load to periods where there is excess supply caused by the variable nature of renewables.

> **Distributed generation (DG)**: the generation of electricity from a diverse set of smaller-scale sources, connected to the distribution system rather than the transmission system. Because power is generated close to where it is consumed it can lower transmission and distribution losses and cost. DG can include the use of technologies such as small-scale solar, wind and biomass as well as combined heat and power (CHP). Some DG technologies are still emerging while others are already widely deployed.[2]

Taken together these represent a large, reliable and cost effective resource which, if integrated into the electricity market, will result in lower energy bills and improved security of supply. The value of D3 is even greater when considered in the context of the massive investment challenge the UK faces: at least GBP £200 billion of investment will be needed in energy infrastructure over the next decade according to government estimates. D3 can

[1] Definitions adapted from D3 Group Electricity Market Reform Consultation Response 10 March 2011.

[2] IEA (2008) Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages: State of the Art Report, Vol 1.

lower the overall need for this capital investment and ensure that new infrastructure is deployed at least cost to rate payers.

Although market arrangements since liberalisation and unbundling in the 1990s have favored investments in supply side capacity above energy conservation and other demand side measures, a number of developments over the past several years including the lower cost of low carbon technologies and information and communication technology (ICT) as well as emerging business models in the energy sector, mean that the UK is now better prepared and able to take full advantage of an active demand side.

Advances in low carbon energy technology

Addressing energy security concerns and meeting legally binding carbon budgets will require a diverse set of low carbon technologies to replace much of existing energy infrastructure over the next several decades. This effort must include both the widespread deployment of existing mature technologies as well as technological innovation on unprecedented scale.

The implementation of the EU ETS as well as other policy support mechanisms have led to important progress in both deployment and innovation, and these efforts have in turn increased the value of D3 and lowered a key barrier to its wider use. Micro-generation, or the onsite generation of low and zero carbon heat and electricity in domestic, public and commercial properties is one example.[3] While exact figures vary by technology and site of installation, the cost of micro-generation technologies including combined heat and power (CHP), micro wind, solar PV and biogas has been falling as the price of fossil fuels rise and technology improves through movement up the learning curve. By one estimate micro-generation has the potential to meet up to 25 percent of UK electricity demand by 2050 without government subsidies.[4] The shift from large scale plants to DG closer to the point of consumption brings other benefits as it will enhance the resilience of the system and reduce transmission and distribution losses.

There have also been improvements in energy storage technology including lithium ion batteries, compressed air storage, flywheels and electric capacitors. Storage can act as a form of demand response by providing power when output from variable renewables is low or storage capacity when output is high. Storage units can also respond faster than traditional sources of generation. Electric vehicles, identified as a policy priority by the UK government which estimates 1.7 million EVs on the road by 2020[5], can serve as storage capacity while recharging and could also be a source of extra revenue for utilities. By one estimate EVs could balance up to 10 percent of UK power needs by 2020 at an annual return

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[3] UKERC (2009) Power from the people: Domestic Microgeneration and the low carbon buildings programme, Environmental Change Institute.
[4] Energy Savings Trust Potential for Microgeneration Study and Analysis: Final Report. Element Energy, Cambridge November 2005
[5] Strbac, G. Benefits of advanced smart metering for demand response based on control of distribution networks, Imperial College April 2010.

to car owners of £50.[6] EVs have been prioritized by the Government in large part due to the critical role they can play in helping to reduce UK dependence on foreign oil – which grew by 50 percent from 2009 to 2010[7]. While the country imported just 8 percent of its oil in 2008, by 2020 that figure is expected to rise to 50 percent.[8] Rising oil prices will come at enormous cost to the British economy; the Department of Energy and Climate Change (DECC) estimates that a doubling in the price of oil from USD $80 per bbl to USD $160 per bbl would cost British taxpayers GBP £45 billion in GDP over just two years.[9]

Advanced metering and Information and Communication Technologies (ICT) are developing rapidly and will be essential in exploiting the potential of demand side resources. ICT provides the ability to integrate the various components of demand management and response with distributed generation, storage and other network infrastructure and to optimize system processes and efficiency. ICT systems involving advanced analytics, automation and control technologies – also known as the smart grid – many of which are already proven and available, can improve the flexibility of the grid and the ability to manage customer loads and demand side resources. The smart grid will provide the scale that demand side resources, including energy storage technologies and electric vehicles will need to be cost effective.[10] ICT also provides the capability behind Virtual Power Plants (VPPs) through monitoring of demand side resource units, forecasting load capacity and handling data management. These are discussed in more detail below.

New business models offering better cost, service and resilience benefits

Removing artificial barriers to D3 participation will open up opportunities for the development of innovative business models in the electricity industry, which has seen relatively little innovation since privatisation. This will have benefits for both the demand and supply sides of the industry. Commercial and residential end users will be rewarded for providing demand side services, while utilities will be able to better manage compliance obligations from new environmental regulations and policies while still delivering affordable and reliable electricity and an acceptable return to shareholders.

Some of these new business models have already begun to develop and expand. One example is the Virtual Power Plant (VPP) which involves the use of software to aggregate a

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[6] Kari Lundgren Electric Cars Could Balance 10 percent of U.K. Power Needs, Report Says, Bloomberg May 10 2011.
[7] James Herron and Alexis Flynn U.K., Oil Producers to Discuss Tax Increase The Wall Street Journal March 31 2011
[8] DECC (2011) UKCS oil and gas production projections. Available at : https://www.og.decc.gov.uk/information/bb_updates/chapters/production_projections.pdf
[9] UK government turns to low carbon economy amid oil price fears, New Energy World Network 2 March 2011. Available at: http://www.newenergyworldnetwork.com/cleantech-features/by-technology-f/energy-efficiency-f/uk-government-turns-to-low-carbon-economy-amid-oil-price-fears.html
[10] IEA (2008) Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages: State of the Art Report, Vol 1.

collection of several hundred or more demand side resources including micro-generators, storage and demand response capability in order to provide the same capacity as a traditional large-scale power plant. VPPs are already operating in the form of aggregated demand response programmes from larger industrial consumers or activities that involve the aggregation of a range of smaller scale micro-generators. The next phase of VPP innovation will be to incorporate both the supply and demand side into a single scheme so that the benefits of these distributed energy resources are fully exploited.

The VPP model offers at least two advantages to traditional GW-scale sources of supply:

> Including a diverse mix of demand side resources can mitigate the inherent reliability problems with any individual renewable source.

> VPP allows the utility to segment customers based on characteristics such as geography or distribution definition, which provides better forecasting capability and analytical information about the value of particular customers. Utilities can then optimise their resource portfolio to determine how to best shift peak loads and reduce generation costs.

Importantly, VPPs can be introduced with minimal disruption to current grid infrastructure as the process primarily involves upgrading communications infrastructure to link together a range of demand side resources.

New business models such as the VPP that have developed show that D3 resources can be used at scale – but barriers to market entry must be removed through market reform. These approaches improve the reliability of the system by taking advantage of a diverse set of hundreds or even thousands of resources, and deliver greater value to electricity consumers through lower costs and new revenue streams. Utilities benefit through improved system control and reliability and the avoidance of infrastructure investments.

The inability of demand to compete on level ground with supply side generation has meant that to date, developments in demand side resources have predominantly been the result of technology push through government R&D support rather than market pull. This has resulted in promising new business models and technologies, and a number of demand-oriented and distributed generation technologies have already reached maturity. However many others are not yet competitive with fossil based generation and there is still significant potential for further innovation. Reform is needed in order to create viable D3 markets.

The benefits of an active demand side

Greater integration of demand side resources would result in the development of new business opportunities and a range of benefits for actors all along the energy supply chain, including generators, network operators, suppliers, retailers, customers and manufacturers. But until recently evidence on the benefits and costs of D3 has been fairly limited, helping to explain the slow take up of demand side technologies. A series of recent modeling and forecasts, data from forward capacity markets in the United States and large-scale pilots in the UK, EU and US provides more clarity and a solid evidence base which should further strengthen the case for market reform. An overview of this evidence is presented below.

Managing variability and smoothing peak load

Variability

The increase in variable renewable generation capacity will require a significant amount of new flexible reserve capacity that can be brought online on short notice to maintain system balance. Demand side resources represent a cost effective and reliable alternative to expensive new combined cycle gas turbines (CCGT) or open cycle gas turbines (OCGT). The cost of using this natural gas-fired plant as flexible reserve can be up to six times higher than employing reductions in demand or efficiency measures.[11]

Demand response acting as a form of standing reserve could improve system performance by increasing the amount of wind power that can be absorbed as fewer generating units are scheduled to operate.[12] According to estimates from the UK energy regulator Ofgem, over the next decade demand response could yield GBP £1.5 billion to £6.2 billion in avoided wholesale electricity costs, GBP £1.3 billion to £5.4 billion in avoided capital costs for new generation, and GBP £140 million to £280 million in avoided capital costs for networks.[13] Smart meters and accompanying smart network infrastructure will allow for the dynamic pricing programmes that will facilitate demand response. An impact assessment for DECC of a UK-wide rollout of smart meters showed total benefits of £14.6 billion compared to a cost of £8.6 billion; with roughly half of the total benefits by the end of 2030 going to consumers.[14] The Electric Power Research Institute (EPRI) estimated that benefits from smart grid technologies in the US could reach up to USD $2 trillion by 2030 – compared to a cost of between USD $338 billion and USD $476 billion.[15]

Advances in large-scale energy storage as an ancillary service in place of spinning reserve can also play a critical role in managing variability. Both compressed air storage and hydrogen storage could become potential candidates for large scale storage and could provide a competitive alternative to peaking plant with low load factors.[16]

Peaking plant

Around 10 percent of electricity in the UK is produced by peaking plant. Meeting peak demand represents a similar challenge to that of addressing variability as it requires the use

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[11] Dan Watkiss Focus on Demand Response to Ensure Adequate Capacity Electric Light and Power March/April 2006.
[12] Strbac 2008 Demand side management: benefits and challenges Energy Policy 36 4419-4426.
[13] Ofgem Demand side response: A discussion paper, 15 July 2010.
[14] DECC Impact Assessment of a GB-wide smart meter roll out for the domestic sector. December 2009.
[15] EPRI (2011) Estimating the Costs and Benefits of the Smart Grid – A Preliminary Estimate of the Investment Requirements for a Fully Functioning Smart Grid
[16] Grunewald et al. (2010) Role of large scale storage in a UK low carbon energy future. Imperial College.

of expensive peak capacity which operates for as little as a few hours per year.[17] Compounding this problem, the rise in demand from renewables and the electrification of heat and transport sectors will mean that in the absence of demand side resources the need for peaking plant capacity will increase substantially. By one estimate full penetration of electric vehicles and heat pumps could increase daily electricity consumption by about 50 percent while doubling system peak.[18] Low average utilisation of generation capacity in the UK (around 50 percent) means there is significant scope for demand resources to shift load from peak to off-peak periods avoiding the capital cost of this extra generation.[19]

In the UK the optimal use of demand response could restrict peak increase by over 20 percent thereby reducing need for network investment.[20] WADE research finds that the UK could save about £1.4 billion of avoided capital costs (27 percent lower than with a centralized alternative), have lower energy costs and reduce emissions by 17 percent by using DG to meet demand rather than traditional power plant.[21] These cost reductions should eventually be passed along to consumers through lower energy bills. The Brattle Group has also estimated significant cost and emission savings from household demand response in the UK from 2010 to 2030 (see table 1). Taken together household demand response activity could lead to customer savings of £8.7 billion by 2030.

Table 1: Customer benefits and CO2 savings potential from household demand response to 2030 (Source: Brattle Group)

	Consumer savings 2010-2020 (£m)	Consumer savings 2021-2030 (£m)	Carbon savings 2010-2020 (Mt CO2)	Carbon savings 2010-2020 (Mt CO2)
Electricity demand reduction	520-1400	1000-2650	5-16	7-18
Electricity demand response	>130	>270	0.4-1.7	0.4-1.8
Gas demand reduction	450-1350	700-2150	4-13	8-24
Fuel switching (e.g. electric cars, heat pumps)	140-400	1100-4000	0.5-1.0	3-22
Total	1240-3280	3070-9070	9.9-31.7	18.4-65.8

Evidence from US modeling and forward capacity markets also shows significant potential for demand response to reduce peak load. The Brattle Group estimates that, under a high level demand response scenario, DR could reduce peak load in 2019 by as much as 150 GW

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[17] Will Nichols KiWi Power delivers demand management vision – "it's essentially free money Business Green 18 March 2011. Available at: http://www.businessgreen.com/bg/interview/2032588/kiwi-power-delivers-demand-management-vision-essentially-free-money

[18] Strbac at al. Benefits of Advanced Smart Metering for Demand Response based Control of Distribution Networks: Summary Report Version 2.0 April 2010. Imperial College.

[19] Strbac (2008) Demand side management: benefits and challenges Energy Policy 36 4419-4426

[20] Strbac et al. Benefits of Advanced Smart Metering for Demand Response based Control of Distribution Networks: Summary Report Version 2.0. April 2010. Imperial College.

[21] WADE 2006 Decentralizing UK Energy: Cleaner, Cheaper, More Secure Energy for the 21st Century.

or 20 percent of current peak load compared to business as usual (BAU) – a reduction equivalent to closing 2000 peaking plants.[22] The financial benefits of DR could exceed USD $65 billion by 2030.[23] A large-scale pilot pricing study in California found that well designed dynamic pricing programs which enable demand response can also result in significantly reduced peak loads. For customers in a Critical Peak Price (CPP) pilot program, the estimated average reduction in peak-period energy use on critical days was 13.1 percent. For the Time of Use (TOU) pilot, the reduction in peak period energy use resulting from a TOU rate in the summer of 2003 was 5.9 percent. Customers who had enabling technology reduced reductions in peak demand by as much as 27 percent mostly through smart thermostats.[24] Studies have consistently found that TOU rates induce a drop in peak demand of between 3 – 6 percent and that CPP tariffs induce a drop of 13 – 20 percent. When accompanied by an element of automation, CPP tariffs lead to drop in peak demand of 27 – 44 percent.[25]

An EU-wide study has estimated that dynamic tariffs enabled by smart grids could result in benefits of EUR €67 billion over a 20 year time horizon through the present value of savings in peaking infrastructure – relative to a cost of installing smart meters of EUR €51 billion.[26] Analysis has also shown that a shift of investment towards DG typically saves between 15-40 percent of total delivered energy costs by displacing the need for peak generating capacity and grid capacity.[27]

Increased predictability and lower reserve margin requirements

Security of supply has traditionally been achieved by ensuring an adequate capacity margin, requiring the total amount of installed generation in the system to be larger than the maximum possible level of demand. Before power sector liberalisation in the UK the Central Electricity Generating Board used forecasting models to determine the least cost mix of generation needed to meet demand at an acceptable reliability standard. This resulted in a requirement of roughly 24 percent plant margin to deal with variations in demand due to unpredictable circumstances. Since deregulation new infrastructure and capacity build has largely been left to market forces. Current arrangements do not include a formal generation security standard that would define a capacity margin.[28]

A key benefit of D3 is that a predictable source of demand side resources can act in place of long term reserve capacity while also reducing the need for high cost transmission and

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[22] FERC National Assessment of Demand Response Potential. Prepared by the Brattle Group. June 2009.
[23] Faruqui, Ahmed, Peter Fox-Penner, and Ryan Hledik “Quantifying Benefits” Public Utilities Fortnightly, July 2009.
[24] Faruque & George. Quantifying Customer Response to Dynamic Pricing. The Electricity Journal. May 2005.
[25] Gill Owen and Judith Ward Smart Tariffs and Household Demand Response for Great Britain. Sustainability First March 2010.
[26] Unlocking the €53 Billion Savings from Smart Meters in the EU: how increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment," by Ahmad Faruqui, Dan Harris, and Ryan Hledik, Energy Policy, October 2010.
[27] WADE 2006 Decentralising UK Energy: Cleaner, Cheaper, More Secure Energy for the 21st Century
[28] Strbac, G. (2008) Demand side management: benefits and challenges Energy Policy 36 4419-4426.

distribution infrastructure. Lower investment in capacity would also likely depress the price of electricity in the wholesale market.

Because large-scale interruptions in supply only occur fairly infrequently a small amount of available load can serve as adequate replacement of a large amount of reserve generation capacity. By one estimate the value of demand side management in place of the use of a modern gas-fired plant is between £250 and £400 per kW; but this could increase significantly when the costs of difficulties and delays in the planning process of building new generation are taken into account.[29] These benefits will rise further as more renewable energy is introduced into the power system.

Security of supply concerns can also be addressed through capacity payments which are designed to encourage the construction of either flexible plant or demand reduction. Payments are awarded through a competitive tendering process and delivered only to resources that are needed to cover a short fall in the market. The penetration of D3 into the energy mix would lessen the need for capacity mechanism and also lower the price of the payments which should translate into savings for consumers. To the extent that a capacity mechanism is required as part of a reform package, it should be designed to allow demand side resources to be given equal treatment as supply. Capacity payments also represent the possibility of a new revenue stream for D3 which should encourage entry of new players into the space thereby increasing competition and consumer choice.

Consumer benefits: lower energy bills and greater choice

Data collected from forward capacity market auctions in the US show a rapid increase in participation of demand side resources The average impact of demand response at the national level is estimated at 58 GW, or 7.6 percent of the peak demand, up from 4.2 percent from two years ago.[30] This has resulted in lower wholesale prices and significant savings for consumers.

Evidence summarised by the Regulatory Assistance Project (RAP) from a recent forward capacity market auction in the PJM energy market showed that demand side resources reduced the unit clearing price from USD $178.78 to USD $16.46; a savings of USD $162.32 per MW. Participation of demand side resources in the first ISO-New England auction potentially saved consumers as much as USD $280 million by lowering the price paid to all capacity resources in the market.[31]

Wider use of demand response programmes will also result in lower energy bills. The Department of Energy and Climate Change (DECC) estimates that a 20 percent take-up of TOU tariffs would lead to a 3 percent overall electricity bill reduction for consumers and a 5

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[29] Strbac, G. (2008) Demand side management: benefits and challenges Energy Policy 36 4419-4426.
[30] Kelly Smith and Ryan Hledik. Drivers of Demand Response Adoption: Past, Present and Future. Issue Brief. The Brattle Group. March 2011.
[31] The Role of Forward Capacity Markets in Increasing Demand-side and Other Low-Carbon Resources, Experience and Prospects," page 3, by Meg Gottstein and Lisa Schwartz, The Regulatory Assistance Project (May 2010), available at www.raponline.org

percent peak use reduction.[32] DECC examined a number of trials of demand response targeted at domestic consumers and found there were clear benefits including savings on electricity bills between 7 – 10 percent.[33]

Proper valuation of D3 and the deployment of new ICT technology including advanced metering infrastructure will also enable utilities and other energy companies to offer improved service to customers through, for example, bundling energy and data management tools into a single service provision. Data on consumption enabled by smart meters and networks can be mined to provide consumers with detailed individual energy saving programs. The US-based energy efficiency company OPower, which uses data analysis and behavioral research techniques to deliver energy efficiency programmes to utilities, has demonstrated average energy savings of between 1.5 percent and 3.5 percent and claims to have saved consumers USD $24 million in energy bills since 2007.[34]

While there is already a solid evidence base on proven benefits of D3 there would be value in additional research and analysis to provide estimates on the associated costs and benefits likely to accrue from new demand side programmes and technologies. This would not only strengthen the case for market reform but also provide support to policymakers in how to best liberate value from D3.

Risk management through broader technology choices

Studies have shown that decarbonisation of the power sector is technically feasible and economically affordable across a wide range of emission reduction pathways even whilst maintaining the current standard of reliability. Each pathway requires large-scale penetration of renewable and distributed generation technologies as well as significant improvement in energy efficiency. The Committee on Climate Change (CCC) estimates that cost of decarbonisation (reducing carbon intensity from 540 gCO2/dWh to 50 gCO2/kWh) in the UK would be in the order of 0.4 percent of GDP in 2030 with investment requirements in generation capacity through the 2020s in the order of GBP £100 billion.[35] Importantly the CCC analysis highlights both the importance of providing certainty to investors through long term contracts for generation as well as the importance of the UK successfully achieving its objective of deploying smart grid technology and incorporating demand response. Modeling done at the European level has shown that there is no significant difference in these approaches in terms of cost to consumers.

There is still a significant degree of technical and economic uncertainty with regards to the various low carbon technology options that could contribute to this effort and therefore there is a need to adopt a risk management approach to ensure that policy objectives are achieved cost effectively. Analysis from the United Kingdom Energy Research Centre

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[32] DECC Consultation Impact Assessment of Smart Metering Rollout. December 2009.
[33] Ibid
[34] Courtney Boyd Myers OPower is about to save the US $500mn in Energy Bills. The Next Web. April 11, 2011. http://thenextweb.com/apps/2011/04/11/opower-is-about-to-save-the-u-s-500-million-in-energy-bills/
[35] Committee on Climate Change The Fourth Carbon Budget: Reducing emissions through the 2020s.

(UKERC) finds that while there are numerous technically achievable and affordable decarbonisation pathways, one of the key trade-offs between them is the speed of reduction in energy demand versus decarbonisation of supply. The reduction in demand brings a number of benefits including insuring against[36]:

> the possible failure of critical low carbon technologies

> social resistance to the use of certain technologies

> price shocks and import dependence.

Investment in demand side resources should be part of a robust 'no-regrets' approach to electricity market reform that will keep open a broad range of possible decarbonisation pathways. The overall regulation and policy framework must be able to support financing for both centralised and decentralised renewable systems. China has made 70 percent of its clean energy investments over the last 5 years in a centralised wind system, as opposed to Germany which has made 80 percent of its investments in decentralised solar power[37]. Given the uncertainty between centralised and decentralised pathways, there is value to keeping options open. Activating the demand side of the market can provide a critical part of an overall risk management strategy for the power sector. Building in availability of D3 in the market will also provide insurance value against low probability, high impact events that threaten the stability of the power grid. If demand response capability and other mechanisms are put in place early they can be used to avoid potential future system outages; resulting in cost savings that can be passed on to consumers.

Demand side power market reform

Current programmes

A number of initiatives designed to promote the uptake of D3 technologies and resources are either already in place or have been proposed. These include:

> The UK National Infrastructure Plan includes a sub-section on investment in energy infrastructure. In addition to promoting a low carbon supply base it includes incentives for improving commercial and industrial energy efficiency, encouraging investment in small scale DG technologies and changes to the regulatory regime to support the roll out of smart grid technology in order to moderate peak demand and balance the grid given increased variability from renewable generation.[38]

> The Green Deal, part of the 2010 Energy Bill, focuses on energy saving measures for homes and businesses. The plan involves establishing a framework to enable private firms to offer consumers energy efficiency improvements to their homes, communities

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[36] UKERC (2010) Energy 2050 Making the Transition to a Secure Low Carbon Energy System.
[37] Pew Charitable Trusts (2011) Who's winning the clean energy race? G-20 Investment powering forward. Available at http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/G-20Report-LOWRes-FINAL.pdf
[38] HM Treasury and Infrastructure UK National Infrastructure Plan 25 October 2010.

and businesses at no upfront cost. Payments are recouped through a charge in installments on the energy bill.

- The Carbon Emission Reduction Target (CERT) requires all domestic energy suppliers with a customer base in excess of 250,000 to make savings in the amount of CO_2 emitted by householders. Suppliers meet the target by promoting the uptake of low carbon energy solutions to household energy consumers, thereby assisting them to reduce the carbon footprint of their homes. Measures include improving energy efficiency, for example through loft and wall insulation; as well as increasing the amount of energy generated from renewable technologies such as wind turbines, solar panels and ground source heat pumps.
- Ofgem has launched a Low Carbon Networks Fund which will provide up to GBP 500m to fund large-scale smart grid demonstration projects and innovative commercial initiatives. The objective of the projects is to help all DNOs understand what they need to do to provide security of supply at value for money as Great Britain (GB) moves to a low carbon economy.

These initiatives, while certainly not insignificant, do not represent a strategic and holistic approach to driving demand side markets. CERT and the Green Deal proposals are only likely to deliver significant energy efficiency investments in heat, leaving a gap in support for power improvements. The programmes and mechanisms remain fragmented, with relatively limited levels of deployment of D3 measures. Demand side resources are not treated on an equivalent basis to supply side investment, meaning that opportunities for savings are missed.

Electricity market reform

The UK Government has recognised that reform of the electricity market is needed in order to attract sufficient levels of investment in energy infrastructure whilst maintaining current standards for security of supply, delivering the low carbon transition and keeping costs down. However, the current electricity market reform proposals largely overlook D3 resources and risk continuing to lock out potential cost effective investments. Demand side incentives are bolted onto a capacity payment mechanism primarily designed to bring forward supply side investment. As currently framed, security of supply objectives are also biased towards buying more generation capacity rather than achieving system-wide security.

Unless a more fundamental re-evaluation of the role of the demand side within the electricity market reform package is undertaken, market arrangements will remain biased against demand side participation, and opportunities to increase power system performance and drive down cost will be missed. Timing is critical – if workable arrangements for activating the demand side of the power market are not incorporated in the current electricity market reform process, the opportunity could be lost for a decade.

Objectives and principles for market reform

The Government's forthcoming electricity market reform white paper must clearly set out the objective of *fair and equivalent treatment of demand side resources*, with the aim of securing best value investment across the power system. The EMR package must be designed to:

> Minimise system costs through deployment of all demand side investments that are cost effective compared to supply side alternatives

> Create new, competitive customer-facing markets and improve competition in the electricity market

> Create a set of real options for large scale deployment of distributed energy resources

> Focus on supporting innovative technologies and business models

> Reduce the risks related to the integration of low carbon generation in the system

> Reinforce other UK carbon reduction policies, for example by providing a complementary flow of finance into the Green Deal

Institutional implications

Demand side resources are more diverse and diffuse than centralised power generation. Making optimal use of demand side will require arrangements actively seek out cost effective resources and opportunities. This necessitates:

> Expert purchasing facilities to procure any available demand side resources when they are cheaper than supply side alternatives, as it will be necessary to proactively identify the opportunity and devise the commercial arrangement that will attract the necessary investment. To ensure transparency and accountability this facility should be an independent, arms-length body operating under a clear mandate.

> An amended mandate for the System Operator to act as the agency incentivised to purchase the demand response services that will reduce the costs of maintaining security of supply. The separate low carbon purchasing agency would then focus on procuring demand side services that will reduce the overall costs of the low carbon transition.

Functions

Finally, some initial conclusions can be drawn regarding the sharing of functions between Government and the delivery agencies.

Government must:

> Define the appropriate minimum security standard that must be maintained throughout the low carbon transition based on the advice from Ofgem

- Set minimum levels of low carbon resources (both supply and demand side) for the next [10] years based on a strategy to cost effectively meet overall carbon reduction targets, and define the process for updating this objective
- Set minimum levels of individual technologies (both supply and demand side) for the next [10] years to drive innovation and manage delivery risks, and define the process for updating these targets
- Establish the statutory and governance framework for the new delivery institutions

The System Operator and low carbon purchasing agencies must:

- Identify the range and extent of the products and services required to deliver the security standard, low carbon and technology objectives, and develop a procurement strategy for endorsement by Ofgem
- Proactively seek out demand side providers and develop new commercial arrangements that will bring forward the necessary investment. These arrangements must define how the services interact with the spot and balancing market arrangements and must be endorsed by Ofgem
- Perform a monitoring and evaluation role by having the capability for measuring and auditing delivery
- Demonstrate the business case to Ofgem where investments in network infrastructure are required to realise demand side services (the so-called 'smart grid' functionality).