Sustainability First

GB Electricity Demand Project – *realising the resource*

Paper 13

Realising the Resource: GB Electricity Demand Project Overview

Sustainability First Authors:

Clare Dudeney, Gill Owen & Judith Ward.

October 2014

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Sponsored by : BEAMA ; British Gas ; Consumer Futures ; EDF Energy; Elexon ; Siemens ; E.ON UK ; National Grid ; Northern Powergrid ; Ofgem ; Scottish Power Energy Networks ; UK Power Networks ; Vodafone.

Smart Demand Forum Participants : Sponsor Group ; Energy Intensive Users' Group ; Citizens Advice (formerly Consumer Futures) ; Which ? ; National Energy Action ; Ofgem ; DECC ; Sustainability First.

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Preface

Sustainability First

Sustainability First is a UK environment think-tank with a focus on practical policy development in the areas of sustainable energy, waste and water. Sustainability First undertakes research, publishes papers and organises policy seminars. It is a registered charity with independent trustees – www.sustainabilityfirst.org.uk.

Since 2006, Sustainability First has produced a series of major multi-sponsor studies on GB household smart energy and brings significant knowledge and insight in the fields of energy efficiency, smart metering, smart energy tariffs and demand response.[1]

The Sustainability First project '**GB Electricity Demand – *realising the resource*'** is a three-year multi-partner project (2011-2014) focused on the potential resource which the electricity demand side (industrial, commercial and household customers) could bring to the GB electricity market, through both demand response and demand reduction.

Key themes for the project include:

- Customer Response and Consumer Issues.
- Commercial and Regulatory Issues.
- Public Policy Issues.

The project was supported in its first year under the Northern Powergrid Low Carbon Network Fund project - and thereafter for a further two years to 2014 via a multi-sponsor group.

Sponsors include : BEAMA ; British Gas ; Consumer Futures ; EDF Energy; Elexon; E.ON UK ; National Grid ; Northern Powergrid ; Ofgem ; Siemens ; Scottish Power Energy Networks ; UK Power Networks ; Vodafone.

Work is coordinated through a **Smart Demand Forum,** whose participants include the sponsor group together with Ofgem, DECC and key consumer bodies: Energy Intensive Users Group, Consumer Futures (now Citizens Advice), Which? and National Energy Action.

1 Sustainability First smart meter papers are available on the website – www.sustainabilityfirst.org.uk

The project has sought to:

- Evaluate and understand the potential GB electricity demand-side resource across all economic sectors (including the role of distributed generation and micro-generation);
- Develop a clearer understanding of the economic value of this resource to different market actors and to different customers over the next 10-15 years;
- Evaluate the key customer, consumer, commercial, regulatory and policy issues and interactions.

The project has developed a substantive knowledge-base, and provides visibility and thought-leadership for GB electricity demand-side issues. The project's work is relevant to:

- GB smart meter deployment.
- Low Carbon Network Fund and Network Innovation Competition projects – emerging lessons & insights.
- The DECC / Ofgem Smart Grid Forum & its workstreams.
- Plans for the electricity demand-side (DSR & electricity demand reduction) in Electricity Market Reform.

The work for the GB Electricity Demand project has been delivered through the Smart Demand Forum, through wider stakeholder events, and through thirteen published papers.

The project has also drawn upon relevant information from demand side developments in other countries to inform its work (notably the EU, US and Australia).

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GB Electricity Demand Project papers – www.sustainabilityfirst.org.uk	
1	**GB Electricity Demand – context and 2010 baseline data**
2	**GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model: scope for demand reduction and flexible response.**
3	**What demand-side services could customers offer?** • **Household customers.** • **Industry customers.**
4	**What demand-side services can provide value to the electricity sector?**
5	**The electricity demand-side & wider energy policy developments**
6	**What demand-side services does Distributed Generation bring to the electricity system?**
7	**Evolution of commercial arrangements for more active customer & consumer involvement in the electricity demand-side.**
8	**Electricity demand and household consumer issues**
9	**GB Electricity Demand – 2012 and 2025. Impacts of demand reduction and demand shifting on wholesale prices and carbon emissions. Results of updated Brattle modelling.**
10	**The electricity demand-side & local energy: how does the electricity system treat 'local'?.**
11	**How could electricity demand-side innovation serve customers in the longer term?** Joint paper with Frontier Economics.
12	**The household electricity demand-side & participation in the GB electricity markets.**
13	**Realising the Resource: GB Electricity Demand Project Overview.**

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1 Executive summary

Over the past three years, Sustainability First has worked collaboratively with experts across government, Ofgem, industry and consumer groups to explore the potential contribution demand reduction and demand-side response (DSR) could make in the GB electricity markets.

The GB Electricity Demand project has produced a series of twelve in-depth papers, covering a wide range of issues including: the size of demand-side resource, potential for demand-side services; costs and benefits to the system; the value offered to different market actors and customers; enabling policies; commercial challenges; consumer issues and protections; the supply chain and the opportunity for innovation.

This final project paper pulls together findings of our previous twelve papers with recent developments and the latest work of others, identifies gaps where further work is needed and offers recommendations on the changes needed to enable a more active demand-side in the GB electricity markets.

Considerable work has taken place, particularly over the past two years on: household and industry electricity end-use and energy behaviours; the opportunities for a more active demand side, including through innovation trials such as the Low Carbon Network Fund projects; local / community scale projects; industry commercial arrangements; and consumer protection issues. Government has also introduced new schemes through the Electricity Market Reform process for demand reduction and DSR.

However, gaps remain and there are still issues that require further focus, such as: how to ensure that trial and anonymised smart meter data can be used to inform public policy; what the costs and benefits of DSR are and where the value is likely to lie in future; how to enable local generators to sell their output to local customers; and how DSR sits with wider changes to retail markets arrangements and regulation, especially in the context of convergence between markets (e.g. energy and communications).

The paper finds that: the demand-side resource is there to some extent; the technical enablers are being put in place and demand-side markets are developing; industrial customers are already engaging in demand-side markets; the business case for market actors is currently weak, but will likely strengthen as the system modernises and faces new cost-challenges; the household side has potential, but greater focus is needed on how different consumers might want to engage with the energy market in future and how policy incentives can be bundled to make it easier for consumers.

There is some potential for households to provide peak avoidance services including through basic, voluntary Time of Use tariffs. However, over the coming decade the greatest impact on peak electricity-use, savings on electricity bills and carbon reduction, would come if households were to replace their power-hungry lights and old appliances with more efficient ones.

The paper concludes with a short list of recommendations for industry, government, the regulator and consumer champions.

Industry

- Share lessons and data from smart metering, demand and innovation trials.
- Continued focus on communications and commercial arrangements for market actors.
- Suppliers start offering basic, voluntary TOU tariffs.

Government

- Take a more holistic view of the customer proposition – bringing together D3 initiatives and support for demand reduction, demand response, energy efficiency, storage and distributed generation in a joined up way.
- Concerted push on lighting efficiency, including through existing support schemes.
- Consider a cold-appliance / refrigeration scrappage scheme.
- Target 0.5 million on-peak heated homes with thermal efficiency and off-peak electric heating.
- Assess the impacts of introducing more cost-reflection in supplier pass-through costs.
- Ensure lessons and data from consumer trials funded by customers & tax-payers is available for development of public policy and more widely.

Government & Regulator

- Holistic consideration of local administrative arrangements to enable local matching of supply and demand.
- Government departments and different regulators working together to consider the implications of converging markets and how to regulate them (such as energy and communications).

Regulator

- Develop a clearer view of how retail markets for low-carbon, demand-side and flexibility might evolve in the future.

Consumer champions

- Develop a stronger consumer voice in discussions on DSR, gauge the views of consumers on DSR more systematically, looking particularly at the interests of different customer groups.

2 Introduction

Over the past three years, the GB Electricity Demand project has sought to develop a greater understanding of the capacity and opportunities in Great Britain for demand-side response (DSR) and for demand reduction, for different customers and market actors, now and in the future.

It has looked at the value which engaged customers could offer to the GB electricity markets and to different actors, as well as the costs and challenges involved in realising demand-side potential. It has considered the policy, regulatory and commercial enablers of demand-side participation, whether and how to achieve greater cost-reflection in retail tariffs (e.g. time-of-use, location) and the potential for new technologies, services and innovation. The project has had a strong and central focus on the likely impact on customers and consumers – including those who may wish to participate in demand-side activity, as well as those, who for whatever reason, may not.

A major project output has been publication of twelve project papers designed to build a systematic overview of the GB electricity demand-side. The papers have been authored by a group of Sustainability First associates[2] and consultants[3]. Each paper has tackled a discrete demand-side topic where there was little detailed understanding of the issues or consensus on steps to be taken. The papers are a product of desk research plus information and inputs from the project sponsors, Smart Demand Forum members,[4] plus others working in this area.

Since conception of the project in 2010, there have been some significant changes in the GB energy policy landscape – including major reforms both of the wholesale and retail markets in GB – as well as many new developments which support demand-side participation. This includes collection of better data, trialling of new customer-facing demand-side technologies, tariff approaches and services, and the early stages of the rollout of both smart meters and smart grids.

A substantial amount of work has been undertaken by different market actors – DECC, Ofgem, distribution networks, the system operator, suppliers and other market actors – since the project began, which has deepened our understanding of energy use, load flexibility and appetite for demand-side services. There is now a growing recognition of the need to bring various policy streams together, to understand the consumer proposition and the value the demand-side could bring in the round. Ofgem is addressing some of these issues via its Smarter Markets Programme. Other issues will need to be taken forward by DECC, market actors, in particular the energy suppliers, and the consumer bodies.

This paper reflects upon the ground covered by the GB Electricity Demand project to date.

- **Part I** discusses the main project findings; recent developments and the work of others; remaining issues and gaps; and recommendations.
- **Part II** includes individual 'one page' summaries of each of the twelve main project papers.

[2] Judith Ward, Gill Owen, Sharon Darcy, Rebekah Phillips, Maria Pooley, Jon Bird and Clare Dudeney.
[3] Serena Hesmondhalgh, Brattle Group ; Sarah Deasley & Claire Thornhill, Frontier Economics ; Stephen Andrews, Lower Watts Consulting ; Syed Ahmed, Energy for London.
[4] Project sponsors: BEAMA, Consumer Futures, British Gas, EDF Energy, Elexon, E.ON UK, National Grid, Northern Powergrid, Ofgem, Scottish Power Energy Networks, Siemens (E-Meter), UK Power Networks, Vodafone.
Smart Demand Forum participants include the sponsor group, DECC, Ofgem & consumer bodies: Energy Intensive Users Group, Consumer (now Citizens Advice), Which? and National Energy Action.

3 Main project findings

Below are headline findings of the GB Electricity Demand project.

Electricity demand-side potential

- Technical potential for shiftable electricity load across all sectors today may be up to ~18GW of 54GW on a January weekday winter evening and ~10 GW of 35 GW on an August weekend evening, according to the Brattle Model in Paper 2[5].

- Sources of end-use flexibility include: on-peak electric heat, on-peak electric water heating, cold and wet appliances. For industrial and commercial customers also: lighting, heating, cooling, ventilation, industrial motors and compressors. In future: electric vehicles and heat pumps.

Services customers could offer

- Only the largest industrial customers - and domestic customers on Economy 7 - presently adapt their consumption.

- Industrial customers provide various demand-side services currently – including Balancing Services for National Grid (frequency and reserve services) and also system peak avoidance. Many use back-up generation – either directly, or to offer generation/demand side services to National Grid.

- The main focus of household DSR is currently on peak avoidance in the wholesale market (i.e. Economy 7). In future, the main value will remain in the wholesale market, but there will be opportunities to participate in other markets and the focus may shift to managing periods of low wind. However, we do not yet fully understand either the timing or likely eventual impact of such a change upon retail market demand-side incentives.

- There is scope for the 0.5 million households who use on-peak electric heating to install insulation and to shift to off-peak heat.

- Householders may be willing to accept interruption of some appliances for financial benefit, but there may be limited match between what currently contributes to peaks (heating, lighting, cooking, TV and consumer electronics) and what householders are generally willing or able to shift (washing machines, tumble driers, dishwashers).

- In the longer-term, automation is likely to be the most effective and reliable way of realising household DSR potential, but this will require customer buy-in and ability to override. ‘Ease of use’ and sense of ‘being in control’ are critical.

[5] Sustainability First, Paper 2, ‘GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model: scope for demand reduction and flexible response’.

Benefits and costs of demand-side services

- Benefits of demand-side services include potential savings in generation capacity, network reinforcement, and system operation – but these benefits need to be better understood and quantified[6].

- The likely costs of providing demand-side services have not been quantified, but include the cost of communications, upgrading smart appliances, retrofitting control devices, changes to tariff structures and billing systems; and some network changes.

Value to market actors

- Presently, for most market actors, the value proposition to engage in DSR is unclear.

- Suppliers have a lead role with customers and smart meter rollout, but presently have few commercial drivers.

- DNOs have reasons to promote DSR at particular locations, but presently lack interface with customers and can offer only limited value to share.

Enabling policies and regulation

- Technical enablers for demand-side engagement are already being put in place by the Government and Ofgem including via the smart meter arrangements. However, greater focus is needed on how to bring together various policy initiatives – e.g. energy efficiency, heat and distributed generation, demand reduction, DSR, to make it easier for customers to engage. Through a recent report on D3[7], DECC has begun to look at these issues in the round[8].

- Appliance standards should be very effective at reducing both overall and peak demand – and product standards need to be driven forward in a far more strategic and concerted way, including ensuring appliances are designed for a smarter world e.g. for automation.

Cost reflectivity and Time of Use (ToU)

- More cost-reflective retail prices and tariffs are likely to be needed to promote an efficient electricity system. This means finding ways to combine incentives for time-of-day and / or varying wholesale prices – plus the costs and benefits of location – while at the same time safeguarding more vulnerable customers who are unable to become more flexible in their electricity use.

- ToU tariffs are already available to half-hourly settled industrial and commercial customers.

[6] Some work on this is currently underway in the DECC/Ofgem Smart Grid Forum – Work Stream 6 (Distribution of Value Sub-Group).
[7] D3 stands for Demand reduction, Demand response and Distributed generation.
[8] DECC 'Opportunities for integrating demand side energy policies'. Syed Ahmed. July 2014.

- For domestic customers, it is possible to offer basic static ToU retail tariffs today with a suitable meter, billing IT and a minor adjustment to settlement. Smart meters and half-hourly settlement are important enablers for more 'responsive' forms of household DSR such as automation and dynamic tariffs – including possible Critical Peak Pricing (CPP), household TRIAD and wind-twinning.

Matching of supply and demand locally

- In addition to the role of National Grid in balancing the national system, greater focus is needed on the potential for local matching of supply and demand, including via storage, to create 'pro-sumers' – but this will involve detailed reform of current administrative silos and grappling with current approaches to industry network charges.

Innovation

- The Low Carbon Network Fund has had a positive impact on network innovation, but many projects are inevitably technology-focused – rather than primarily customer–focused. Many projects tend not to be fully 'end-to-end' across the full value chain.

4 Recent developments

This section looks at the main issues explored through the GB Electricity Demand project, the work of other parties and developments over the past three years.

4.1 Customer end-use and baseline data

It is critical to establish a baseline understanding of how demand is met today and electricity end-use for different sectors, appliances and times of day. **Paper 1** gathered data on how electricity is used today[9]. In **Paper 2** Brattle developed a model of end-use[10]. At the time, there was some limited empirical data on household and commercial end-use, but very little on the industrial sector.

Over the past three years various studies of household end-use have offered a much better picture of the appliances people use, their willingness to reduce or shift load and the challenges they face. **Table 1** summarises some of these findings. These reports highlight the importance of replacing inefficient lighting and appliances to save electricity at peak.

Study	Approach	Headline findings
EST, DECC and Defra Household Electricity Use Survey[11]	Survey of appliance use in the home. 250 homes monitored incl. 26 for a full year & 225 on a rolling basis for a month each in 2010/11.	Leaving appliances in standby costs household £50-86 per year. Higher relative energy usage of single occupancy dwellings. High usage of TV, washing machines and tumble driers.
Further analysis of the EST/DECC/Defra Household Electricity Use Survey[12]	Series of eleven papers analyse in more detail the 2010-11 HEUS data – including empirically-based data about patterns of UK household electricity-use.	Appliance efficiency improving. Replacement of white goods could save over one-fifth of the power that these appliances presently use. Replacing old bulbs with low energy ones could save each home 230 kWh p.a. (~£35). Some scope for load-shifting (e.g. wet appliances) - but increasing appliance efficiency makes a bigger difference.
BRE follow-up survey to the 2010/11 English Housing Survey (EHS)[13]	Focused on how energy is used in the home. Interviews with 2,616 households previously visited as part of 2010/11 EHS. Some with electricity consumption monitors installed. Results used to update BREDEM and SAP.	Average annual consumption of electricity is ~3,700kWh. High use of conventional lighting in living & bed- rooms - only 30% CFLs. 17% leave lights on at night. Significant scope to replace old appliances with new energy saving ones (but may need incentives). 2.1m washing machines, 2.6m tumble driers, 2.5m fridges/freezers & 4.5m ovens are over 10 years old.
Electricity Demand Research Project (EDRP)[14]	Four supplier led trials: 60,000 households and 18,000 smart meters, designed to test the impact of interventions on customer energy use.	Smart meter enabled interventions, e.g. real-time displays, clear information and tailored advice, have an impact on demand reduction. Two trials explored load shifting, with customers shifting ~7-10% without automation.

Table 1. Recent studies on household electricity use. Summary compiled by Sustainability First.

[9] Sustainability First, Paper 1, 'GB Electricity Demand – context and 2010 baseline data'.
[10] Sustainability First, Paper 2, 'GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model: scope for demand reduction and flexible response'.
[11] Energy Saving Trust, DECC and Defra 'Powering the Nation: Household electricity-using habits revealed,' Jun 2012.
[12] Powering the Nation 2: Electricity Use in Homes, and how to reduce it. Eleven papers for DECC & DEFRA, by Cambridge Architectural Research Ltd, Loughborough University, Element Energy & Cambridge Energy. Apr-Jun 2014.
[13] BRE for DECC 'Energy Follow-Up Survey 2011 – Report 1: Summary of Findings,' Dec 2013.
[14] AECOM report for Ofgem 'Energy Demand Research Project: Final Analysis,' Jun 2011.

Further work is underway to improve our understanding of how people use electricity in homes and businesses. DECC has developed a National Household Model, to be made publically available in late 2014. The department also wants to develop a better understanding of energy related behaviours and assess the impact of energy efficiency measures in domestic and non-domestic buildings by including data from current schemes in the National Energy Efficiency Data-Framework (NEED) [15].

DECC has contracted a major study of non-domestic energy use[16], to provide a disaggregated view of energy end-use across various sub-sectors as well as abatement potential. This is known as the Building Energy Efficiency Survey (BEES), starting in September 2014, reporting in summer 2015.

Smart meters will create a huge amount of data, and it is important that this is used for the benefit of customers, and in particular to inform public policy. Cambridge Architectural Research Ltd and Loughborough University were asked by DECC to set out a proposal for a new National Household Energy Survey using smart meter data – starting with a pilot scheme[17]. The Carbon Trust is also undertaking a study for DECC on the use of industrial smart meter data.

[15] DECC 'Developing DECC's Evidence Base,' January 2014.
[16] DECC 'Developing DECC's Evidence Base,' Jan 2014.
[17] Cambridge Architectural Research Ltd and Loughborough University 'The Potential for Smart Meters in a National Household Energy Survey,' Oct 2013.

4.2 Demand-side potential

Once there is a baseline understanding of demand and end-use in different sectors, it is possible to assess sources of end-use flexibility for different customers at different times of day, and model the potential for demand reduction and response now and in future.

The Brattle Model was used in **Paper 2** to assess what proportion of end-use could technically be flexible[18]. It suggested that technical potential for shiftable load today across all sectors is ~18GW of 54GW load on a January weekday winter evening and may be up to ~10 GW of 35 GW load on an August weekend evening – which is about one-third of total load for both. However, the amount that is realistically shiftable is not clear, but certainly considerably less.

Element Energy and De Montfort University[19] quantified for Ofgem the technical potential for demand-side response focusing on non-domestic buildings – estimating technical potential of 1.2-4.4 GW (i.e. 8-30%) of demands during the peak hour.

In the household sector, various trials have explored realisable end-use flexibility and the types of demand-side services customers could offer. The EDRP supplier-led trials demonstrated that smart meter enabled interventions have an impact on demand reduction, and the load shifting trials found customers shifted ~7-10% without any automation[20].

Further analysis was undertaken on the EST/DECC/Defra Household Electricity Use Survey to assess the potential for peak load shifting[21]. This showed household peak-load was on average three times higher than base-load – with cooking, lighting and audio-visual the largest contributors. This suggested that there is some potential to shift load off-peak with controls on washing machines, tumble driers and dishwashers. But, in the end, **replacing inefficient household appliances with the most efficient ones, especially efficient lighting and refrigeration will have a more significant impact on peaks.**

DECC has also been looking at the opportunities for electricity demand reduction. They asked McKinsey to model demand reduction potential across all sectors – suggesting that savings of up to 146 TWh (36% of total demand) may be technically possible in 2030[22].

[18] Sustainability First, Paper 2, 'GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model: scope for demand reduction and flexible response'.
[19] Element Energy and De Montfort University ' Demand-side response in the non-domestic sector,' July 2012.
[20] AECOM report for Ofgem 'Energy Demand Research Project: Final Analysis,' Jun 2011.
[21] Cambridge Architectural Research Ltd, Element Energy and Loughborough University 'Further analysis of the Household Electricity Survey – Early Findings: Demand side management,' Nov 2013.
[22] DECC 'Electricity Demand reduction initial impact assessment' Nov 2012.

4.3 Services customers could offer

With some indication of the technical potential for demand response and reduction, we can then consider what services customers could provide for their own benefit and to support an efficient electricity system. **Paper 3** looked at the demand-side services customers could offer - looking separately at the household[23] and industrial sectors[24]. **Table 2** summarises current services that are offered and the benefit they provide to different market actors.

	Demand-side benefit	**Schemes**
System operator	Frequency response and reserve services for balancing.	Frequency Control by Demand Management Short Term Operating Reserve (STOR) Demand-Side Balancing Reserve (DSBR)
Distribution networks **Transmission**	Load management for constraint management (deferred/ avoided network reinforcement) and for improved fault management.	Distribution Use of System (DUOS) time/price banding Low Carbon Network Fund innovation trials Bi-lateral peak avoidance agreements TRIAD management/peak avoidance
Suppliers	Offer flexible/time-varying pricing to their customers.	Wholesale markets (e.g. I&C STOD tariffs (seasonal time of day) & Economy 7 for SME & household customers). Voluntary Load Management for I&C customers (VLM)
Capacity market	Ensuring sufficient capacity to meet future demand.	Electricity demand reduction pilot Demand-side response in the capacity market

Table 2. The benefit that the demand side offers different market actors and the schemes in place to capture this benefit. Source: Sustainability First.

Since our project began, a number of new schemes have been announced and are being developed: an electricity demand reduction (EDR) pilot via the capacity market; inclusion of demand-side response in the capacity market; and National Grid's demand-side balancing reserve (DSBR).

Currently, it is mostly large industrial users who participate in the demand-side schemes in **Table 2** and they are also likely to lead on the new schemes. Many I&C customers deploy their on-site back-up generation (such as diesel or CHP), either to boost local generation output or to reduce their own import without disrupting their own operations. In terms of carbon emissions, the alternatives of using diesel back-up for demand-side response (versus spinning reserve from large generation-sets; or, use of load turn-down) have not been properly assessed, & we touch on this in **Paper 6**[25].

Over the past few years, revenues to demand-side providers have fallen in the STOR market due to current over capacity. Greater market interest in TRIAD management has also had the unintended effect of making it increasingly difficult and risky to predict the three TRIAD winter peaks – as everyone tries to avoid the peaks, which changes the shape, making them ever-harder to predict.

[23] Sustainability First, Paper 3a, 'What demand-side services could household customers offer'.
[24] Sustainability First, Paper 3b, 'What demand-side services could industrial customers offer'.
[25] Sustainability First, Paper 6, 'What demand-side services does Distributed Generation bring to the electricity system?'

With various different schemes in which to participate, industrial customers are finding it harder to assess which scheme offers them the best price and terms – especially as bidding into one scheme may preclude participation in another. Aggregators can help industrial customers find the most appropriate schemes. However, industrial customers would welcome greater price transparency for demand-side services, through the new markets and potentially, in the long-run, via new IT platforms or exchanges.

The aggregation market has established in GB, but aggregators need secure, predictable and long-run sources of revenue to share with their demand-side partners – as well 'fair' access to the electricity markets to ensure a sustainable aggregator business model. In the capacity market, user-friendly rules for demand-side aggregation providers have yet to be finally resolved.

There are fewer schemes demand-side schemes designed to incentivise householders. Householders mostly offer peak avoidance services to suppliers in the wholesale market, such as on the Economy 7 tariff. **Paper 12** considered in detail which markets householders would be able to participate in, in future[26]. It suggested that pre-2020 the focus is likely to remain on peak avoidance in the wholesale market. However, there are no barriers, *in principle*, for households to participate in other schemes like the capacity market, electricity demand reduction pilot, TRIAD management in future, provided load-shifting is firm (e.g. via automation), aggregated for scale, and, measurement is satisfactorily resolved.

[26] Sustainability First, Paper 12, 'The household electricity demand-side & participation in the GB electricity markets'.

4.4 Value to market actors

With an understanding of technical constraints for both market actors and customers, when and where savings need to be made, and what services customers could provide, we then need to look at the value demand-side services can provide to the system and to different market actors.

The benefits that demand-side services can offer to different market actors and the schemes in place to capture this value are summarised in **Table 2**. **Paper 4** assessed the benefits and costs of DSR, its value to different actors and what DSR services they currently contract[27], including:

- *The System Operator* – contracts the most DSR today. Approx. £383m for balancing services including for frequency response, fast reserve, short-term operating reserve (STOR) and system security. True demand side services balancing are ~200MW, the remainder is on-site back-up generation.

- *Suppliers* – undertake relatively little activity, mainly flexible contracts with industrial and commercial (I&C) customers to avoid peak usage and TRIAD periods and from domestic customers on Economy 7 to shift load to off-peak/night usage. In principle, there should be value from avoided costs for new generation, wholesale procurement and network charges.

- *Distribution networks* – actively exploring DSR to: manage constraints & losses by avoiding capital costs, improve fault management and automated load management, incl. direct contracts with I&C customers for avoided network reinforcement; Economy 7 load switching; half hourly settled customers winter peak avoidance; innovation trials. **Distribution network benefits are location specific**. In future distribution networks expect to deal with uncertain volumes and locations of loads (e.g. electric vehicles, heat pumps, microgeneration). Possible value range for distribution network DSR is estimated at £40-£60/kW/pa.

Since **Paper 4** a number of other studies have looked at the potential value of DSR and flexibility:

- Redpoint, Baringa and Element Energy modelled the potential future system benefits of DSR[28] from domestic customers and small and medium sized enterprises (SMEs). The work suggested that the main savings were from generation operating costs, avoided new generation investment and avoided DNO reinforcement. The modelled DSR benefits increase over time approaching £500m, with a peak reduction of 2.5 GW by 2030.

- Poyry has also looked at the value of flexibility and interconnection highlighting the importance of reflecting true costs of imbalance[29].

- Frontier Economics has produced a report for Elexon that suggests suppliers are likely to get the most substantial benefit from DSR in the wholesale market[30].

[27] Sustainability First, Paper 4, 'What demand-side services can provide value to the electricity sector?'
[28] Redpoint, Baringa & Element Energy 'Electricity System Analysis: future system benefits from selected DSR scenarios,' Aug 2012.
[29] Poyry 'Revealing the value of flexibility: How can flexible capability be rewarded in the electricity markets of the future?' 2014.
[30] Cross-party impacts of DSR actions. Frontier Economics. A report prepared for Elexon. May 2014.

No recent study has looked comprehensively end-to-end at demand-side value - although Work Stream 6 of the DECC/Ofgem Smart Grid Forum is starting to do so.

In spite of the benefit that the demand-side can offer, there is a lack of strong commercial incentives for any individual market actor, in particular for household DSR.

Paper 12 proposes that suppliers are well placed to enable householders to make DSR offers, with the rollout smart meters and related technical 'enablers' for demand management by 2020[31]. Currently suppliers have little commercial incentive, due to the way costs are socialised and the lack of price reflectivity. But by 2020 suppliers will also start to face increasing risk (imbalance, accurate settlement, and possibly greater separation of generation & retail arms) which may lead them to see the household demand-side as a viable commercial strategy / 'hedge'. But this would require controllable household load at scale (e.g. electric heat, storage heaters & hot-water storage, heat pumps, electric vehicles) – but there is little headway on new uptake of such load.

DNOs may also benefit from household DSR - in particular in constrained locations - directly with commercial customers, with communities or in partnership with other market actors. To capture the full benefits from demand-side services, information sharing and collaboration between different market actors may be necessary[32]. Various industry working parties are looking in considerable detail at the contractual and commercial arrangements required to enable DSR:

- **Smart Grid Forum Work Stream 6** – looks in depth at regulatory and commercial issues for facilitating DSR in the Distribution Networks, including: options, commercial arrangements and barriers for consumers to participate in a future smart grid.[33].

- **Electricity Networks Strategy Group** - distribution-transmission boundary issues.

- **Electricity Networks Association (ENA) DSR Working Group** – produced a paper on the interactions across parties and contractual arrangements required for sharing DSR benefits[34].

[31] Sustainability First, Paper 12, 'The household electricity demand-side & participation in the GB electricity markets'
[32] For example the CLASS project which National Grid and Electricity North West are working on together (Customer Load Active System Services) which trials voltage control to manage electricity consumption at peak times, in particular locations. For more info see: http://www.enwl.co.uk/class/about-class/what-is-class.
[33] Demand Side Options Report. April 2014. Smart Grid Forum Work Stream 6 papers on Ofgem website..
[34] ENA 'Demand-side response shared services framework concept paper,' Apr 2014.

4.5 Enabling policies and regulation

Policies to enable demand-side participation in the GB electricity market were explored in **Paper 5**[35]. In the meantime, the policy context has evolved considerably over the past two years. Below we look at policies that help to move the demand-side along the track - and other developments in train - that could be useful, as well as developments that will impact on the demand-side. The role of distributed generation is also considered.

Policies to enable demand-side:

Policies and work helping to move the GB demand-side along the track, especially (but not exclusively) for households:

- **Smart Meter Implementation Programme** – rollout arrangements and especially clarification of SMETS 2 [36] meter capabilities.

- **Ofgem Smarter Markets programme** – proposed DSR Framework in September 2014; a forward view of how universal half-hourly settlement may be taken forward including extension of half-hourly settlement to profile classes 5-8[37]; and Consumer Empowerment & Protection response in September 2014.

- **DECC / Ofgem Smart Grid Forum** (esp. Work Stream 6) – now looking at commercial & regulatory frameworks for DSR in the distribution networks, building on early papers and the publication of a Smart Grid Vision and Routemap[38].

- **Distribution level** – many trials and pilots are exploring the commercial & technical arrangements for local DSR, for example through the Low Carbon Network Fund & the Network Innovation Competition[39] and, for the future, via RIIO-ED1[40].

- **Data gathering** – various studies have improved our understanding of householder end-use including the Household Electricity Usage Study[41]. DECC has developed the National Household Model and is gathering data on non-domestic end-use through BEES.[42]

[35] Sustainability First, Paper 5, 'The electricity demand-side & wider energy policy developments'.
[36] Smart Metering Equipment Technical Specifications – Version 2.
[37] Ofgem 'Electricity settlement reform – moving to half-hourly settlement,' April 2014.
[38] DECC & Ofgem Smart Grid Forum 'Smart Grid Vision and Routemap,' Feb 2014.
[39] ENA Smarter Networks Portal - http://www.smarternetworks.org/
[40] This is the electricity distribution price control. RIIO stands for Revenue = Incentives + Innovation + Outputs.
[41] Powering the Nation 2: Electricity Use in Homes, and how to reduce it. A series of eleven papers produced for DECC & DEFRA, by Cambridge Architectural Research Ltd, Loughborough University, Element Energy & Cambridge Energy. April-June 2014.
[42] DECC 'Developing DECC's Evidence Base,' January 2014.

Developments in train, which should support demand-side development – but may add some near-to-medium term uncertainty:

- **National Grid Demand-Side Balancing Reserve (DSBR);**
- **Capacity Market – EDR pilot & DSR transitional scheme;**
- **Electricity Balancing Significant Code Review of cash-out / imbalance payments; and**
- **Retail Market Review tariff arrangements, and Ofgem review of Consumer Empowerment and Protection.**

Other developments with unknown / uncertain impacts for the demand-side:

Developments being pursued separately from specific electricity demand-side policies but are nevertheless likely to impact the demand-side:

- **Affordability of energy** – policy-maker concern about how to make cost savings to reduce energy prices – this may impact on the appetite for more cost-reflective retail pricing and the availability of funds for demand-side schemes.
- **Energy efficiency schemes** – focus on ways to drive demand for Green Deal and on the next phase of the Energy Company Obligation (ECO)[43]. Currently, very limited focus on electricity efficiency and on creatively bringing together the combined benefits of energy efficiency and demand-side policy.
- **Carbon pricing** – the decision in Budget 2014 to freeze the carbon price floor at £18 per tonne from 2016/17 and to provide additional support to energy intensive users[44]. This may impact commercial drivers for energy intensive users to reduce demand, but equally the support package could help them with the cost of energy efficiency and demand-side measures.
- **Electricity Market Reform** – focus has been on promoting new low carbon generation. Other than modest demand-side measures via the capacity mechanism, the demand-side has therefore been second order.
- **Market structure and competition** – a CMA energy market investigation is currently underway with implications for the future structure of the market e.g. vertical integration, liquidity. Labour party proposal for a mandatory exchange or pool[45]. Development of new *retail* market models for low-carbon, flexibility and the demand-side.

[43] DECC 'The Future of the Energy Company Obligation: Consultation' 2014.
[44] An extension to the current compensation scheme for energy intensive users for the cost of carbon price floor and EU Emissions Trading Scheme. This will now be in place until 2019-2020. A new compensation scheme will also be introduced from 2016 to help intensive users with high electricity costs from renewable obligation (RO) and the feed in tariff (FiT) for renewable generation.
[45] Labour Party 'Powering Britain: One Nation Labour's plans to reset the energy market,' Nov 2013.

A theme running through the GB electricity demand papers is the importance of joined-up thinking on policy development particularly: between energy efficiency, distributed generation and the demand-side; and on the customer proposition. It needs to be clear and simple for customers to engage with the demand-side.

DECC is undertaking work currently on how the demand-side is treated in various policies and how to enable D3, and they published a helpful paper in August 2014[46]. This joined-up thinking also needs to extend to our engagement with EU policy and legislation on D3 issues. We will also wish to ensure that product standards are consistent with the requirements of smarter systems – such as enabling automation.

4.6 Distributed generation

The demand-side role that distributed generation can play both directly and as back-up was covered in **Paper 6**[47]. This highlighted the active use of distributed generation to offer demand-side services, but also that current incentives (such as the Feed in Tariff and Renewable Obligation) encourage renewable generators to maximise export, with no 'Time of Use' component.

Since the project began we have seen a stronger policy focus on distributed generation and heat including through: the Community Energy Strategy[48]; PV Strategy[49], Heat Strategy[50] and retention of present approaches to embedded benefit payments for distributed generation.

There remains an issue for distribution networks that they tend to get notified of plans for new distributed generation at a late stage, making it difficult to plan network operation and investment. Some distribution networks are now working with local government to ensure early notification of new developments with distributed generation through the planning process[51]. Work is also underway between National Grid and distribution networks on how to improve the visibility of DG connections to the distribution networks. Distribution charges (DUOS) are designed to encourage larger distributed generators to maximise their output at peak periods to help offset congestion in local networks.

4.7 Cost reflectivity and retail tariffs

To achieve a more cost-efficient market, the true costs of supply – at different times of day and different locations – may in due course need to be reflected to some greater or lesser degree in retail tariffs/charges to customers. The value of demand response at different times and locations would also need to be captured through commercial arrangements.

[46] DECC 'Opportunities for integrating demand side energy policies'. Syed Ahmed. July 2014.
[47] Sustainability First, Paper 6, 'What demand-side services does Distributed Generation bring to the electricity system?'
[48] DECC 'Community energy strategy: people powering change,' Jan 2014.
[49] DECC 'UK Solar PV Strategy Part 1: Roadmap to a Brighter Future,' Oct 2013. DECC 'UK Solar PV Strategy Part 2: Delivering a Brighter Future,' Apr 2014.
[50] DECC 'The Future of Heating: A strategic framework for low carbon heat in the UK,' Mar 2012.
[51] For example UK Power Networks is working with the Greater London Authority.

Paper 7 looked at system constraints at different times of day, how these might change in future and how to signal Time of Use (ToU) to end-users & micro-generators, through network costs, retail prices and different types of tariffs[52]. It focused particularly on households, drawing on the experiences of the current Economy 7 tariff and recent trials of basic static ToU tariffs.

Consumer Focus produced a report on experiences of ToU consumers (e.g. Economy 7 and 10) [53], 50% of ToU tariff users deliberately choose to run appliances, other than water and space heating, off-peak. However, they found lower overall satisfaction for customers with storage heaters than gas central heating.

The Customer Led Network Revolution (CLNR) project is providing insights into ToU tariffs. The British Gas/Northern Power Grid project, which covered 14,000 households and SMEs overall, – trialled ~600 customers on a 2:1 off-peak saver rate. Early findings suggest that electricity consumption fell for those in the ToU group, but whilst 60% customers saved money on the ToU tariff, 40% paid more[54].

DECC's smart meter benefits review group is looking at what benefits from ToU approaches can be enabled through smart meters[55]. Ofgem's current thinking, after the smart meter roll-out, is eventually to introduce universal half hourly settlement. This would make it feasible for suppliers to develop far more flexible / dynamic tariff options.

Paper 10 looked at how physical constraints at different network locations, can be signalled in network costs, the opportunity for local matching of supply and demand, and what issues/barriers would need to be addressed[56]. This is discussed in more detail below under 'local community schemes'.

[52] Sustainability First, Paper 7, 'Evolution of commercial arrangements for more active customer & consumer involvement in the electricity demand-side'.
[53] Consumer Focus 'From devotees to the disengaged: A summary of research into energy consumer' experiences of Time of Use tariffs and Consumer Focus's recommendations,' Oct 2012.
[54] Customer-Led Network Revolution (CLNR) Project, 'Progress Report 7' Annex 6, July 2014.
[55] Through the DECC Smart Meter Benefits Review Group.
[56] Sustainability First, Paper 10, 'The electricity demand-side & local energy: how does the electricity system treat local?'

4.8 Consumer issues

Throughout the papers there has been a major focus on the issues and barriers consumers might face in participating in DSR. These issues were covered in particular detail in **Paper 8** which looked in some detail at TOU tariffs and set out principles by which to judge the DSR market (see **Figure 1**), and **Paper 12** which looked at how and when households might participate evolving GB demand-side markets, which markets would be best, the value for consumers, barriers and consumer protection issues[57].

Principles for judging the DSR market:

1. *Clear objectives and consumer outcomes* (e.g. lower prices, accuracy of billing, reduced energy consumption, protections for vulnerable consumers etc.)
2. *Distributional impacts* - have these been taken into account?
3. *Clarity* - how clear / simple is the DSR proposition?
4. *Appropriateness* of the tariff to the consumer's circumstances
5. *Information* - adequacy, accessibility, comparability and privacy issues
6. *Flexibility* to switch between tariffs without significant penalties
7. *Choice* – on matters such as: automated response and controls and over-ride facilities; data sharing.
8. *Timing* – of offers - e.g. are they part of a wider energy efficiency scheme or on the back of new tighter product standards?
9. *Intermediaries and aggregators* – can customers access these and provide data to them if they wish; regulatory and consumer protections.
10. *Dispute resolution and remediation* - clear responsibilities and processes.

Figure 1. Principles for judging the DSR market[58]. Source: Sustainability First.

The combination of smart meters, half-hourly settlement, data management and new smarter controls has the potential to enable demand-side participation for customers large and small. However, issues remain including: knowledge of schemes/ways to participate; size of financial incentives/payback; impact on lifestyle/business; technologies to enable automation (including the costs & benefits).

Further work is needed to understand what will really motivate customers to participate and overcome barriers. From tariff trials so far (EDRP EDF Energy, Ireland, CLNR, Low Carbon London) it is still not altogether clear what truly motivates customers, including how far financial incentives alone impact householder willingness to participate in demand reduction or response[59].

In **Paper 12**, Sustainability First argues that a stronger consumer voice is needed to ensure that the preferences, views and concerns of customers are taken into account through the rollout of smart meters, development of new tariffs and demand-side services. Consumer engagement, information and easy ways of comparing tariffs are critical.

[57] Sustainability First, Paper 12, 'The household electricity demand-side & participation in the GB electricity markets'
[58] Sustainability First, Paper 8, 'Electricity demand and household consumer issues'.
[59] AECOM report for Ofgem 'Energy Demand Research Project: Final Analysis,' Jun 2011.

The recent DSR paper by Citizens Advice reiterates these messages[60]. It recommends that market actors actively share findings of DSR trials, work together to agree phased introduction of DSR and consult with Ofgem and consumer bodies before introducing tariffs with direct control of consumer appliances. It highlights the need for tariff comparison tools, DSR accreditation, consumer protections including to prevent unwanted 'lock-in' to schemes, and assessment of the impacts of DSR on vulnerable consumers. Ofgem's Smarter Markets Programme has very helpfully brought together work on retail markets, demand-side, consumer empowerment and protection.

4.9 Local and community schemes

Local energy schemes are where personal energy, drive and commitment sit to transform the energy sector to low-carbon. Community schemes can be important show-cases & test-beds to promote the demand-side and to break down institutional and administrative barriers

DECC and Ofgem have recently instigated a number of initiatives, which could help enable local participation. Policy developments include: Community Energy Strategy funding for local demand-side projects; Licence Lite; consideration in the PV Strategy of balancing challenges and the potential for innovation[61].

Trials are also beginning to look at some of the opportunities for 'prosumers' i.e. customers who produce electricity and/or provide other services such as self-balancing / DSR. For example, the CLNR trial and the So La Bristol/Western Power Distribution project are each testing PV cells with different approaches to home storage (CLNR - hot water, SoLa - battery pack).

In order to achieve a greater degree of local match in supply and generation, certain administrative 'silos' (e.g FIT administration rules, Data Protection arrangements) will need to be considered in detail. Suppliers and DNOs must make best use of the data they have to enable cost-efficient demand-side solutions. Suppliers also need to shape commercial approaches to their PV and retail customers to encourage the development of 'prosumers'. Some of the concerted regulatory and charging discussions, required before prosumers (individuals, communities) can gain institutional 'recognition', are just beginning[62].

[60] Citizens Advice Bureau 'Take a walk on the demand-side: Making electricity demand side response work for domestic and small business consumers,' Aug 2014.
[61] DECC 'UK Solar PV Strategy Part 2: Delivering a Brighter Future,' Apr 2014.
[62] For example, DECC working groups to inform the Community Energy Strategy – plus the work of groups such as Community Energy Scotland ; the newly formed Community Energy England ; Forum for the Future's Community Energy Coalition etc.

4.10 Impact of demand-side measures on the market

The impact of demand-side measures on wholesale prices and carbon abatement was considered in **Paper 9[63].** This updated and extended our earlier Brattle demand-side modelling. Further work still is needed to understand the complex interactions of policies and the implications for wholesale prices. We need to better understand how the increasing tendency for wholesale prices to reflect short-run prices rather than underlying long-run costs will impact the retail markets. Energy UK produced a brief paper on policy interactions in 2013[64]. But there is no coherent, quantified assessment of how various policies will impact wholesale costs and prices - and how these may then transfer into future retail prices.

Paper 12 made a start on unpicking some of these issues. It considered the impact of costs passed through to consumer bills (for networks and policy levies). It highlights that by 2020 these pass-through costs will make up over one-half of the end electricity bill and possibly two-thirds by 2030[65]. As these costs are passed through as a fixed cost or a per-unit cost (p/kWh), they do not reflect time of use, especially peak related cost. In seeking to develop a stronger ToU retail signal, the impact of such a large cost 'pass-through' in flat p/kWh, may need to be addressed, for example by 'peak-sculpting' pass-through costs to *suppliers*.

The paper also highlighted that around one-half of the total estimated cost-savings on electricity bills in future are as a result of EU product policy and regulation (£167 less p.a. *per customer* by 2020). Therefore, it remains critical to focus on implementing product standards for appliance efficiency.

4.11 The role of customer-facing innovation

The role of demand-side innovation and how this serves customer interests was discussed in **Paper 11[66]**. The paper highlighted the important focus on network innovation through the Low Carbon Network (LCN) Fund, suggesting that this has fostered collaboration, culture change, value for money (~£2/customer/year) and knowledge sharing. There did, however, appear to be a tendency towards technology rather than customer-facing innovation, which made it difficult to develop projects across the full value chain, as this would require additional external (non-DNO) funding.

Better coordination and information sharing is needed among funders of demand-side innovation trials and projects. There should also be more 'joined-up' and 'end-to-end' approaches to funding of customer-facing demand-side innovation – which includes behavioural not just technological measures. Beyond the smart meter rollout, the innovation supply chain lacks a coherent 'forward view' for their businesses, of how the demand-side market is likely to develop for households.

[63] Sustainability First, Paper 9, 'GB Electricity Demand – 2012 and 2025. Impacts of demand reduction and demand shifting on wholesale prices and carbon emissions. Results of updated Brattle modelling.'
[64] Energy UK 'Policy interactions in the UK electricity market: A guide to the impact of policies,' Nov 2013.
[65] Sustainability First, Paper 12, 'The household electricity demand-side & participation in the GB electricity markets'.
[66] Sustainability First, Paper 11, 'How could electricity demand-side innovation serve customers in the longer term?' Joint paper with Frontier Economics.

5 Remaining issues and gaps

Below are areas we have identified where significant gaps and issues remain. Further work will be needed across these many areas to move forward on successful development of the GB Electricity Demand-Side.

Data and modelling

- Disaggregated data for the industrial and commercial sectors on electricity end-use by process, appliance and time of day, as well as the flexibility/depatchability of load. Potential survey of half-hourly settled customers.

- A comprehensive database of distributed generation – including renewables, combined heat and power, back-up fossil fuel etc.

- Sampling, collation and publication of anonymised data-sets from customer & publicly-funded smart trials (e.g. LCNF) and smart metering data for public policy. There is a challenge for suppliers that data can only be used by specific partners, as agreed in the terms and conditions with customers.

- Updated economic scenarios of the costs, benefits and electricity system impacts of: demand reduction, DSR, cost-reflective tariffs (e.g. ToU, locational charges), automation, distributed generation for DSR and local matching of supply and demand.

Services customers can provide and their value to market actors

- Demand-side markets which households can participate in: currently only wholesale markets e.g. on Economy 7 (other than trials) – and, only a weak market actor business case to develop customer demand-side actions in the wholesale markets, although there may be greater opportunities in future.

- Development of new approaches to price-discovery for the demand-side, to introduce some visibility and eventual transparency into the kind of demand-side prices / revenues available to customers. In time, customers will wish to start to understand where the main cost-savings and demand-side values exist across different demand-side markets.

- Systematic evaluation and modelling of where the values of demand-side flexibility are likely to be in future (say, 2020, 2025, 2030).

Market actors

- Strong commercial drivers / business case currently lacking for any *single* market actor – both now and possibly in 2020. Particular consideration needed of cost allocations between market actors and impact of socialisation of industry charges.

- Improved industry notification / channels of communication (e.g. between suppliers, DNO, SO and aggregators) – to avoid unintended costs and risks (e.g. imbalance risk) falling on those market actors who may not be aware of DSR activity, including distributed generation, procured for the benefit of other market actors. This will be considered in Ofgem's DSR framework, due late-2014.

- Consideration of the role of new entrants, business-models, supply-chain development, and new partnerships - as part of the development and evolution of demand-side markets.

Enabling policies, regulation and interactions

- Policy silos – joining-up of policy streams for energy efficiency, demand-side and distributed generation. DECC is in the foothills of looking at this[67].

- Inclusion of *specific* measures to promote the electricity demand-side in Green Deal and the Energy Company Obligation.

- Potential for demand reduction to reduce peaks (such as lighting schemes and appliance scrappage – especially refrigeration).

- Affordable household level storage – initially thermal storage, later, potentially battery.

- Consideration of the evolution of retail market models for low-carbon, for flexibility, and the demand side - with customer issues at the core – including affordability and adequate safeguards for vulnerable customers.

- Given the potential for rapid convergence in household DSR between the energy and communications worlds, there is a need for greater co-ordination between different regulators and policy makers. Ofgem, Ofcom, DECC, DCMS & BIS need to lead. Such coordination is presently in its infancy via the UK Regulators Network (UKRN), which covers economic regulators, but not relevant government departments and the ICO[68].

- Consideration of the interaction between electricity demand-side and greater gas/heat efficiency.

Matching of supply and demand locally

- Holistic review of administrative and regulatory arrangements to enable local generators to sell their output to local customers.

[67] DECC 'Opportunities for integrating demand side energy policies'. Syed Ahmed. July 2014.
[68] Sustainability First, Paper 12, 'The household electricity demand-side & participation in the GB electricity markets'.

Consumer issues

- A better understanding of the value customers place on using electricity when they wish, and the trade-offs they would make to pay less. Also, customer appetite to participate in DSR and for cost-reflective tariffs, automation, local matching of supply and demand.

- Strong consumer voice to inform discussions about smart metering, new types of tariff and demand-side services.

Innovation

- Improved co-ordination of innovation funding across the customer-facing demand-side area (DECC, Ofgem, TSB, research councils, other arms of government) - plus improved arrangements for learning the lessons from the many smart trials – and feeding these into policy development and adoption of measures.

It is recommended that DECC and Ofgem explore these issues further. Some are also being taken forward through expert working groups. Sustainability First will also continue to look at a number of these issues.

6 Conclusion and recommendations

Over the course of the GB electricity demand project, we have looked from all angles at what it would mean to have a more active GB demand-side, exploring different questions and developing in-depth knowledge. Below we seek to summarise the main conclusions and headline recommendations for different market actors.

- **The demand-side resource is there –** there is significant 'technical' potential across all sectors to reduce demand (DECC estimates up to 36% by 2020[69]) and to shift load (Sustainability First estimates up to a third[70]). However, a lack of hard data on end-use makes it unclear how much of this customers would be either able or willing to reduce / shift. Further modelling of 'realistic' potential for demand reduction and DSR is therefore needed, drawing on new sources of data on end-use.

- **Technical enablers are being put in place** – with the rollout of smart meters, move to half-hourly settlement and lessons from innovation trials, the main technical enablers for a more active demand-side are being put in place. A critical issue that remains is whether there will be sufficient flexible load available at peak, either via automated control of existing load (e.g. appliances), or new load (e.g. hot water, storage heaters, electric vehicles and heat pumps) or thermal/battery storage.

- **Demand-side markets are developing** – there are already a number of different demand-side markets – suitable particularly for I&C customers but in which 'in principle' householders could also participate, either directly or via aggregators. For customers, price-visibility and price-comparison in these markets will become critical.

- **Industrial customers are already engaged –** industrial customers are already actively reducing their demand and offering DSR services. The focus should be on helping to facilitate this, by concerted efforts to remove barriers – certain changes to I&C DSR schemes (DSBR, capacity, EDR) could make it easier for customers to participate (e.g. notice periods, contract lengths). It is also important to engage the wider commercial buildings sector, and which we have not looked at in detail.

- **Households can help reduce peak load** –. The greatest cost-savings in the electricity system as a whole are likely to stem from peak-avoidance in the wholesale markets – and households are the largest contributor to peak. It is already possible to offer static Time of Use tariffs to households and trials show that many customers shift peak and reduce overall demand. In particular, there is a significant opportunity to encourage on-peak electric users to insulate and to move to off-peak heat. In the longer-term, automation plus changes to the settlement system could enable more dynamic retail tariffs. A question remains on consumer appetite for demand-side engagement, be that via TOU tariffs and / or automation - especially as bill-savings, at least in the near term, seem relatively modest. In addition, all such schemes should remain voluntary.

[69] DECC 'Electricity Demand reduction initial impact assessment' Nov 2012.
[70] Sustainability First, Paper 2, 'GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model: scope for demand reduction and flexible response'.

- **Electricity demand reduction is critical –** improving electricity efficiency and reducing electricity demand **offer the most significant impact on reducing peak load**, making energy more affordable to customers and reducing carbon emissions. EU product standards and labelling will help drive electricity efficiency in the long-term. In the meantime, concerted action is needed to encourage customers to make an early switch to low-energy lighting and to more efficient appliances (especially refrigeration).

- **Consumers need to be empowered and protected** – in a new smarter world, consumers need to have access to the tools to choose tariffs and services that are right for them – including information, advice and tariff comparison tools. The challenge will be to strike a balance between enabling vibrant, entrepreneurial demand-side markets, and ensuring that vulnerable customers are protected.

- **Local and community projects have a key role –** local projects can help build bottom-up commitment, trialling and showcasing initiatives in a manageable way. With more distributed generation there should be a significant opportunity for local generators to sell to local consumers, thereby reducing pressure on the system in particular places. Administrative silos continue to make it hard for suppliers to look at an individual or a community *as a single prosumer entity* – and create strong incentives to 'self-balance'. This needs to be addressed with some urgency.

- **The business case for market actors to develop DSR is currently weak, but will get stronger –** there is currently a lack of strong commercial drivers for any single market actor to engage with DSR, particularly at household scale. The system operator is currently the largest contractor of DSR services from industrial customers for balancing. Distribution networks are also starting to contract more with large customers for constraint and fault management. Suppliers do not play a very active role currently (mainly peak avoidance in the wholesale market) but in future the commercial drivers may be stronger – with half hourly settlement, sharper signals for imbalance, stronger separation of generation and supply, and more wind on the system making wholesale prices more volatile. Suppliers are well placed to take a lead on household DSR – they have a relationship with customers, access to smart meters, and potentially appliances/data (with customer permission). Due to questions of market trust & confidence, new market actors and partnerships may also be needed.

- **Policy and scheme design should start with consumers** – policies and schemes are often designed by groups of government and industry experts. DSR is a prime example. Most consumers would have no idea what DSR is. The consumer voice is lacking in this debate. What do consumers want? Consumer champions can help provide a perspective, but understandably may tend to be cautious to ensure the most vulnerable are safeguarded. It would be helpful to reassess the demand-side policy landscape starting from the point of view of consumers, drawing on lessons from consumer trials, and considering how the viewpoints of different consumers could be more systematically gauged as smart and demand-side policy develops. Evolving retail market models for the demand-side need to allow innovative and entrepreneurial responses to customer needs and wishes.

Recommendations:

Industry

- Share lessons and data from smart metering, demand and innovation trials.
- Continued focus on communications and commercial arrangements for market actors.
- Suppliers start offering basic, voluntary TOU tariffs.

Government

- Take a more holistic view of the customer proposition – bringing together D3 initiatives and support for demand reduction, demand response, energy efficiency, storage and distributed generation in a joined up way.
- Concerted push on lighting efficiency, including through existing schemes.
- Consider a cold-appliance / refrigeration scrappage scheme.
- Target 0.5 million on-peak heated homes with thermal efficiency and off-peak electric heating.
- Assess the impacts of introducing more cost-reflection in supplier pass-through costs.
- Ensure lessons and data from consumer trials funded by customers & tax-payers is available for development of public policy and more widely.

Government & Regulator

- Holistic consideration of local administrative arrangements to enable local matching of supply and demand.
- Government departments and different regulators working together to consider the implications of converging markets and how to regulate them (such as energy and communications).

Regulator

- Develop a clearer view of how retail markets for low-carbon, demand-side and flexibility might evolve in the future.

Consumer champions

- Develop a stronger consumer voice in discussions on DSR, gauge the views of consumers on DSR more systematically, looking particularly at the interests of different customer groups.

Part II

GB Electricity Demand Project Papers 1-12: Short Summaries

GB Electricity Demand project papers – all available at www.sustainabilityfirst.org.uk	
1	**GB Electricity Demand – context and 2010 baseline data.**
2	**GB Electricity Demand 2010 and 2025 – Initial Brattle Demand-Side Model : scope for demand reduction and flexible response.**
3	**What demand-side services could customers offer?** • **Household customers.** • **Industry customers.**
4	**What demand-side services can provide value to the electricity sector?**
5	**The electricity demand-side & wider energy policy developments.**
6	**What demand-side services does Distributed Generation bring to the electricity system?**
7	**Evolution of commercial arrangements for more active customer & consumer involvement in the electricity demand-side.**
8	**Electricity demand and household consumer issues.**
9	**GB Electricity Demand – 2012 and 2025. Impacts of demand reduction and demand shifting on wholesale prices and carbon emissions.** **Results of updated Brattle modelling.**
10	**The electricity demand-side and local energy: how does the electricity system treat 'local'?**
11	**How could electricity demand-side innovation serve the electricity customer in the longer term?** (Joint paper with Frontier Economics).
12	**The household electricity demand-side & participation in the GB electricity markets**
13	**Realising the Resource: GB Electricity Demand Project Overview**

Paper 1. GB electricity demand - context and 2010 baseline data	
Purpose	Understand the role of the demand-side in the GB electricity market today and its potential in future.
Scope	• How demand was met in the GB electricity system in 2010. • Electricity end-use for different customer segments (household, commercial, industrial & public sector), profiles over different time periods, peaks and variability. • Current role of demand-side and policy, regulatory and commercial context.
Approach	• Compilation of baseline GB data in 2010 – using DECC energy statistics (DUKES) and other sources incl. Ofgem and National Grid. • Identification of critical issues from literature review and discussion with market actors.
Findings	• GB demand is currently predictable, expected to be stable to 2020, increasing and becoming less predictable during 2020s (esp. due to electric vehicles, heat pumps). • Household and SME customers make up a third of electricity end-use but form the largest proportion of peak demand. Sustainability First estimates 20-25% of annual household load could be deferrable / flexible. • Industrial and commercial (I&C) customers make-up two-thirds of electricity end-use. They are most likely to provide flexibility services in the near-term. • Only the largest industrial customers - and domestic customers on Economy 7 - presently adapt their consumption. • Current demand-side schemes are run by: - *The system operator* – frequency response and reserve services for Balancing; - *Distribution networks* – improved fault management and constraint management through load management (deferred or avoided network reinforcement); and - *Suppliers* – to offer flexible / time-varying pricing for I&C customers and to support them in TRIAD management/peak avoidance. • National Grid estimates ~2 GW of demand side response at peak to be feasible by 2020 (compared with 300 MW today)[71]. • Customers have high expectations of electricity system security and reliability. Few realise they could adapt their consumption patterns to support system cost-efficiency. • Consumers may be willing to accept interruption of some appliances (e.g. white or pre-set wet appliances) for financial return[72].
Gaps	• Little known about flexibility, despatchability and/or elasticity of either large Industrial or Commercial load. • Lack of transparency of demand-side pricing across different schemes. • Limited evidence of the value consumers place on uninterrupted electricity supplies / lost load, or what trade-offs they would make to pay less.
Recent developments	• New demand-side schemes: electricity demand reduction (EDR) pilot, demand-side response (DSR) eligible for the capacity market, National Grid demand-side balancing reserve (DSBR). • Value of lost load (VOLL) set for capacity market. • See Paper 2 summary for data and Paper 5 for further policy developments.

[71] National Grid 'Operating the Electricity Transmission Networks in 2020 (Update),' Jun 2011.
[72] Mori/University of Cambridge '2010 Electricity Policy Research Group Public Opinion Survey: Policy Preferences and Energy Saving Measures' Aug 2011.

Paper 2. GB electricity demand 2010 and 2025. Brattle End-Use Model	
Purpose	Explore the technical scope for GB electricity demand reduction and flexible response, both today and looking to 2025 through a new Brattle end-use model.
Scope	• Build-up a quantitative picture of GB electricity demand and customer-use today, and use this as a baseline to look ahead to 2025. • Current potential for electricity demand reduction and demand shifting at peak or other times of the day.
Approach	• Develop an end-use model with Brattle Group to explore maximum technical potential for GB electricity demand reduction and flexibility, both today and in 2025. The model disaggregates electrical load by estimated end-use, consumption in different sectors (domestic, commercial, industrial), and time of day in half-hour periods in each calendar month for all sectors of the economy. • Use DECC 2050 Pathways Analysis for scenarios to 2025. • Improve the model over time through critique of the methodology and enabling interested parties to use and adapt it.
Findings	• End-use profiles in different sectors: - *Household* – variability through the day with evening/morning peak, pronounced in winter, flatter curve in summer. - *Commercial* – morning rise, plateau during the day, steady 'coasting down' through the day, no evening peak. Little seasonal variation. Most space heating directly acting. Lighting estimated at 39% of annual load. - *Industrial* – assumed as all residual end-use (i.e. not household or commercial). Flat / gently rising load curve with prolonged evening peak, most marked in winter also with a sharper morning peak. Steady overnight consumption. • Likely sources of electricity end-use flexibility: on-peak electric heat; on-peak electric water heating; cold and wet appliances. In I&C sector there is also potential for greater efficiency or flexibility in: lighting; heating; cooling and ventilation; industrial motors and compressors. • Technical potential for shiftable load today across all sectors is ~18GW of 54GW load on a January weekday winter evening and may be up to ~10 GW of 35 GW load on an August weekend evening – which is about a third of load for both. • Looking ahead to 2025: new load as a result of potential economic growth and electric vehicles; demand reduction from product regulation; new sources of demand-side flexibility from electric vehicles and heat pumps.
Gaps	• **Data** – lack of up-to-date disaggregated demand data across all sectors • No published data on industry end use by subsector or time of day. • DECC and Ofgem need to address how to improve upon present arrangements for sampling, collation and publication of GB electricity demand data and statistics – particularly in the context of smart metering and Low Carbon Networks Fund (LCNF) projects.

Recent developments	• *Household surveys and data:* - Analysis and survey data from the Electricity Demand Research Project[73]; - Energy Saving Trust study of household electricity-using habits[74]; - BRE follow-up survey to the 2010/11 English Housing Survey (EHS) on how energy is used in the home[75]; - Cambridge Architectural Research Ltd and Loughborough University proposal for a National Household Energy Survey using smart meter data[76]; - DECC has developed a National Household Model[77] which will be made available publically in the latter part of 2014; - Series of eleven papers for DECC & DEFRA which analyse in more detail the 2010-11 HEUS data (Household Electricity Usage Study) – including empirically-based data about patterns of UK household electricity-use[78]; - Upcoming Energy Technologies Institute £3 million study on consumer behaviour in heat and energy consumption; - Research Council's TEDDI Projects for technology-led behaviour-change energy efficiency trials[79]; - Centre for Sustainable Energy report for Ofgem on the impact of policies on different archetypal consumers[80]. • *I&C data*: - With half-hourly metering, it should be feasible to develop a better picture of both the industrial and commercial sectors through comprehensive surveys. - Element Energy and DeMontfort University Study for Ofgem on technical potential for demand-side in non-domestic buildings[81]; and - DECC has commissioned a major study of non-domestic energy use to report summer 2015[82]. - Carbon Trust study on the use of industrial smart meter data.

[73] AECOM report for Ofgem 'Energy Demand Research Project: Final Analysis,' Jun 2011.
[74] Energy Saving Trust, DECC and Defra 'Powering the Nation: Household electricity-using habits revealed,' Jun 2012.
[75] BRE for DECC 'Energy Follow-Up Survey 2011 – Report 1: Summary of Findings,' Dec 2013.
[76] Cambridge Architectural Research Ltd and Loughborough University 'The Potential for Smart Meters in a National Household Energy Survey,' Oct 2013.
[77] DECC 'Developing DECC's Evidence Base,' Jan 2014.
[78] Powering the Nation 2 : Electricity Use in Homes, and how to reduce it. A series of eleven papers produced for DECC & DEFRA, by Cambridge Architectural Research Ltd, Loughborough University, Element Energy & Cambridge Energy. April-June 2014.
[79] www.teddinet.org
[80] CSE (Centre for Sustainable Energy). Report for Ofgem 'Beyond Average Consumption'. Beyond average consumption. Development of a framework for assessing impact of policy proposals on different consumer groups. Updated report to Ofgem. March 2014.
[81] Element Energy and DeMontfort University 'Demand response in the non-domestic sector' 2012.
[82] DECC 'Developing DECC's Evidence Base,' Jan 2014.

Paper 3a. What demand side services could customers offer: Households	
Purpose	Understand what household customers could offer in terms of demand response/ reduction.
Scope	• Focus on householder end-use. • What appliances customers have and how they use them. • What the technical potential is for demand reduction and demand-side response (DSR) – which appliances/times of day. • Willingness of customers to provide DSR services and on what basis: incentives required; implications of Time of Use (TOU) tariffs; and role of automation. • Barriers to DSR participation, and whether behaviour change persists.
Approach	• Examine trends in electric heating, hot water heating and appliance usage. • Examine survey data on how customers respond to incentives.
Findings	• Significant scope to shift on-peak (day) electric heating to off-peak (night). • Difficult to link behaviour change to bill impacts. In the Irish trials customers overestimated savings on the bill and lost interest when realising the real savings[83]. • Potential willingness to sign up to direct control of appliances for financial benefit[84]. • There appears to be limited match presently between what contributes to peaks and what customers are willing to shift: peak use is mainly heating, lighting, cooking, TV and consumer electronics; customers are most willing to shift washing machines, tumble driers, dishwashers. • Appliance standards – will help reduce overall load and peak demand. • In future higher cost periods may correspond with high wind. • Automation and load limiting may eventually be valuable for household DSR.
Gaps	• Limited availability of data on appliance use at different times of day. • Empirical data would be helpful on usage patterns of customers with: PV; Economy 7 / storage heaters; electric space/water heating. • Understanding the value customers place on using electricity when they wish and the trade-offs they would make for lower prices.
Recent developments	• Frontier Economics & Sustainability First literature review of major trials covering demand-response in the domestic sector[85], which suggested customers do shift demand in response to economic incentives and automation brings about greatest/most sustained shifts in demand. • Frontier Economics report for Elexon on the impacts of DSR actions[86], suggests impact of householder DSR greatest in wholesale market. • Customer Led Network Revolution (CLNR) project – British Gas/Northern Power Grid - test-cell looking at PV & hot water storage; So La Bristol/Western Power Distribution testing PV with home battery storage. Found very few households, not on Economy 7, who heat their water with electricity. • Consumer focus research on satisfaction of Economy 7 users[87].

[83] Commission for Energy Regulation 'Electricity Smart Metering Customer Behaviour Trials Findings Report,' CER/11/080a, May 2011.
[84] University of Cambridge, '2010 Electricity Policy Research Group Public Opinion Survey: Policy Preferences and Energy Saving Measures,' Jul 2011.
[85] Frontier Economics & Sustainability First for DECC ' Demand side response in the domestic sector – a literature review of major trials,' Aug 2012.
[86] Cross-party impacts of DSR actions. Frontier Economics. A report prepared for Elexon. May 2014.
[87] Consumer Focus 'From devotees to the disengaged: A summary of research into energy consumer' experiences of Time of Use tariffs and Consumer Focus's recommendations,' Oct 2012.

Paper 3b. What demand side services could customers offer: Industry	
Purpose	Explore the potential for unexploited demand flexibility in Industry.
Scope	• Focus on industry demand. • Electricity end-uses in different subsectors today and variations across the day, week/weekend, seasons in 2011. • Technical potential for demand reduction and flexibility now and in future. • Demand-side participation – current schemes, financial incentives, drivers and barriers.
Approach	• Small-scale Sustainability First survey of large industry electricity users - broadly representative across key subsectors: food and drink; paper; chemicals; cement; industrial gases; ceramics; water; and retail.
Findings	• Industry demand profiles tend to be baseload heavy, higher during the day, lower and predictable at night. Some have evening peak; for others peaks cannot be predicted. • Difficult to generalise demand-side potential as processes specific to industry subsectors, but some common to all: running of motors, pumps and fans. • Companies observe good efficiency standards and are willing to carry out energy efficiency improvements for reasonable payback and with minimal disruption. • Companies where electricity is > 10% of overall running costs were more likely to be aware of or already participating demand-side response (DSR) schemes than those where it is <10%. • Industrial customers engage with a range of DSR schemes, including: - *System operator* – frequency response and reserve services for Balancing such as Short-Term Operating Reserve (STOR); - *Suppliers* - TRIAD management, voluntary load management; and - *Distribution networks* – DUOS banding. • Some companies used brokers or aggregators; others had in-house expertise. • Self-generation (e.g. combined heat and power, diesel) is mainly to meet baseload requirements with any excess exported to the grid. But many companies use this back-up generation in order to offer DSR services. • Issues affecting DSR participation include: financial incentives/payback; lack of price visibility; impact on manufacturing process; ability to automate; risk appetite; impact of the recession. For STOR the lengthy time period (2 to 3 months) between tendering and provision of DSR is difficult for companies – framework contracts might be better. • The Government Procurement Service (GPS) has significant potential to participate actively in DSR, but specific issues would need to be addressed.
Gaps	• No published or disaggregated data on industry end-use, by time of day or across the year, making it difficult to estimate how much load is shift-able.
Recent developments	• Quantitative analysis by DECC on I&C demand for summer 2015. • Government Procurement Service framework agreement with aggregators • The aggregation market is established in Balancing services. • Short Term Operating Reserve (STOR) has over-capacity. • TRIAD management becoming more risky – everyone tries to avoid the peaks, which changes the shape, making it harder to predict peaks. • Opportunity to participate in new schemes: electricity demand reduction (EDR) pilot but timescales tight, demand-side response (DSR) in the capacity market, National Grid demand-side balancing reserve (DSBR). • Difficult to know which scheme is best, if have to choose between.

Paper 4. What demand-side services can provide value to the electricity sector	
Purpose	Consider how customers might provide demand-side response services to market actors.
Scope	• Value of demand side response (DSR) to market actors and customers today. • What DSR services market actors already procure. • Issues for market actors in realising DSR potential.
Approach	• Discussions with market actors – including system operator, suppliers, distribution networks, settlement agent, aggregators and power exchange.
Findings	• Modest DSR contribution today ~1-1.5GW against generation capacity of ~80GW. • Value of DSR to market actors and current schemes: - *System operator* – contracts the most DSR today ~ £383m for balancing services including for frequency response, fast reserve, short-term operating reserve (STOR) and system security. True demand side services are ~200MW, remainder is on-site back-up generation. - *Suppliers* – undertake relatively little activity, mainly flexible contracts with industrial and commercial (I&C) customers to avoid peak usage and TRIAD periods. But, in principle, there should be value from avoided costs for new generation, wholesale procurement and network charges. - *Distribution networks* – actively exploring DSR to: manage constraints & losses by avoiding capital costs, improved fault management and automated load management, incl. direct contracts with I&C for avoided network reinforcement; Economy 7 load switching; half hourly settled customers winter peak avoidance; innovation trials. **Distribution network benefits are location specific**. DNOs expect to deal with uncertain volumes and locations of loads (e.g. electric vehicles, heat pumps, microgeneration). Possible range value £40-£60/kW/pa. • Suppliers have lead role with customers but few commercial drivers; DNOs have reasons to promote DSR, but lack interface with customers and offer limited value. • Issues in realising DSR potential today: lack of individual incentive when charges socialised; poor alignment of incentives for suppliers; lack of price visibility and transparency; possible need for half-hourly settlement for dynamic tariffs, a general risk-aversion leading to pre-disposition toward generation (e.g. asymmetric imbalance costs); the fit of customer load characteristics with market actor requirements (e.g. response time, location, reliability). • In future, substantial shift-able load is needed for automation, e.g. electric vehicles, heat pumps & thermal storage. Smart meters will help suppliers develop new offerings.
Gaps	• Systematic approach to analyse DSR avoided-cost values and comparing costs/ benefits with other flexibility options e.g. generation, storage, interconnection[88].
Recent developments	• *System operator* – new demand-side balancing reserve (DSBR). • *Supplier* – lack of business case except for market differentiation. Competition review may take up time / reduce appetite for innovation. • *Distribution networks* – LCNF projects beginning to test commercial arrangements for constraint management at local hotspots. • *Government* – DSR opportunities within capacity market. Current D3 project to look at any supply-side bias and how to join up/develop policies to enable D3[89]. • *Consultant studies* - Future system benefits of DSR[90]; value of flexibility[91]; Frontier report for Elexon on demand-side value[92].

[88] A need to update & extend earlier Redpoint, Baringa, Element Energy analysis. August 2012.
[89] DECC 'Opportunities for integrating demand side energy policies' July 2014.
[90] Redpoint, Baringa & Element Energy 'Electricity System Analysis: future system benefits from selected DSR scenarios,' Aug 2012.
[91] Poyry 'Revealing the value of flexibility: How can flexible capability be rewarded in the electricity markets of the future?' 2014.
[92] Cross-party impacts of DSR actions. Frontier Economics. A report prepared for Elexon. May 2014.

Paper 5. The electricity demand-side and wider policy developments	
Purpose	Explore the interactions of policy and regulation with the demand side.
Scope	• Implications of different policy initiatives for delivery of electricity demand reduction and response. • Focuses on: overarching targets; the role of price; smart metering; electricity market reform; energy efficiency initiatives such as the Energy Company Obligation (ECO), Green Deal and Carbon Reduction Commitment (CRC); microgeneration and heat; electric vehicles; smarter markets; and EU Directives on energy efficiency and eco-design. • Price impacts of various policies. • Impact on certain customers of demand-side initiatives.
Approach	• Desk-based research, literature review and discussion with market actors.
Findings	• Factors likely to encourage demand reduction and response: more cost-reflective electricity prices; product efficiency standards and appliance features (e.g. remote automation); potential flexible demand (e.g. heat pumps, electric vehicles); types of retail tariffs/offerings; payment for demand response services from networks and system operator; and customer on-site generation. • Price effects – rising wholesale and network costs and environmental policies will increase electricity prices in the short to medium term and should increase the incentive for demand reduction. In the longer term, prices may fall due to low carbon generation increasingly setting the average wholesale price. Demand response value will increase as both balancing and capacity costs increase. • Recommend that Government actively promotes electricity-specific demand-side measures through a more joined up approach to existing policy.
Gaps	• Better understanding of which costs can be avoided in the electricity system and when, from which end-use demand reduction measures. • Joined-up focus by government on demand-side opportunities, how these fit with existing policies (e.g. energy efficiency; microgeneration/storage) and whether new policies are required. • How to use smart metering data for public policy.
Recent developments	• *Demand-side* – inclusion of DSR in capacity market[93] and electricity demand reduction pilot (2-years 2014-16, £20m). DECC undertaking internal work to look across policies at how demand-side is treated[94]. • *Energy efficiency* – energy efficiency strategy[95] and focus on how to increase uptake of Green Deal. Energy Company Obligation II[96]. Carbon Reduction Commitment review. • *Ofgem Smarter Markets Programme* – proposed DSR Framework to set out the relations and market arrangements between market actors due Sept 2014. • *Smart metering and grids* – timescale for delivering smart meters extended to 2020. DECC/Ofgem Smart Grid Forum has developed a Vision and Routemap[97] - mainly distribution-focused not transmission. End-to-end forward view / vision also

[93] DECC 'Electricity Market Reform: Capacity Market – Detailed Design Proposals,' Jun 2013
[94] DECC 'Opportunities for integrating demand side energy policies'. Syed Ahmed. July 2014.
[95] DECC 'The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK,' Nov 2012.
[96] DECC 'The Future of the Energy Company Obligation: Consultation' 2014.
[97] DECC & Ofgem Smart Grid Forum 'Smart Grid Vision and Routemap,' Feb 2014.

	needed. • *Wholesale market* – Reviews of liquidity, cash-out & future trading arrangements. Opposition proposals for 'electricity pool' [98]. • *Retail market* – retail market review[99] tariff arrangements and consumer empowerment. CMA energy market investigation. • *Energy security* - DECC/Ofgem security of supply report[100] & Ofgem Capacity Assessment 2013[101] suggests tightening in winter 2015/16. National Grid proposal for demand-side and supplemental balancing reserve. • *Distributed generation & heat:* Community Energy Strategy[102] – extension of Feed in Tariff (FiT) to 10MW for community schemes. PV strategy[103]. Heat strategy[104].

[98] Labour Party 'Powering Britain: One Nation Labour's plans to reset the energy market,' Nov 2013.
[99] Ofgem 'Retail Market Review – Implementation of Simpler Tariff Choices and Clearer Information' Aug 2013.
[100] DECC & Ofgem 'Statutory Security of Supply Report,' November 2012.
[101] Ofgem Electricity Capacity Assessment Report 2013. 105/13. 27 June 2013. https://www.ofgem.gov.uk/ofgem-publications/75232/electricity-capacity-assessment-report-2013.pdf
[102] DECC 'Community energy strategy: people powering change,' Jan 2014.
[103] DECC 'UK Solar PV Strategy Part 1: Roadmap to a Brighter Future,' Oct 2013.
[104] DECC 'The Future of Heating: A strategic framework for low carbon heat in the UK,' Mar 2012.

Paper 6. What demand services does distributed generation bring to the electricity system? (with Lower Watts Consulting)	
Purpose	Understand role of distributed generation (DG) in the GB demand-side picture.
Scope	• DG defined as plant not connected to the transmission network. • Role of DG in today's GB electricity system and potential over the next 10-15 years. • Technical and commercial issues and challenges.
Approach	• Desk-based research, literature review and discussions with market actors, jointly with Stephen Andrews, Lower Watts Consulting.
Findings	• DG actively participates in demand-side services to the balancing mechanism including contracts for Short Term Operating Reserve (STOR). • Current incentive schemes fixed Feed in Tariff (FiT) (<5MW) and Renewable Obligation Certificates (ROCs) (>50kW) have no Time of Use (TOU) component. • Dispatchable DG such as hydro, gas fired Combined Heat and Power (CHP) and back-up diesel generators could contribute to ancillary services. • Report for former DTI[105] on realistic opportunities for DG: TSO frequency response; TSO regulating & standing reserve; and DNO security of supply. • RWE npower LSE study[106] suggests 17 GW of installed standby generation in the UK, other sources suggest volumes of back-up diesel generation available for DSR may be rather less in practice. • Currently renewable generation incentivised to maximise export and income from subsidies. Locational advantage from avoided transmission charges. Access to Power Purchase Agreements (PPAs). • Levels of DG expected to increase in future.
Gaps	• Need for comprehensive DG database and comprehensive study of amount / location of standby generation and suitability to offer demand-side services. • Commercial frameworks - interactions and notification between system operator, distribution networks and other actors in the context of greater levels of DG. • Costs/benefits and especially carbon implications of using back-up diesel DG for demand-side services. • Recognition of TOU in FiT.
Recent developments	• Community energy strategy[107] - Fixed FiT threshold increased to 10MW for community schemes. High uptake of PV. • NG review of embedded benefit for DG requested by Ofgem [108] – decision not to change present arrangements at present. • Little progress on bringing together DG data. • Some distribution networks starting to work with local government to ensure early notification of new development through planning process – e.g. UKPN and GLA.

[105] DTI 'Ancillary service provision from distributed generation,' 2004.
[106] RWE npower LSE 'Demanding times for Energy in the UK,' Nov 2011.
[107] DECC 'Community energy strategy,' Jan 2014.
[108] National Grid 'Review of the Embedded (Distributed) Generation Benefit arising from transmission charges,' December 2013.

Paper 7. Evolution of commercial arrangements for more active customer and consumer involvement in the electricity demand-side.	
Purpose	Understand commercial arrangements needed to enable demand-side participation.
Scope	• How to signal underlying supply-side costs in the GB electricity market, e.g. Time of Use (TOU), to retail customers and microgenerators • Commercial drivers/barriers to ToU tariffs & timeline of key enablers. • Options for a ToU element to the Feed-in Tariff (FiT) • Paper does not cover locational signals, storage or renewable heat.
Approach	• Case studies: (1) Distribution network location specific DSR; (2) Balancing system demand turn down; (3) Static household ToU tariff incentivising load shifting & reduction; and (4) Small-scale PV and DSR interaction.
Findings	• Role of ToU for different customers: - *Industrial and commercial sector* – ToU already available to half-hourly settled/larger customers & larger distributed generators. Some non half-hourly business customers can participate in balancing/peak avoidance schemes. - *Households* – it is already feasible to offer basic static ToU tariffs with a two-rate meter & billing IT. But also need to consider peak period *demand reduction*, 'demand-matching' and/or storage of PV output. - *FiT customers* – costs of imbalance (i.e. supplier under- or over-contracted in wholesale markets) due to unmetered 'spill' may become problematic in the long-run (but not today). It may not prove practical or economically viable to introduce time-varying payments under the FiT. PV output has a relatively weak correlation with times of high/low customer load so focus may be on household 'self-balancing' using thermal storage (hot water, storage heaters), low-cost batteries, or local ToU tariffs to encourage near-neighbour use. • Incentives for market actors to offer ToU tariffs: - *Suppliers* - weak incentives to offer ToU tariffs voluntarily other than for market differentiation today, but smart meters should enable more ToU offers. In future, with *both* smart meters and half-hourly settlement it will be possible for suppliers to develop more sophisticated / dynamic tariffs such as Critical Peak Pricing (CPP), household TRIAD and wind-twinning. - *Distribution networks* – innovation trials. High impact of PV in-terms of estimating on-site use, metered export & unmetered spill.
Gaps	• Need improved industry notification / channels of communication. • Commercial barriers & policy silos inhibit development of active 'prosumers'. • Need to consider consumer issues and willingness to accept ToU tariffs.
Recent developments	• ENA work on interactions across parties & framework for sharing DSR benefit[109]. • CLNR trial found 60% customers saved, 40% paid more on basic ToU[110]. • DECC considering what benefits from ToU are enabled through smart meters[111]. • Ofgem plans to follow smart meter rollout with universal half-hourly settlement[112]. • Smart Grid Forum Work Stream 6 looking at options, commercial arrangements and barriers for consumers to participate in a future smart grid[113]. • Consumer Focus report on experiences of ToU consumers (e.g. Economy 7 and 10). Found lower satisfaction for those with storage heaters than gas central heating[114].

[109] ENA 'Demand-side response shared services framework concept paper,' Apr 2014.
[110] Customer-Led Network Revolution (CLNR) Project, 'Progress Report 7' Annex 6, July 2014.
[111] Through the Smart Meter B
enefits Review Group.
[112] Ofgem 'Electricity settlement reform – moving to half-hourly settlement,' Apr 2014.
[113] Ofgem. Smart Grid Forum Work Stream 6. DSR Options paper. April 2014
[114] Consumer Focus 'From devotees to the disengaged: A summary of research into energy consumer' experiences of Time of Use tariffs and Consumer Focus's recommendations,' Oct 2012.

Paper 8. Electricity Demand and Household Consumer Issues	
Purpose	Consider household consumer issues in developing the electricity demand-side.
Scope	• Household sector only. • Demand-side response (DSR) only. • Costs and benefits of DSR and implications for different customers. • Issues for three main DSR offers: static time of use (ToU) tariff, critical peak pricing (CCP) and direct load control (DLC).
Approach	• Desk-based research, qualitative analysis.
Findings	• Benefits of DSR as outlined by Redpoint Energy/Baringa/Element Energy[1] include: avoided generation capacity; not reinforcing the distribution network; and operational savings. They estimate a benefit of £7.50 per customer who takes up DSR (with 2 million take up) in 2015. Savings could be higher in future, but would vary considerably based on the type of tariff. • Cost items associated with development of DSR to: - *Households* – upgrading smart appliances; retrofitting control devices; time and inconvenience; risk of not making financial savings. - *Suppliers* – changes to billing systems; developing & marketing DSR tariffs. Reduced revenue if demand shifted to low-priced periods, and if own generation. - *Distribution networks* – operational and capital costs to redesign parts of the network to facilitate DSR. Networks can recover revenue to a cap. • Voluntary versus universal ToU tariffs: - *Voluntary* – customer choice, but those with peaky demand/large loads less likely to choose ToU tariff. **If only those with non-peaky demand participate, the tariffs will not deliver value.** - *Universal* - everyone pays based on costs they impose on the system but this would create winners and losers and may result in consumer backlash. • Automation may provide benefits to households, but need to consider willingness to accept and ability to over-ride. • Pre-2020 focus should be on trialling tariffs rather than large-scale rollout of DSR. • DSR tariffs likely to be most appropriate for households with electric vehicles, heat pumps and solar PV. • Extra protections will be needed for vulnerable customers. • Costs and risks of introducing static ToU tariffs could negate benefits, but there is likely to be more value in CPP or DLC.
Gaps	• The consumer proposition – what they want and are willing to accept. • Consumer input to the development of DSR services. • No-one has quantified the **costs** of DSR. • Distributional impacts of cost-reflective tariffs – e.g. unwinding of cross-subsidies. • Gaps in consumer protections. • Issues for dual-fuel and gas smart markets. • Potential for affordable household level storage.
Recent developments	• Ofgem Smarter Markets Programme – has brought together work on retail markets, demand-side, consumer empowerment and protection. • Retail market – Retail Market Review & competition assessment. • See Paper 2 summary for recent household surveys, and Paper 5 for policy update.

Paper 9. GB electricity demand – 2012 and 2025: impacts of demand reduction and demand shifting on wholesale price and carbon emissions. Updated Brattle Modelling.	
Purpose	Investigate the likely impacts on wholesale prices and carbon emissions of assumed levels of demand reduction and shifting in the GB electricity market through updated Brattle modelling.
Scope	• Realistic demand-side potential – reduction and shifting. • Model of end-use demand by sector (domestic, commercial and industrial) and usage within those sectors (heating, lighting, hot water, appliances etc. • Model of electricity wholesale market dispatch. • Does not consider network perspective.
Approach	• Uses the model developed by the Brattle Group for Sustainability First. • Takes into account updated data from Elexon, DECC and National Grid and new data, including: - *Household Electricity Survey* [115] – the DECC, Defra and EST project involved monitoring of end-use electricity demand in 251 households (only 25 were monitored for a whole year, the rest for one-month periods through the year); - *Demand-side response in the non-domestic sector* [116] – undertaken by Element Energy and DeMontfort University for Ofgem, this includes 24-hour estimated demand profiles for non-domestic sub-sectors and a break down of their end-use.
Findings	• Modelling results: - *Before 2020* - winter peak demand load continues to drive wholesale electricity costs **and** prices. Most carbon reduction will be achieved in the summer months. Need to better align load with low carbon generation, e.g. with electric vehicles, heat pumps and storage heaters. Static time of use (ToU) tariffs may support cost efficiency, but the practicality of implementing them at scale before 2020, pre smart-meters, may be limited. - *After 2020* – wind and other low carbon generation starts to determine wholesale prices at times of low demand. Prices generators offer to the wholesale market will reflect the low carbon and capacity incentives they get. Winter evenings may no longer be the highest priced period as low wind can occur at any time. Post 2020 incentives for networks and suppliers to reduce peak-loads may diverge somewhat: with network costs driven by evening peaks; supply focus on wholesale price variability through the day. • Retail tariff initiatives such as wind-twinning and other measures to support dynamic tariffs such as customer and grid level storage and flexible load could be useful to support efficiency in the electricity wholesale market for suppliers. Dynamic critical peak pricing tariffs could be relevant both for capacity support and / or to the networks, but half-hourly settlement would be needed. Automation may be required.
Gaps	• Lack of empirical data on electricity end-use by process, appliance and time of day. Particular lack of disaggregated data for industry. • Poor understanding of the growing impacts of wholesale prices increasingly tending to short-run prices in the future, and so potentially creating weak price signals by which to encourage DSR as an alternative to investment (generation, networks).
Recent developments	• For new data sources see Paper 2 summary.

[115] EST, DECC & Defra 'Household Electricity Survey – A study of domestic electricity product usage', May 2012.
[116] Element Energy & DeMontfort University for Ofgem 'Demand-side response in the non-domestic sector,' 2012.

Paper 10. The electricity demand-side and local energy: how does the electricity system treat 'local'?	
Purpose	Consider how the electricity demand side could play a more active role at a local level and how to match local generation and local electricity customers.
Scope	• Role of location and locational match in the electricity system. • Underlying commercial and regulatory areas to be tackled before a local GB demand-side can be realised at scale. • What local means to different market actors. • Consumer issues in a more localised electricity world.
Approach	• Desk based research, literature review. • Six local and community electricity demand-side case studies.
Findings	• Enabling steps to improve the local match of supply and generation: smart meters; half-hourly data recording; possible half-hourly settlement for some forms of local retail tariff ; data management; flexible load; automated load; retail tariffs incentivise flexibility; customers engaged at scale; and appropriate consumer safeguards. • To achieve an efficient system overall – need to find ways to combine incentives for time-of-day / varying wholesale prices – **plus the costs & benefits of location**. • How local is treated by different market actors: - *Suppliers* – developing interest in DSR but largely neutral to location. - *Distribution networks* – there is value in actively promoting peak-related 'firm' demand-side management at particular locations. Locational costs & benefits are factored in for larger distributed generation (DG) and large/existing loads, but not for smaller generators or new loads. Demand-side benefits only captured through ad-hoc bilateral agreement. Explicit local signals could be achieved through: greater transparency of network charges on end-bills; possible connection charges for microgeneration post 2023 in RIIO-ED2; possible capacity component to distribution charges for large and / or new loads. - *Transmission networks* – already flag locational inefficiency via charges with some success through TRIAD response, which could serve both national demand-side interests as well as local constraint management. - *System operator* – needs more granular information about the location, output and dispatchability of DG to avoid unnecessary balancing costs. • Explicit local signals may be controversial, as some customers may be unable to respond with flexible demand actions. Capacity charges may be worth exploring. • Role of low-cost storage needs exploring (probably household thermal storage initially) as a cost-efficient buffer in local balancing. • Sense of community ownership. Local balancing esp. in isolated communities.
Gaps	• Holistic review of administrative and regulatory arrangements to enable local generators to sell their output to local customers. • Costs, benefits and consumer impacts of local matching of supply and generation. • Role of local authorities or other local actors in DSR and local balancing.
Recent developments	• DECC Community Energy Strategy[117] fund demand-side projects + 'Licence Lite'. • PV strategy looked at challenges of balancing and potential for innovation[118]. • Smart Grid Forum Work Stream 6 - regulatory and commercial issues for facilitating DSR in the Distribution Networks. • Electricity Networks Strategy Group - distribution-transmission boundary issues. • ENA paper on contractual arrangements for sharing DSR benefits[119].

[117] DECC 'Community energy strategy: people powering change,' Jan 2014.
[118] DECC 'UK Solar PV Strategy Part 2: Delivering a Brighter Future,' Apr 2014.
[119] ENA 'Demand-side response shared services framework concept paper,' Apr 2014.

Paper 11. How could electricity demand-side innovation serve the electricity customer in the longer-term? (with Frontier Economics).	
Purpose	Considers how electricity demand-side innovation could best serve customers long-term.
Scope	• Particular focus on households. • Present approaches to demand-side innovation funding. • Opportunities for customer-serving innovation – e.g. automated control & small-scale thermal storage, major gaps and challenges.
Approach	• Desk-based research and discussion with market actors (incl. distribution networks, suppliers, aggregator, trade body, product developers, DECC & Ofgem)
Findings	• Essential regulatory steps: network innovation (e.g. Low Carbon Network (LCN) Fund and Network Innovation Competition) and smart meter rollout. • Barriers to innovation: knowledge spill over /dispersed benefits; risk aversion; long payback periods; inadequate knowledge networks; technology lock-in; diversity of interests across value chain; capital constraints; and skills gaps. • LCN Fund provides early lessons on demand-side innovation and encourages networks to prepare for low carbon transition – has fostered collaboration, culture change and value for money (£2/customer/year). Flexible intellectual property means knowledge sharing, but still questions on data usability & whether results are "warts and all". Apparent bias toward technology innovation. Difficult to develop projects across full value chain, as requires outside funding. • TSB funding helpful for smaller innovators and consumer-facing initiatives. • Lack of householder pull for demand-side technology. Heat pump and electric vehicle take up is lower than expected. Smart meters meant to catalyse services. • Examples of consumer serving innovation - *Remotely automated control* – opportunity for 'prosumers'. Need to combine demand-side and energy efficiency (e.g. energy management systems). In future, powerful mix of wireless communication, computing power to process consumer data, digital control & sensors could transform the market. But this is some way off – after smart meters, auxiliary load control switches, consumer access devices (CADs) – and requires controllable sources of load. Appetite for automation may follow-on from voluntary ToU tariffs. - *Thermal storage* – shift demand for heating and hot water to times when electricity cheaper. High levels of insulation required. Today could: shift 560,000 people from on- to off- peak electric heating with storage heaters; link PV to hot water tank storage. In future, water tanks and storage heaters could respond to fluctuations in wholesale prices/wind matching. • For automation and thermal storage, there are opportunities today and greater potential in future with smart systems, new equipment and communications. But there are costs involved and no real drive, business case or clear incentives.
Gaps	• Coordination of customer-facing innovation funding streams & better knowledge of 'funding gaps'. • Joined-up policy – energy efficiency, demand side and distributed generation. • Practical demonstration of demand-side end-to-end across the value chain. • Costs/benefits of household DSR, automated control & storage heating in 2020s. • Understanding of which automated appliances best placed to provide which services & where greatest value lies. • Individual market actor business case for household DSR. • Lack of 'forward view' for the supply chain of likely timeline & dependencies for development of customer-facing innovative products and services.
Recent developments	• LCICG and Ofgem beginning to address coordination of innovation funding streams and distilling thematic lessons from funded projects.

Paper 12. The household electricity demand-side & participation in the GB electricity markets.	
Purpose	Understand the opportunities and barriers for household electricity demand-side participation in GB electricity markets today and in future. Understand the key issues for the 'smart consumer' of demand-side developments in the retail markets – including customer safeguards.
Scope	• How & when households might participate in the evolving GB electricity demand-side markets. • Where demand-side value might lie, both for market actors and for consumers – and how to access this. • 'Routes to market' for household demand-side services and barriers. • What a 'smart consumer' means in practice. • Consumer empowerment and protection, through a competitive market / regulation. • Which future retail market models might serve customers best, including those who participate in the demand-side and those who do not.
Approach	• Stakeholder roundtable discussion and desk-based research.
Findings	• By the 2020's, the biggest *overall* benefit to the electricity system from household demand-side actions will be from day-in, day-out peak-avoidance, load smoothing & price-matching in the wholesale markets (& capacity markets) rather than from network savings and / or balancing. However, at constrained places on the networks, or in terms of providing specialized balancing services, higher individual demand-side 'rewards' may be available to the individual customer. • Suppliers will be well placed to enable householders to make demand-side offers with the rollout of smart meters and related technical 'enablers' for demand management by 2020. On the same timescale, suppliers will also start to face increasing risk (imbalance, accurate settlement, greater separation of generation & supply) which may lead them to see the household demand-side as a viable commercial strategy / 'hedge'. However, controllable household load would need to be available at scale (i.e. electric heat, storage heaters & hot-water storage, heat pumps, electric vehicles). • Ofgem's DSR Framework needs to recognise the pivotal role of suppliers in the household smart meter arrangements and what this means for fair access to end-customers for other actors. • Local energy schemes are where personal energy, drive and commitment sit to transform the energy sector to low-carbon. Community schemes can be important show-cases & test-beds to drive forward the demand-side and to break down institutional and administrative barriers. • Demand reduction critical to achieving customer cost savings and can make a significant contribution to peak avoidance through product standards and scrappage (e.g. white goods).
Gaps	• The paper recommends consideration of a number of issues by different market actors: - *Regulator* – approaches to retail market models for DSR & DSM; metrics for market health; criteria to assess moves to greater cost reflectivity in DSR offers; how to compare basic DSR offers and ensure consumers have adequate information; early development of regulatory backstops; and applying a 'principles-based' approach to regulation of smarter retail markets. - *Government* – clear hierarchy of priorities for policy and regulatory focus as between energy efficiency, electricity demand reduction and DSR. With the regulator, encouraging a strong consumer voice in the development of DSR and consulting early on education and information requirements. Need for greater co-ordination between different regulators and policy makers to safeguard

	customers, especially the vulnerable, in a smart world. - *Market actors* - consumer engagement and mechanisms to ensure that consumers and company interests are aligned – so that customers provide firm response in return for a dependable, efficient and trusted service. Need for better information sharing between market actors.
Recent developments	• Ofgem Consumer Empowerment & Protection in Smarter Markets: Updated Work Programme. (Sept 2014). Notes that Ofgem will consider impact of RMR on ToU tariffs – & brings forward plans to consider 'advanced DSR' • Ofgem Work Stream 6 Consumer Sub-Group - exploring the detail of consumer issues & the smart grid. • Present uncertainty surrounding a post RMR-world, plus the CMA energy market investigation, may dampen enthusiasm among some suppliers for entering the DSR space in the near-term.

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