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Centre for Challenge Prizes

Dynamic Demand Challenge

THE CHALLENGE OF SHIFTING PEAK ELECTRICITY DEMAND

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Centre for Carbon Measurement

July 2013

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About this report

This report was produced by the Centre for Carbon Measurement on behalf of Nesta's Centre for Challenge Prizes, to provide context for the Dynamic Demand Challenge.

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Dynamic Demand Challenge

In July 2013, the Centre for Challenge Prizes in partnership with the Centre for Carbon Measurement will launch the Dynamic Demand Challenge Prize.

The aim of the Challenge is to find:

> *"(To create) a new product, technology or service that utilises data to significantly improve the ability of households or small businesses to demonstrate measurable reduction in carbon emissions by shifting energy demand to off-peak times or towards excess renewable generation."*

The Challenge will focus on households and small businesses with daily electricity usages of up to 50 kWh. Expected outcomes are:

- Demonstrable shift in peak usage to off-peak times.
- Measureable reduction in CO_2 emissions.
- Responsiveness to dynamics of supply of renewable energy.

The challenge is open to entries from anyone across the European Union. The solution however must be applied within a UK context. We are encouraging entries from sustainability and energy businesses, small and medium enterprises (SMEs), charities, NGOs, community groups, developers, engineers, students and sustainability and energy professionals.

Financial support and professional guidance will be provided to Semi-Finalists. And a final award of £50,000 will be made to the entry that demonstrates the most significant impact (measured by the Centre for Carbon Measurement) within the challenge timeframe.

For more information

For more information about the Dynamic Demand Challenge Prize, please go to **dynamicdemand.nesta.org.uk** or contact **dynamic.demand@nesta.org.uk**

Expert Guidance

Experts were consulted and contributed to this paper through interviews and participation in workshops. We would like to thank those listed below for their support and input:

Dr Anne Wheldon, Ashden; Dennis Moynihan, Institute for Sustainability; Dora Guzeleva, Ofgem; Elaine Kearney, Elexon; Elizabeth Milsom, DECC; Giles Bristow, Forum for the Future; Graham Ayling, Energy Saving Trust; James Russill, Energy Saving Trust; Jane Burston, Centre for Carbon Measurement; Joe Short, Demand Logic Ltd and Dynamic Demand; Judith Ward, Sustainability First; Lamia Baker, Imperial Innovations; Neil Hughes, National Grid; Paul Clarkson, National Physical Laboratory; Paul Wright, National Physical Laboratory; Steven Burns, Western Power Distribution; Valerie Livina, National Physical Laboratory; and Zoe Redgrove, Centre for Sustainable Energy.

EXECUTIVE SUMMARY

This report aims to support potential entrants to the Dynamic Demand Challenge Prize but also inform the wider audience through a high-level introduction to the topic of dynamic demand.

The UK's electricity system is under increasing pressure to keep up with the ever growing demand for electricity. Pressure on and from governments to move towards a low carbon economy adds complexity to this problem through increased use of decentralised renewable energy generation. Dynamic demand, or demand side response (DSR) is the exchange of information between electronic devices, responding to signals from the grid directly or indirectly. These products or technologies can help shift electricity consumption away from peak hours where electricity consumption is high, or enable greater usage of excess electricity generation from renewables, as well as help maximise the use of a smart infrastructure.

Drivers that will encourage wider uptake of dynamic demand measures are highlighted and barriers are outlined that have yet to be overcome:

1. **Drivers:**
   - The move towards low-carbon economies.
   - Technology developments.
   - Appropriate incentives.
   - Regulatory frameworks.
   - Transparency and clear communication.
2. **Barriers:**
   - Uncertainties.
   - Incentives are needed, but which will work?
   - Consumer engagement.
   - Public concern over automated DSR.
   - Need for unified technical standards.
   - Lack of widespread DSR technology.

The report lists examples of DSR solutions already on the market ranging from smart plugs to smart meters and from electricity storage technology to software that helps manage a household's electricity consumption.

Key datasets are outlined that can be used to assess how well such solutions can shift demand. They can show the shift in demand away from peaks or towards renewables, allowing maximised use of these, and can also help to establish how many emissions have been saved. Sources of this data include government statistics, national real time generation and demand data, and also potential sources such as smart meter trials.

The Dynamic Demand Challenge Prize will support the development of innovative DSR solutions that will increase the potential of demand side response management, which will have a positive impact on current load balancing and capacity issues, as well as achieving emissions reductions.

Dynamic Demand Challenge

THE CHALLENGE OF SHIFTING PEAK ELECTRICITY DEMAND

CONTENTS

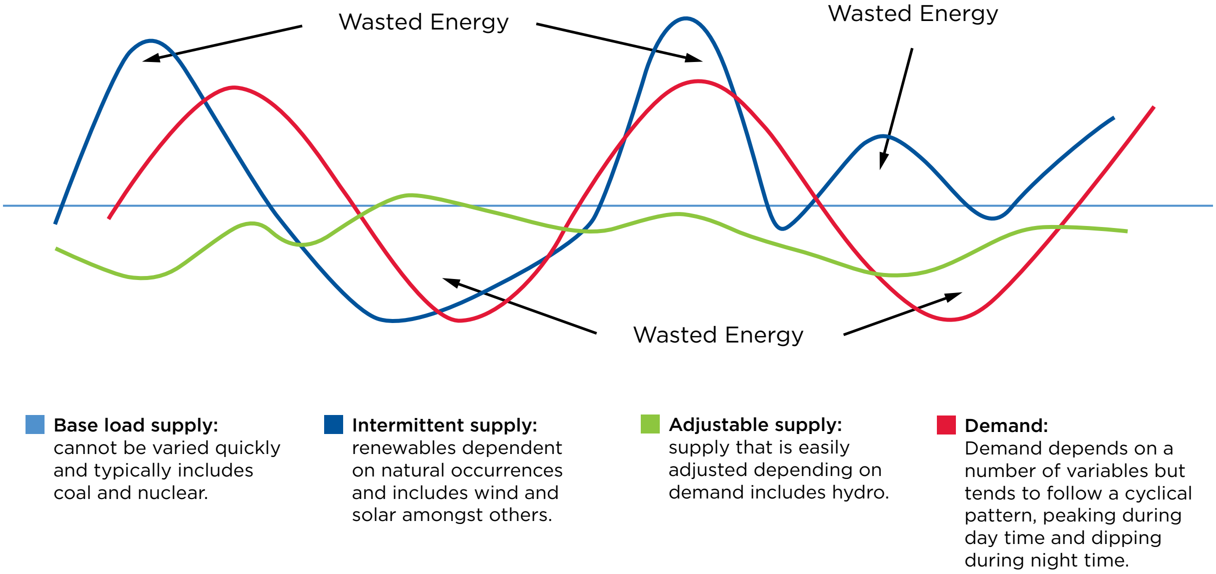
1 INTRODUCTION

This report aims to support potential entrants to the Dynamic Demand Challenge Prize but also inform the wider audience through a high-level introduction to the topic of dynamic demand.

The report provides contextual information on the topic of the UK electricity market, the underlying systems and its market players. It will outline some of the present workings of the grid as well as future challenges. The main focus lies on shifting demand away from peak times and to match this demand with the intermittent supply from renewables (see Figure 1). One way of making this happen is through demand side response. The report explains dynamic demand and the principle of demand side response, including what drivers encourage wider uptake of such measures and also what barriers have yet to be overcome.

Finally the report lists particular key data sources that are relevant in the development and assessment of dynamic demand solutions that entrants may need in the course of the Challenge Prize.

Figure 1: **Example electricity supply and demand**



2 THE ELECTRICITY SYSTEM IN CONTEXT

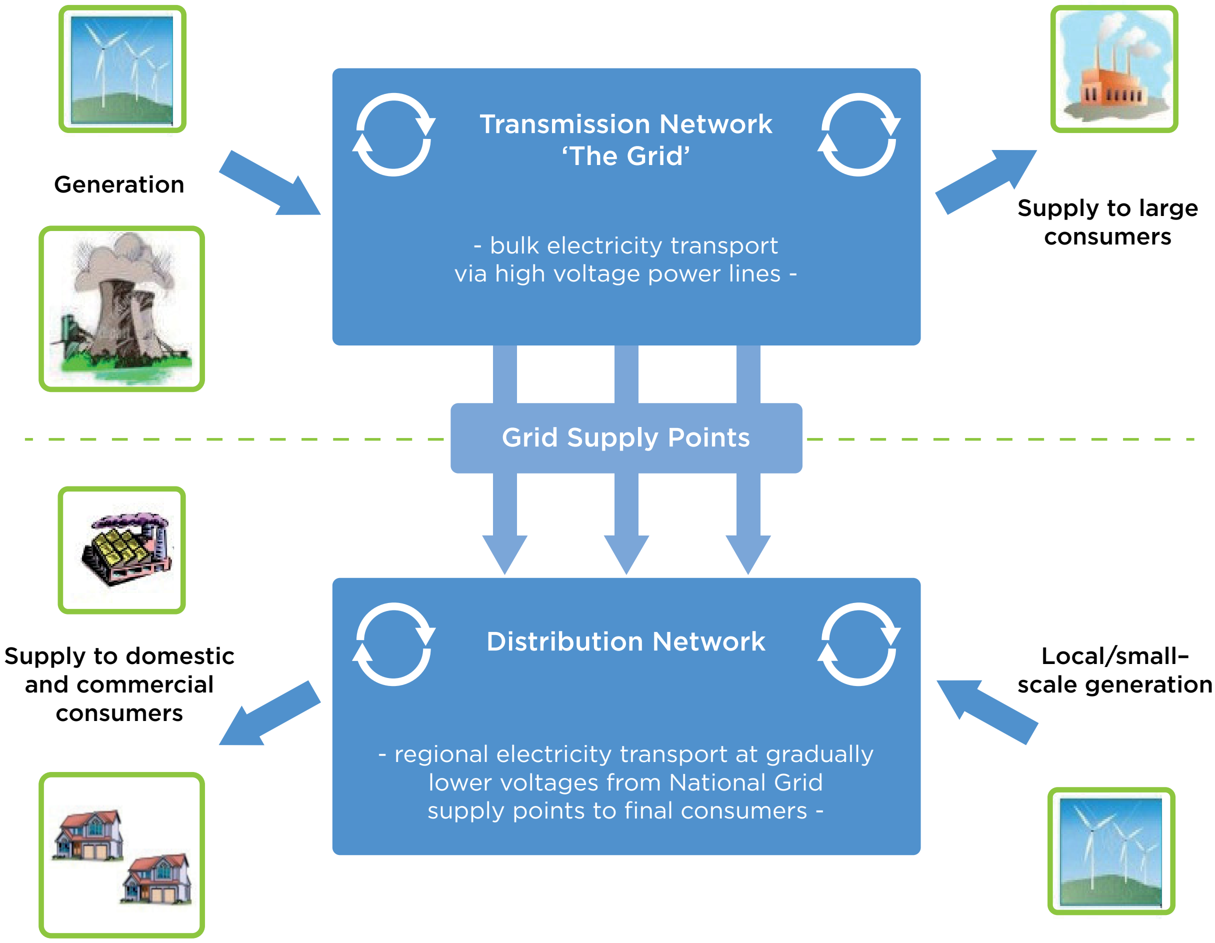
Introduction to the grid

When we flick the switch to turn on the lights, use our computers and other electrical appliances in our houses, naturally we expect these to turn on and work. Little consideration goes into the complex systems behind making this happen.

Energy management is a finely tuned balancing act – physically and financially. Electricity cannot be stored easily which means generation needs to be well–adjusted to the demand coming from a variety of users that range from large–scale, commercial users to widespread domestic users. Electricity generators, distribution network operators (DNOs), and suppliers (the companies we receive our energy bills from) all play a role in this and the electricity transport from generation to consumers can be seen in Figure 2.

Financially, the electricity market needs to be balanced between estimated electricity generation and actual numbers. This is the role of Elexon in the UK.

Figure 2: **Grid overview**[1]

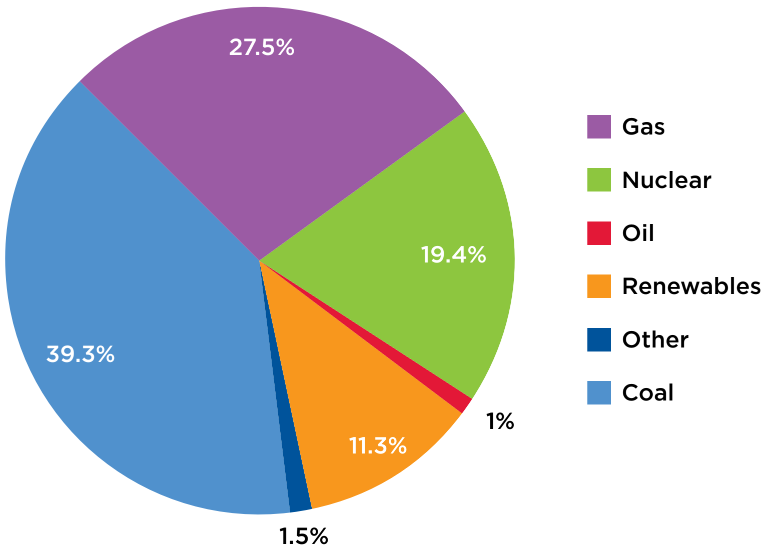


The energy mix and its importance for climate change

The electricity we use is generated from a number of sources including nuclear, coal, oil, gas and renewables. The mix that makes up electricity supplied varies depending on the price of fuel and the geographic location for example. Figure 3 depicts the fuel mix used to generate electricity in the UK in 2012.

The mix is however also impacted by political developments. Whether it is nuclear power that is being phased out as it will be in Germany by 2022, for example, or renewables that are driven by national or international targets.

Figure 3: **Electricity generated by fuel type in the UK in 2012**[2]
(Renewables includes wind, hydro and bioenergy)



Electricity generation is one of the main sources of emissions. In 2012, power stations alone emitted 156.1 Mt CO_2, accounting for just under a third of all UK CO_2 emissions.[3] The UK government is keen to lower this impact and has thus set itself a target to cover 15 per cent of the UK's energy demand from renewable sources by 2020.[4]

Renewable energy sources such as wind, wave and tidal energy are generally CO_2 neutral, but are intermittent due to the unpredictable nature of the weather. The current lack of energy storage capabilities means that matching intermittent supply with consumer demands is a challenge.

The following case study presents an example of this issue and outlines how Cape Verde is utilising renewable energy to minimise its dependency on oil and aiming to shift more of its demand to the excess wind generation.

Case study: Cape Verde's switch to 100 per cent renewables by 2020

Cape Verde has ambitious targets for renewables and has achieved great progress over recent years. Matching demand with supply from its wind farms however poses an issue.

The Republic of Cape Verde is a volcanic archipelago about 600 km off the coast of West Africa, with nine inhabited islands and many small islets. Like many island states, until recently Cape Verde had to rely exclusively on diesel to power its electricity supply. Diesel is expensive on islands because of the cost of transport, and this is particularly true for Cape Verde since it is not on a major shipping route and has to transport fuel to its many small islands.

The Government introduced a target of 25 per cent electricity from renewables by 2012 and 50 per cent by 2020, to reduce the national dependence on oil products and the cost of electricity generation. Cape Verde lies in the path of the north-easterly trade winds, with consistent wind speeds of up to 10m/s and therefore had considerable potential for wind power.

Wind farms were successfully constructed and commissioned on the four main islands and during the 12 months from April 2012 to March 2013 the wind farms generated 64,000 MWh, which is around 18 per cent of the total supply to Cape Verde. On São Vicente and Sal islands, the average exceeded 30 per cent. Further to this, diesel imports were cut by 22,000 tonnes to date, saving about US$1.8 million in 2012. Reducing the use of diesel generation cuts greenhouse gas emissions by an average of about 0.71 kg CO_2 e per kWh (the figure varies between islands because of the different diesel generators used). On this basis, the Cabeólica wind farms have saved 68,000 tonnes of CO_2 emissions to date.

Spurred on by early success, the Government of Cape Verde has increased its target from 50 per cent to 100 per cent of electricity from renewable sources, but needs to get maximum utilisation of the wind farms. A key priority is to enable more of the available wind power to be used.

One way to increase utilisation is to operate the country's desalination plants (which use over 15 per cent of Cape Verde's electricity) at times when there is spare wind capacity. However, shifting electricity demand to match the supply remains a challenge.

Addressing capacity issues and future stresses

Between 1970 and 2011, electricity consumption from a growing number of consumer electronic appliances, including TVs, mobile phones, washing machines, dishwashers and tumble dryers, increased by 369 per cent. Home computing alone rose by 356 per cent between 1990 and 2011.[5] Yet DECC's latest report[6] emphasises that one-fifth of UK power stations are due to close by 2020, requiring £110 billion of new investment to replace the stations and upgrade the national grid. With such increasing demands on the UK electricity infrastructure, DNOs have a big job to make sure the capacity is not surpassed and our lights do not go out at peak times.

The UK currently has around 80GW of electricity generating capacity. The difference between peak demand and supply, which is the capacity margin, is above 20 per cent, which is needed to ensure there is sufficient reserve capacity to maintain continuous supply.[7] Ofgem estimates this margin will decline from around 14 per cent in 2012 to just over 4 per cent by 2015/2016, which highlights the pressure the UK electricity system could face in the near future. DNOs, such as Western Power Distribution are dealing with peak demand on a day-to-day basis to manage local network constraints.

Steven Burns, Innovation and Low Carbon Engineer at Western Power Distribution explained:

> *"Managing networks is just like highway traffic for example. You don't build an 18-lane highway to cope with rush hour traffic but rather use the existing road network to manage traffic flow. Same can be said for power, which is why addressing the peaks is important."*

The move towards a low-carbon economy with increased use of renewable energy will mean a challenging balancing act for DNOs as peak demand and supply often do not coincide.

Further to this, initiatives that aim to save emissions will often increase the demand for electricity – electrification of heating or electric vehicles for example.

Distribution networks, the grid, will need to be able to meet this changing demand.

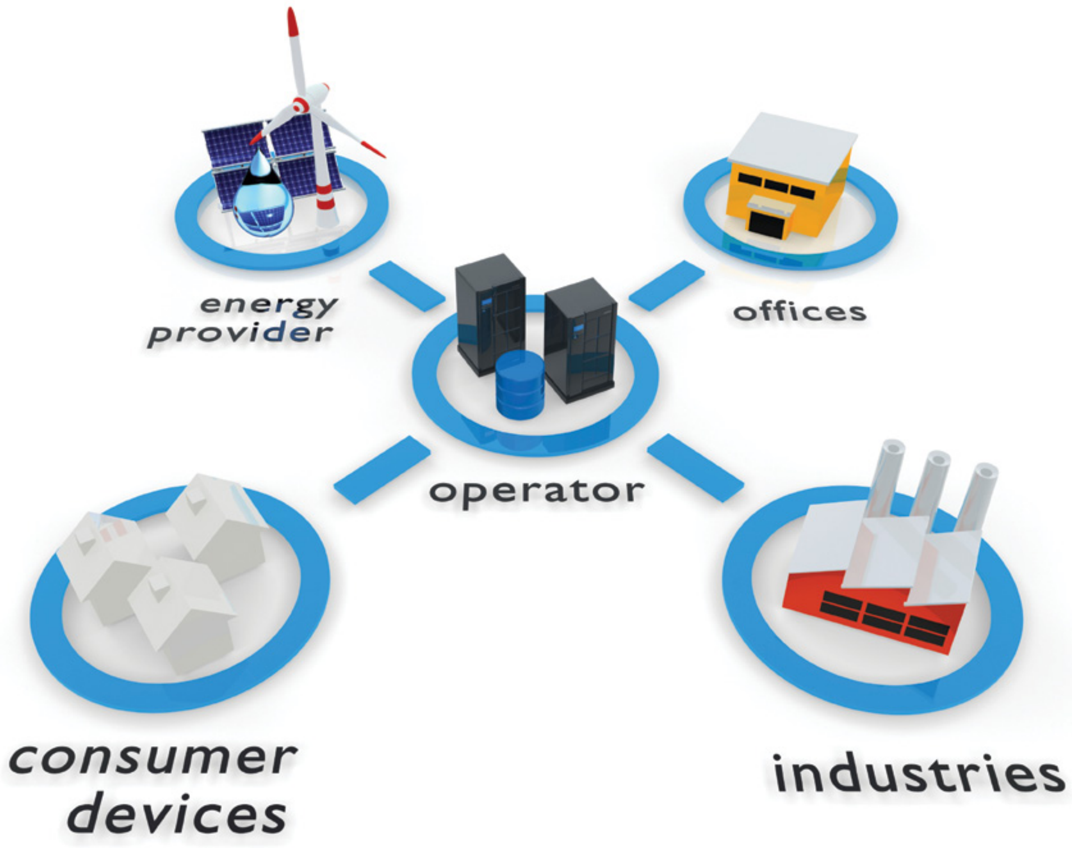
Steven Burns added:

> *"Electrification of heating for example means we might add the equivalent of three to four average houses to the existing demand straight away, which could be a substantial issue for the infrastructure."*

Electric vehicle charging bay in London[8]

How will we manage these increasing stresses on the grid and enable greater generation from renewables? Smart infrastructure and smart technology are the key. The smart grid is crucial in managing demand and supply going forward. It is an ICT-enabled grid that allows information to be exchanged across the system, which in turn allows a more integrated management of supply and demand. Intermittent renewable supply can thereby be redirected in a more effective way to areas of demand.

Figure 4: **Simplified Smart Grid illustration**



Large-scale work on the infrastructure is needed for this shift, and smart meters for domestic and commercial users will be needed in order to make this a success. The smart metering programme is a DECC-led initiative, by which the UK Government is requiring energy companies to install smart meters for their customers.[9] Smart meters will be rolled out as standard across the country by 2020 (mostly between 2015 and 2020) yet there will not be a legal obligation on individuals to have one.

However, a smarter grid and smart meters are not enough to allow for better peak management and maximum use of more renewables. These smart technologies are going to generate extensive amounts of data, which is going to be important to utilise electricity effectively and appropriately value it. Electricity demand also has to be managed by users in a smarter way. Appliances thus need to be able to automatically react to control signals based on the latest grid data in order to adapt electricity demand. The Dynamic Demand Challenge will demonstrate how current data sets can be utilised to support innovation in this area. This might help us gain a better understanding of how future data sets generated from the smart technologies could be used more effectively to support dynamic demand initiatives.

3 DYNAMIC DEMAND

What is dynamic demand?

Dynamic demand, or demand side response (DSR) is the exchange of information between electronic devices, responding to signals from the grid directly or indirectly. These products or technologies can either shift electricity consumption away from peak hours where electricity consumption is high, or enable greater usage of excess electricity generation from renewables.[10]

DSR technology enables electricity use to be managed in a smarter way either automatically or manually. Automation or autonomous DSR is the concept of installing a smart device that can automatically be used to activate a DSR driven technology. In this case the consumer does not have to make a conscious decision to switch on or off any appliances depending on information provided by the grid. It provides increased reliability to DNOs, when for example one million fridges and washing machines are linked up so that the grid operators can rely on the efficiency to happen. This in turn reduces the need for hot standby or spinning reserve,[11] which are by majority gas or coal-fired power stations.

Without smarter appliances or a smart grid, consumers can shift their demand through manually switching electricity use to off-peak hours or even during times where renewables will come into action in particular regions (e.g. consumers in a coastal town near an off-shore wind farm on a windy day).

With international and national commitments to move to a low-carbon economy, the importance of DSR is likely to grow in the UK and more widely across the international community.

Drivers and barriers

We know the smart grid is where we need to shift to in the near future and DSR is an important instrument in the tool box to make the most of the smart grid. But what is driving it and what is blocking the transition?

- **The move towards low-carbon economies** is a big driver for the smart grid. It necessitates investment across relevant supply chains, including investments into distribution networks and other infrastructure.
- **Technology developments,** including general low-carbon technologies or ones that enable DSR such as smart meters, support the transition. The latter facilitate autonomous DSR and can make shifting the demand user-friendly and easier by requiring fewer manual steps.
- **Appropriate incentives** are vital in enabling DSR and are a hot topic that is discussed across the electricity market. Gamification has been shown to help achieve this. Gamification in this context engages participants by letting the competition and fun of a game drive the change in behaviour towards energy savings. For example, the Campus Conservation Nationals is a US nationwide electricity and water reduction competition on college and university campuses. Energy profiles can be compared between dorms where the one that saved most energy would win a perk. The idea is to engage, educate, motivate, and empower students to conserve resources in their residences and to achieve measurable reductions.[12]

- **Regulatory frameworks** are also needed in order to underpin any incentives. Ofgem, the regulator of the UK's electricity and gas markets, and DECC have started the Smart Grid Forum to assess amongst other things the commercial aspects of the smart grid and DSR,[13] aiming to address this issue.

> *"For DSR to work, incentives and regulation need to interlink. Take fridges, for example – if regulation prescribed DSR functionality in fridges, or there was an incentive mechanism like the one behind energy efficiency labels, this would drive manufacturers to include DSR functionality and enthuse consumers to buy eco-friendly fridges."*
>
> **Joe Short of Demand Logic Ltd and Dynamic Demand.**

- Transparency and clear communication is key. It is essential to engage consumers and critical to engage them in the right way. DSR campaigns and initiatives have to be clear and truthful, avoiding over-claimed capabilities and be able to mitigate bad press that could negatively influence consumers' perceptions of smart solutions.

Figure 5: **Consumer engagement is key – households play a big role in DSR**

There are on the other hand a number of barriers that have to be tackled before the smart grid and DSR become standard.

- **Uncertainties** around, for example, what clustering effects there may be, have yet to be verified. Clustering occurs from, for example, electric vehicles being charged that may impact network capability and energy users' experience. Effective measurements around power quality from large-scale solar or wind installations are crucial work that will help to avoid difficulties in this transition.
- **Incentives are needed but which will work?** Will cash incentives encourage us to shift our electricity usage to off-peak times in our homes? How about store card points or gift vouchers? Or community-based incentives that could bring benefits beyond the individual to the wider community? Without functioning incentives, DSR will not work.

- **Consumer engagement** with their electricity consumption is a big stumbling block, despite the various ideas on incentives. An unengaged consumer is unlikely to change their behaviour. Clear and effective communication and incentives are needed to tackle this.
- **Public concern over** automated DSR has been raised and needs to be addressed. The European Network of Transmission System Operators for Electricity (ENTSO-E) put forward a proposal to the European Commission to install smart meters in homes that can then manage some of the devices linked up to it, depending on grid signals. A widely-read UK newspaper headline called the smart technology 'Big Brother' interventions and 'sinister'.
- **Need for unified technical standards.** Current standards on connecting to the grid are fragmented. An open, unified standard that has been established amongst the appropriate stakeholders is needed to establish how and what tools can engage with the grid, interpreting and responding appropriately, avoiding feedback into the grid.
- **Lack of widespread DSR technology.** Although there are DSR solutions available, they are limited to a niche market, emphasising the need for wider technology development.

DSR solutions

There are a number of solutions and approaches that shift electricity usage already available in the market. They can be useful tools for consumers on differential tariff deals, such as Economy 7 in the UK, which offer cheaper electricity at night rather than higher-demand times during the day. This can help maximise energy savings potential.

Sustainability *First's GB Electricity Demand – 2010 and 2025* report[14] takes an in-depth look at the potential for flexibility at peak times and identifies lighting as major demand source which could be reduced. It also lists sources of household electricity demand that appear to show most flexibility and are thus able to be addressed with DSR:

- On-peak electric heat.
- On-peak electric water heating.
- Wet appliances.
- Potentially refrigeration (this however needs widespread uptake, proven technology, existing stock-turnover and customer acceptance).

However, there is still potential for more effective solutions to help household and small businesses shift their consumption to off-peak times and make better use of renewable energies. This is one of the reasons that the Dynamic Demand Challenge has been established, to encourage the development of a broader range of solutions from a wider audience.

Examples: DSR approaches and solutions

1. Chop-Clock

Low-cost energy saving device that is retro-fitted to household boilers. It reduces energy use by placing regular periods of off-time into the heating systems thus reducing energy demand and costs.

2. Using freezers for energy storage

Freezers have large thermal storage and it doesn't necessarily matter exactly when they get electricity. The temperature can thus be dropped during off-peak times and electricity switched off during peak times, allowing the freezer temperature to gradually rise to its viable maximum without affecting the quality of the frozen food.

3. Smart dishwashers

Many new dishwashers already have timing functions that allow deferred running cycles, depending on adjustable settings.

4. Adaptive load-control algorithms

The algorithm builds a profile characterising the energy use of household equipment over 24-hours. Using these profiles, utilities create a custom demand-response plan that brings equipment onto a schedule to curb demand and protect against under-voltage and under-frequency conditions. These systems might also consider the time of day, seasonal changes, and changes in household occupancy to appropriately adjust the profile associated with the controlled device.

5. SolarGuard and PowerGuide Home Energy Monitoring

Real time data feed of a household's electricity consumption and production. Solar PV system is monitored via SolarGuard, showing the amount of power the system generates which is then complemented by the home energy consumption data monitored by PowerGuide. Data can be viewed by day, week, month or year, which allows users to optimise their energy consumption, avoid peak-demand charges and adapt to their own solar energy production.

6. SHIMMER – Smart Homes Integrating Meters Money Energy Research

SHIMMER is a combination of services that combines a metering system with an online interface. Data from smart plugs placed in key points around the home (e.g. electricity meter, any micro-generation meters and household appliances) is sent to a central database in the cloud. This is analysed and cross-referenced with wider demographic and financial information about the household to create a profile of the energy consumption. Households will be set energy-saving targets and provided with specific actions they can take to achieve them.

7. Energy storage through Phase Change Materials (PCMs)

PCMs are materials such as paraffin wax that have natural thermal storage capabilities. They undergo a phase change transition from solid to liquid and vice versa to absorb or release latent heat. The systems can be timed so that rooms can either be heated or cooled with stored energy in the PCMs during most efficient periods and recharge using off-peak electricity.

8. The Grid Friendly Appliance Controller

The Grid Friendly Appliance Controller is a small integrated circuit, that turns normal household appliances into ones that would better regulate energy usage and help prevent local and national blackouts.

Other DSR considerations

There are other considerations to take into account if we want to assess whether or not DSR solutions work and how well.

- Data sets on usage patterns and live trials, amongst other tools, can help to assess this (see Section 4). However, this information alone will not establish whether or not a solution will indeed have the ability to make a substantial difference to electricity demand.
- Other market-based factors are important. It's useful to consider whether or not a solution is affordable and practical but also engaging and user-friendly. The ways in which consumers access and use the technology will have a significant impact.
- Its ability to actually shift demand away from peak hours or towards times where renewable energy generation peaks, will help establish how well one solution compares with another. It is also important to consider the amount of emissions saved, based on the relevant fuel mix.
- Scalability and appropriate business planning are important factors in establishing whether or not a solution will do well in the market place and therefore its wider adoption amongst different demographic groups and users. Scalability and sustainability potential are factors that will be considered as part of the judging process for the Challenge.

Whilst large-scale users have the biggest impact in terms of electricity use and resulting emissions, the Dynamic Demand Challenge will focus on households and small businesses with daily electricity usages of up to 50 kWh. Larger, more complex solutions are the focus of other schemes, some of which can be seen in more detail in Section 4. The Challenge is unique in focussing on solutions for smaller installations, which are not necessarily supported elsewhere.

4 DATA RELEVANT TO DYNAMIC DEMAND

Data sets listed below can be used to assess how well a DSR solution can shift demand. They can inform and demonstrate the shift in demand away from peaks or towards renewables, allowing their use to be maximised and can also help to establish how many emissions have been saved.

There is an abundance of additional sources such as smart grid trials or smart metering community schemes that could also be utilised to inform the development of DSR solutions. Competitors may require further types of data sets in order to develop their ideas for the Challenge Prize.

Data sources for potential use by Prize applicants

Based on the fact that there is a plethora of different market players and a complex electricity market structure, one can imagine the range of data that is being captured. However, not all is made public, due to commercial sensitivities. Below is a list of national data sets that are available and can be used to develop and assess the submissions to the Challenge Prize.

Elexon: Balancing Mechanism Reporting System (BMRS)

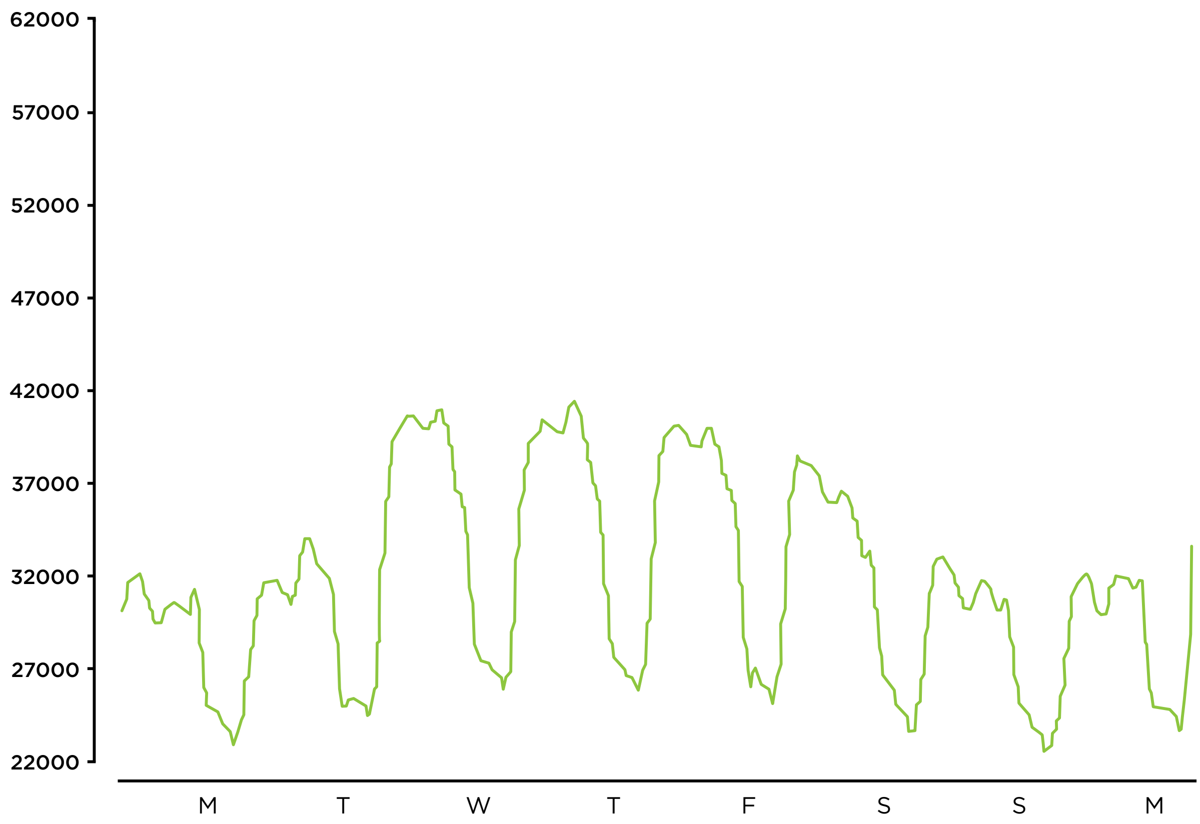
The BMRS website provides near real time and historic data about the balancing mechanism which is used by the system operator, National Grid, as a means of balancing power flows on to and off the electricity transmission system in Great Britain.
See: **www.bmreports.com/bwx_reporting.htm**

Screenshots of BMRS reports

National Grid

National real time data is available for system frequency (affected by the balance between generation and demand from the system – National Grid is under statutory obligations to maintain the frequency within +/– 0.5Hz) and electricity demand. Demand data can be viewed over three separate time intervals: 60 minutes, 24 hours and the last seven days. Frequency traces track movements over the last 60 minutes. The underlying data is available on the BMRS in a variety of formats.
See: **www.nationalgrid.com/uk/Electricity/Data**

Figure 6: **Electricity demand over seven-day period in May 2013**[15]



National Grid contract for services to help balance supply and demand where there is a differential from what the wholesale market delivers and what customers actually use. These services are procured from both generation sources and demand sources. Below is a link to the Balancing Services home.
National Grid: Services: **www.nationalgrid.com/uk/Electricity/Balancing/services/frequencyresponse/ffr**

Digest of UK energy statistics

The Digest, or DUKES, is a source of energy information that contains extensive tables, charts and commentary. Separate sections on coal, petroleum, gas, electricity, renewables and combined heat and power provide a comprehensive picture of energy production and use over the last five years, with key series taken back to 1970.
See: **www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes**

HM Government

Data.gov.uk currently hosts 9,448 datasets from the likes of Office of National Statistics, the Met Office and the Centre for Ecology and Hydrology. Data requests can also be made for information that is not currently available.
See: **data.gov.uk/data**

DECC

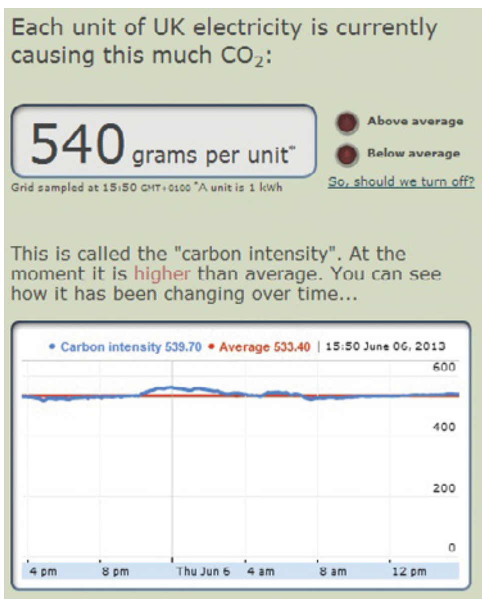
DECC has created a number of online calculators, including the 2050 Calculator. It is a user-friendly model that lets consumers create their own UK emissions reduction pathway, and see the impact using real UK data. The Calculator helps to engage in the debate and lets government make sure its planning is consistent with the long-term aim.
See: **www.gov.uk/2050-pathways-analysis**

Energy Saving Trust, DECC, and Defra

In-depth household electricity use study aimed to cover the electricity usage of a representative sample of English homes. The results, summarised in the report *Powering the Nation,* provide insights into how UK households use electrical products. Raw data is available for research purposes, providing detailed information on, for example, the use of individual appliances and time of use.
See: **www.energysavingtrust.org.uk/Publications2/Corporate/Research-and-insights/Powering-the-nation-household-electricity-using-habits-revealed**

Real Time Carbon

Calculating the carbon impact of generated electricity involves using a single static government conversion factor. The factor is based on a set of average CO_2 emissions per kWh of electricity used at the point of final consumption.[16] The factor changes from year to year as the fuel mix used for electricity generation changes across UK power stations. However, the generation fuel mix varies over time and also by region at any given time, which means that the carbon intensity of electricity needs to be addressed more frequently. Real Time Carbon shows the real time carbon intensity of a single unit of electricity, so consumers can adapt their behaviour in order to shift their demand away from times of high emissions.
See: **www.realtimecarbon.org/**



Screenshot of the Real Time Carbon calculator

University of Loughborough

An Excel Workbook has been developed that provides a high-resolution model of household electricity demand. Household appliances used in a UK dwelling are simulated over a 24-hour period at a one-minute time resolution. The month of the year and the number of residents can be configured and it can also be simulated for a week day or a weekend day.
See: **dspace.lboro.ac.uk/2134/5786**

Trials and pilot schemes

Trials are being undertaken through initiatives such as Low Carbon London, Ofgem's Smart Grid Forum and the Low Carbon Network Fund and are a useful illustration of carbon-saving practices.

Low Carbon Networks Fund

As part of the electricity distribution price control arrangements, Ofgem established the Low Carbon Networks Fund (LCN). The LCN Fund allows up to £500 million of support to projects sponsored by DNOs to trial new technology, operating and commercial arrangements. As part of the LCN Fund, the Energy Networks Association (ENA), established a learning portal in which LCN funded projects are outlined, including trials on DSR.
See: **www.ofgem.gov.uk/networks/elecdist/lcnf/pages/lcnf.aspx**
and **www.ena-eng.org/smarter-networks/Index.aspx**

Low Carbon London

UK Power Networks is leading Low Carbon London with the help and support of organisations including the Greater London Authority, Transport for London and the Institute for Sustainability, amongst others. This initiative brings together key stakeholders whose ambition is to prepare London's electricity network to deliver sustainable, green electricity, to power a low-carbon city. DSR trials are taking place and smart metering and decentralised energy generation are also covered.
See: **lowcarbonlondon.ukpowernetworks.co.uk/our-trials**

Customer-Led Network Revolution

Currently the UK's biggest smart grid initiative is a £54 million scheme in which 14,000 homes and businesses find ways to reduce both their energy spend and carbon emissions.
See: **www.networkrevolution.co.uk/default.aspx**

Community trials

Local communities are also taking action and have in some cases gathered key data during their trials. An example is outlined below:

Case study: **Community smart trial in Oxfordshire**[17]

Hook Norton is a rural community in Oxfordshire with around 2,500 residents and 800 properties. The local community set up a co-operative and community benefit society, Hook Norton Low Carbon Limited. It aims to help the residents reduce energy consumption and carbon emissions as well as save money, and was awarded £400,000 from DECC's Low Carbon Communities Challenge programme. Projects are based on interest-free loans and include, for example, photovoltaic installations on the primary school.

Most recently a project called Smart Hooky was launched to trial a range of new technologies to create one of the UK's first community-scale 'smart grids'. The trial will help Western Power Distribution, a project partner, understand how a rural community uses electricity at different times of the day and find out how electricity networks could accommodate more low-carbon technology.

The project aims to:

- Improve customer engagement and develop an effective incentive programme.
- Address community data measurement and display capabilities.
- Run at-scale power line communications demonstrations.
- Trial high-voltage/low-voltage substation monitoring technologies.
- Pilot a miniature smart grid telecommunications network using two or more technologies.

The Smart Hooky project allows homeowners to track their energy consumption and the impact on the environment. In March 2013 some 50 households had been installed with monitoring nodes and six distribution substations were equipped with measurement equipment and communication infrastructure. An average 24-hour consumption pattern can already be viewed at: **www.smart-hooky.net**

5 SUMMARY

The UK's electricity system is under increasing pressure to keep up with the ever growing electricity demand. Pressure on and from governments to move towards a low-carbon economy adds complexity to this problem. Increased implementation of renewables leads to a decentralised energy generation system with unplanned supply peaks that may or may not coincide with demand. To maximise use of cleaner energy and to help manage the demands on the electricity infrastructure, a smarter approach is needed.

Dynamic demand can help DNOs and the current infrastructure to deal with the increasing electricity demand and to make the most of growing input from renewables. Maximising the use of a smart infrastructure in the near future can also be supported. The Dynamic Demand Challenge Prize intends to encourage smarter solutions from a wide range of disciplines.

The Prize will support the development of innovative solutions that will increase the potential of demand side response management which will have a positive impact on current load balancing and capacity issues, as well as achieving emissions reductions.

The solutions will need to be:

- New – significant improvements on existing technologies, new application of existing technologies or entirely new technologies.
- Demonstrable – working and successfully tested prototypes.
- User-friendly and affordable (in the context of the application).
- Demonstrate potential for wide deployment and, where appropriate, commercialisation.
- Demonstrate potential for major impact – enabling substantial reductions in emissions.

The solutions will be measured against these fundamental outcomes:

- Demonstrable shift in peak usage to off-peak times.
- Responsiveness to dynamics of supply of renewable energy.
- Measureable reduction in CO_2 emissions.

The datasets outlined in this document can be used to support the entry. Additional data sets can be submitted.

The solutions should make it easier for consumers at household and small business level to potentially shift their demand, without significant changes in behaviour.

The Dynamic Demand Challenge Prize presents an exciting opportunity to develop ideas that have the potential to drive systemic change in shifting demand from peak to off-peak times, making better use of renewable energy and supporting the growing demands of the electricity infrastructure.

For more information about this report, or the Dynamic Demand Challenge Prize, please go to **dynamicdemand.nesta.org.uk** or contact **dynamic.demand@nesta.org.uk**

APPENDIX

Acronyms

BMRS	Balancing Mechanism Reporting System
CO_2	Carbon dioxide
CO_2 e	Carbon dioxide equivalent
DECC (UK)	Department of Energy & Climate Change
Defra (UK)	Department for Environment, Food and Rural Affairs
DNO	Distribution network operator
DSM	Demand side management
DSR	Demand side response
ENTSO-E	European Network of Transmission System Operators for Electricity
ICT	Information and communication technology
kg	kilogram
kWh	kilowatt hour
LCN Fund	Low Carbon Networks Fund
MWh	Megawatt hour
Ofgem (UK)	Office of the Gas and Electricity Markets

ENDNOTES

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7. SSE (2013) 'Capacity.' (web page) Available at: http://www.sse.com/EnergyPolicy/FutureEnergyNeeds/Generation/Capacity/
8. velkr0 (2008) 'Newride electric vehicle recharging site.' Available at: http://www.flickr.com/photos/velkr0/2677682538/
9. Smart meters are a new kind of electricity meter that automatically send electronic meter readings to energy suppliers.
10. For clarity it should be noted that, whilst it is an important topic, this report and the Dynamic Demand Challenge Prize do not cover demand reduction in isolation.
11. Spinning reserve/hot standby are generators that are continuously synchronised to the grid and can take over from, for example, temporary loss of main generators at any point in time.
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July 2013

Nesta Operating Company. English charity no. 7706036.
Scottish charity no. SC042833.