GB electricity demand – *realising the resource*

This document gives an overview of the potential contribution of the 'demand-side' in GB electricity markets today and in future, as well as the steps needed to realise this resource. It summarises the findings and recommendations of a three-year multi-partner project led by Sustainability First on GB Electricity Demand. See ***www.sustainabilityfirst.org.uk*** *- for full details of the project and to read our 13 in-depth project papers. Sustainability First is a UK environment think-tank and registered charity with a focus on practical policy development in the areas of sustainable energy, waste and water.*

What is the 'demand-side'?

Shift, reduce or increase demand on the electricity system

When we use the term 'demand-side', we mean activities to shift, reduce or increase demand on the electricity system. This includes permanent reductions in electricity use – 'demand reduction' – as well as changes in use for set periods of time – 'demand-side response' (DSR). These actions could be undertaken by households, industrial and commercial (I&C) customers or distributed generators, and could be achieved, for example, by shifting, reducing or increasing the use of: lights; appliances; heating, ventilation and air-conditioning (HVAC); fridges / freezers; back-up or distributed generation; pumps / motors / compressors; and / or other manufacturing processes. In future electric vehicles and heat pumps could offer new sources of end-use flexibility. We need flexibility to assure a more cost efficient and environmentally friendly future electricity system.

What do we know about electricity use today?

There are approximately 27 million household electricity customers, which is over 90% of all electricity customers. But household customers only consume one third of annual electricity by volume, with industrial and commercial customers consuming the remaining two thirds (see **Figure 1**).

10% of customers use two thirds of annual electricity by volume

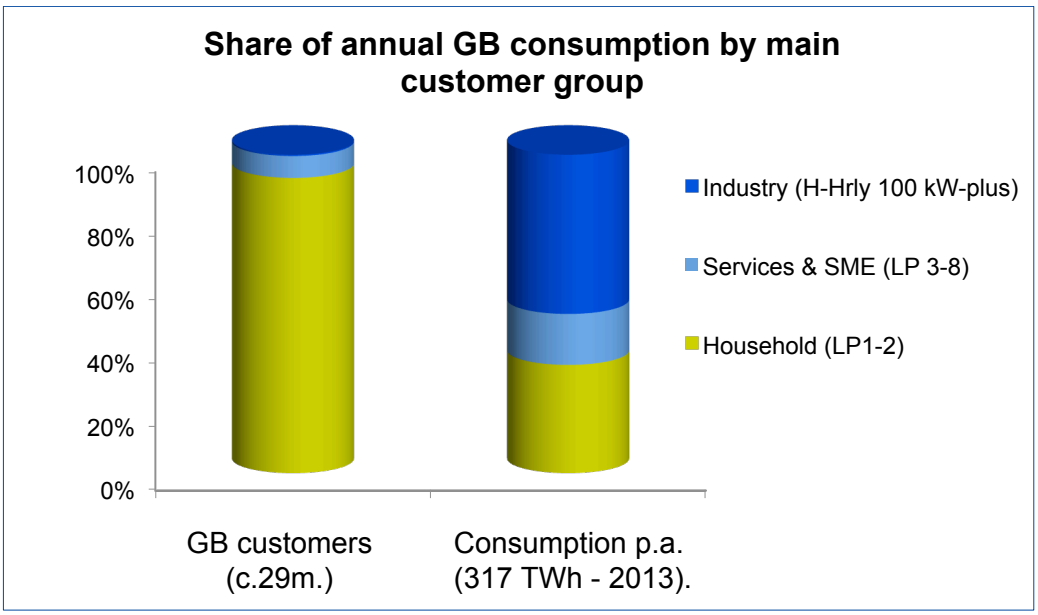

Figure 1: Share of annual GB consumption by main customer groups – industry, services/small & medium-sized enterprises, and households. Source: Sustainability First.

Households make up about a half of total evening peak load

To understand electricity use – it is important to look at variations over the day, week, month and year. We have modelled generic GB household electricity load for a typical day by month for weekdays and weekends (see **Figure 2**). This shows that throughout the year there are distinctive morning and evening peaks, which are more pronounced in the winter months. Households make a significant contribution to total evening peak in winter and summer – around one-half.

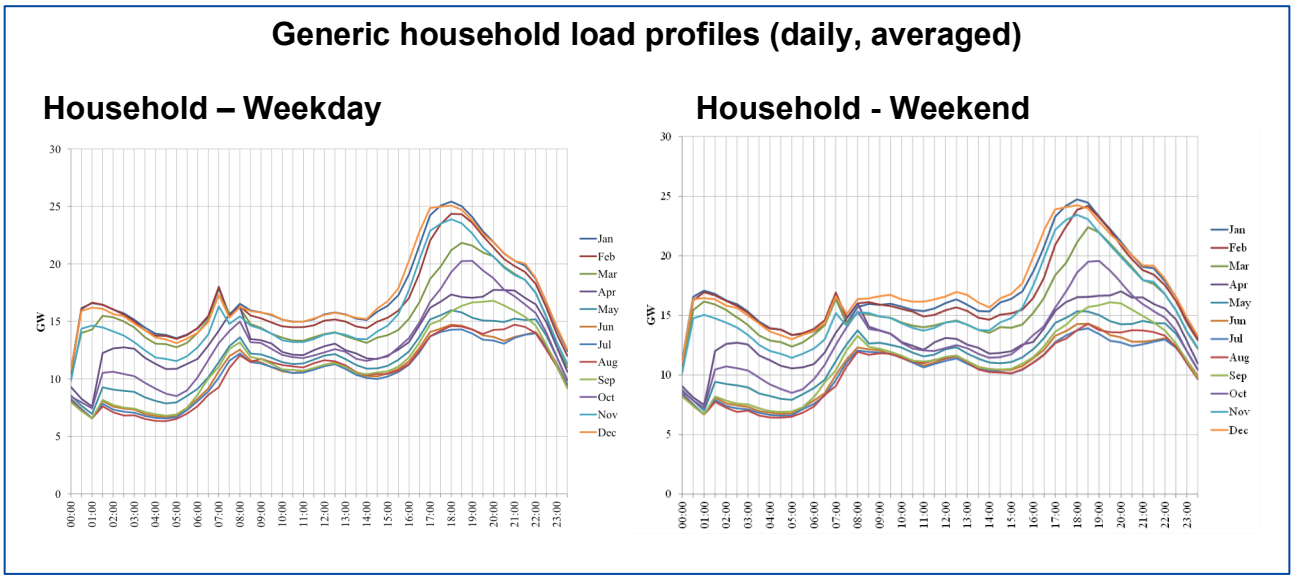

Figure 2: Generic household daily load profiles by month, for a weekday and weekend. Source: Brattle Model, Sustainability First Paper 2.

Industrial daily load is fairly flat, commercial load is high during the working day

We also modelled the GB daily load profiles for industry and commercial customers by month for a weekday (see **Figure 3**). These show a more steady increase in demand during the morning and plateaux during the day, with sustained demand into the night in the industrial sector and a drop off in the evening for the commercial sector.

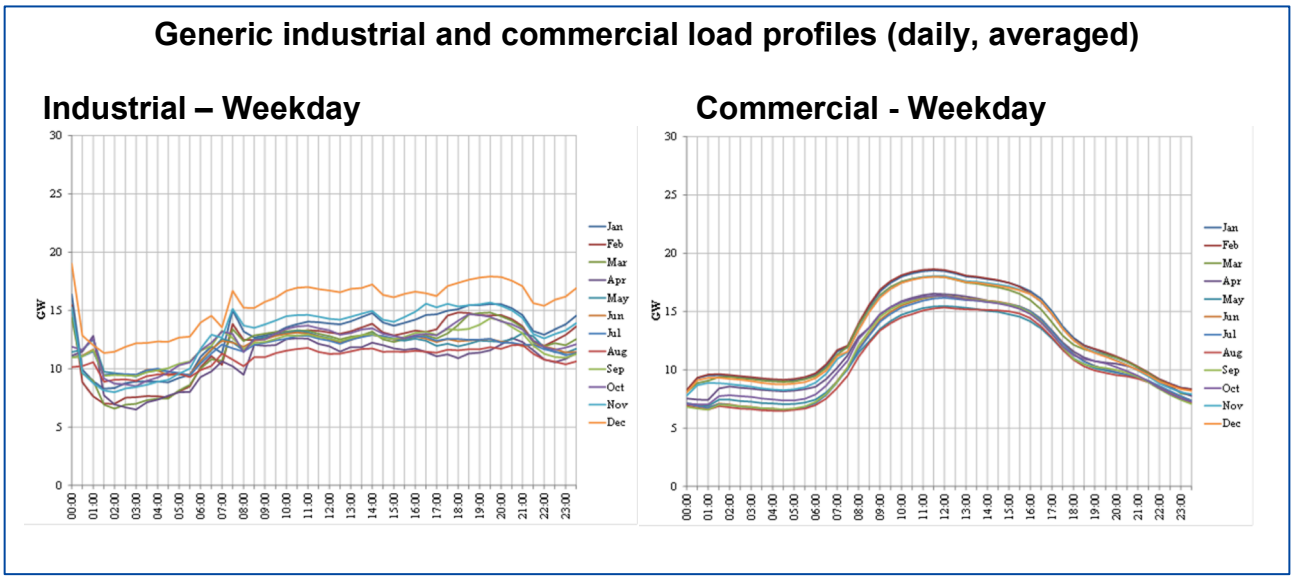

Figure 3: Generic industrial and commercial daily load profiles by month for a weekday. Source: Brattle Model, Sustainability First Paper 2.

Next it is important to understand which electricity-using activities contribute to daily load. **Figure 4** gives an all-sector picture of estimated daily electricity end-use during a winter weekday and summer weekend. This shows that lighting load is significant year-round during the day and night. Lights and 'on-peak' space heating dominate during the winter peak.

Lights and 'on-peak' heating dominate winter peak load

Lighting load is significant year-round

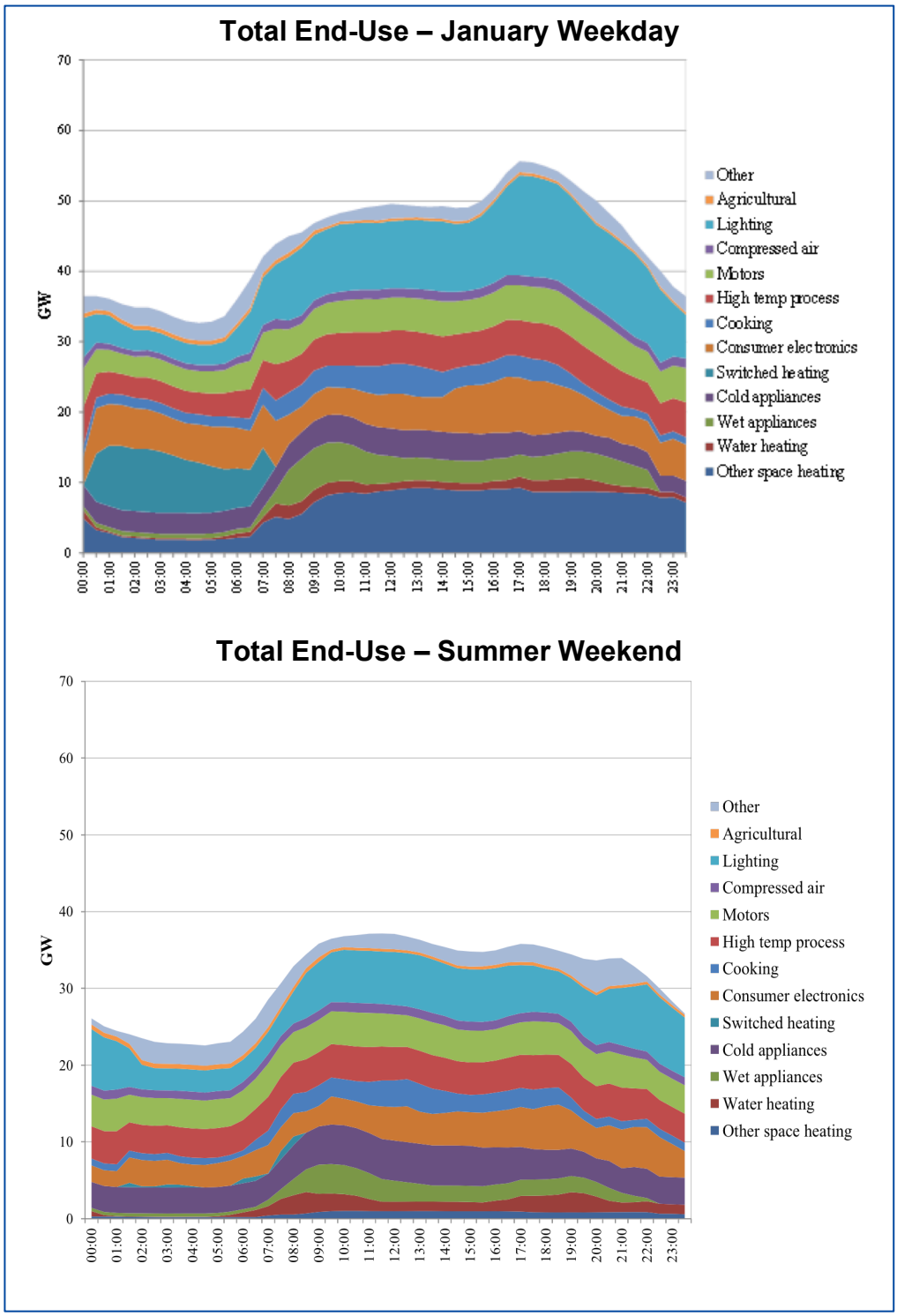

Figure 4: Estimated daily electricity end-use for all sectors during a winter weekday and summer weekend. Source: Brattle Model, Sustainability First Paper 2.

What is the potential to shift and reduce load *at peak*?

Up to third of load could 'technically' be shifted or reduced at peak

We modelled the *technical* potential to shift and to reduce load *at peak* across all sectors, estimating that this could reach ~18 GW at winter evening peak of 54GW. However, work continues to understand what the *realistic* potential is, taking into account the flexibility of end-use activities, customer behaviours, technical capabilities, operational constraints and commercial value. Only the largest industrial customers and domestic customers on Economy 7 presently adapt their consumption. **Figure 5** summarises the load characteristics for industrial, commercial and household customers with Sustainability First' views on where the greatest potential is for demand reduction and DSR.

	Customer numbers % annual usage *(317 TWh 2013)*	**Key Characteristics of Load**
Industry Half-hourly settled	**~117,000** **49 %**	• **Demand reduction potential** – many cost-effective electricity efficiency measures already taken. • **Fairly flat profile** – across the day, night & seasons. Chemicals, food & paper ~40% of consumption. • **DSR potential** – fairly 'bespoke' – business driven. Balancing. Critical peaks (TRIAD - 1-2 GW).
Services / SMEs Load profiles 3-8	**~2 million** **16%**	• **Demand reduction potential** – lighting (significant). • **Morning 'rise' – but thereafter relatively flat profile through the day.** Slow tail-off into evening. • **DSR potential** – HVAC. Chillers. Poss. scope to reduce or stagger morning 'rise'. Some scope evening peak. Balancing & Capacity Markets.
Households Load profiles 1-2	**~27 million** **35 %**	• **Demand reduction potential** – lighting and product standards (especially refrigeration). • **Morning & evening peaks** – lights, cooking, showers and electronics. 'Shiftable' load – limited? GB trials suggest shift of ~5-10 % feasible. • **DSR potential** – for on-peak heat there is some scope to shift (0.5m homes). Otherwise, what *other* flexible household load 5-7 pm? (Some wet appliances? hot water?). In the future – heat, electric vehicles and storage.

Figure 5: Load characteristics and potential for demand reduction and DSR for industrial, commercial and household customers. Source: Sustainability First.

Many industrial customers have already made cost-effective energy efficiency improvements, and some offer flexibility services, often via back-up generation. In services and small and medium-sized enterprises (SME) there is significant potential for further lighting efficiency, as well as potential to flex the use of some appliances, heating, ventilation and refrigeration. For households there is again strong potential for lighting and appliance efficiency improvements (esp. early replacement of fridges and freezers) as well as for the 0.5 million households who use 'on-peak' electric heating to install insulation and to shift to off-peak heat.

Reducing demand *at peak* could deliver more than peak-shifting for households

What role does demand reduction have?

The main policy driving electricity demand reduction currently is EU product regulation. DECC expects this to result in major savings to customers' electricity bills by 2020 and 2030. This is great if it happens, but, if not, it is a major policy risk. Therefore, concerted effort is needed to drive product efficiency / innovation and encourage early replacement / uptake of appliances. Electricity demand reduction *at peak* may deliver more 'peak benefit' than peak-shifting for households. Studies for DECC suggest household reductions at peak could significantly out-strip savings from DSR today.

Activities households are willing to shift are not the biggest contributors to peaks

What form can demand-side actions take?

Demand-side actions can take various forms (see **Figure 6**). The challenge is finding a match between the change in demand that different electricity market actors need and the flexibility service that customers are able to provide. In the household sector we found that 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). Longer term, automation may be the most cost effective and reliable way of realising DSR and major loads will need to be in use i.e. electric heating, hot water and electric vehicles.

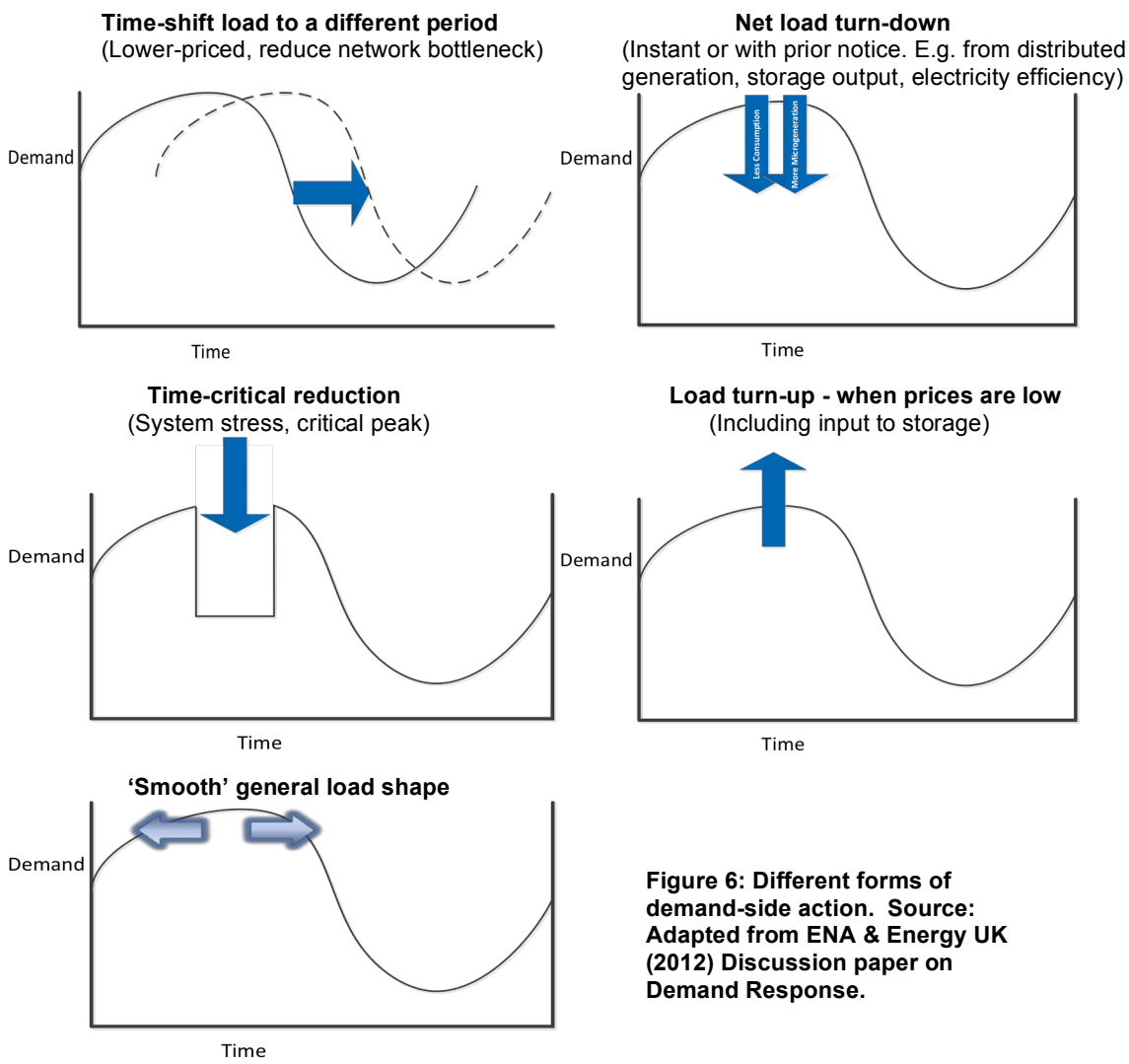

Figure 6: Different forms of demand-side action. Source: Adapted from ENA & Energy UK (2012) Discussion paper on Demand Response.

Demand-side solutions should cost less than supply-side alternatives

What are the benefits of demand-side actions?

Demand-side actions can deliver cost-savings in the electricity system by helping balance the system and reducing the need for new generation or network reinforcement. All things being equal, we should look to demand-side solutions to *cost less than supply-side alternatives* - but there are costs to demand-side delivery, including for new equipment: appliances and controls; communications systems; changes to tariffs and billing systems; some network changes; and service/transaction costs. Customers providing demand-side services will also need some benefit or reward for their actions. Demand-side actions that displace peak plant and promote flexibility can also result in carbon savings.

What schemes capture demand-side benefits in today's GB electricity markets?

Various market actors have the potential to benefit from demand side activities, and different industry schemes offer 'routes to market' to capture this benefit (see **Figure 7**).

	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 7/10 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

Figure 7: Benefits of demand-side activities for different market actors and the schemes currently in place to capture this. Source: Sustainability First Paper 13.

The business case is currently weak for any single market actor to lead on household DSR

What is the business case for market actors?

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 – contracting approximately £383m annually. Distribution networks are also starting to contract more with large customers for constraint and fault management, to avoid network reinforcement. This is location specific. DNOs have incentives to innovate through their price controls and the Low Carbon Network Fund. Most 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 contractual '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 and confidence, new market actors, non-traditional business models and new partnerships may also be needed. The Government has also recognised the potential contribution of demand in the design of the capacity market, with the ability to bid in DSR activities and a pilot scheme for electricity demand reduction.

Which electricity-demand side markets are open to households?

Many of the schemes today have been designed to incentivise participation of generators or large business customers. Therefore, we have looked, in principle, at whether these markets are accessible for household customers to participate today and post-2020 – by which time most households will have smart meters (see **Figure 8**).

With smart meters no insuperable barriers to household demand-side participation

We conclude that although many of these markets are not straightforward to access today, once smart meters have been rolled out, there are no *insuperable,* legal or regulatory barriers to household demand-side participation. Pre-2020 a key question is how far will half-hourly settlement be needed to measure and validate household customer demand-side actions: *Complex* dynamic tariffs *will* need half-hourly settlement; *Simple* dynamic tariffs, possibly, *may not*; *Static* Time of Use (ToU) tariffs *do not.* Balancing DSR services will need to adequately demonstrate delivery, which may or may not require a smart meter.

Demand-side market	I&C Half-hourly	Pre-2020 Household	Post-2020 Household
Wholesale markets	STOD Tariffs	Econ 7 ; ToU	
TRIAD - Avoided Transmission Charges			
Balancing			
Frequency			
Reserve		Fast Reserve	
DSBR			
Distribution - Fault & Constraint Management			
Capacity - DSR			
Capacity – Demand Reduction			
Trials – LCNF, NIC, TSB, Research Council			

How Open to Household DSR ?
Green – open
Amber – could be open
Red – not open

Figure 8: How open are the various demand-side markets to households pre-2020 and post-2020. Source: Sustainability First Paper 12.

What value does flexibility have?

Today the value of flexibility is determined by how much market actors are prepared to pay for demand-side services as part of their schemes. The value for flexibility is likely to change in future, with the variability of wind making wholesale market prices harder to predict. Prices customers' pay may also become more reflective of the cost to serve – for example via Time of Use Tariffs. Greater cost-reflectivity has benefits for system efficiency and therefore benefits for customers as a whole, but may make retail pricing more complex and could have distributional impacts, for example on vulnerable customers and those unable to reduce or shift demand at peak.

Greatest future DSR benefits for system overall in wholesale markets but greatest individual benefit in balancing

We have looked at modelling studies to understand where the value lies for DSR today and in 2020, both for the system overall and for individual customers (**Figure 9** sets this out on a purely illustrative basis for households). This suggests that the greatest benefit for customers overall will be from DSR in wholesale markets, from the avoided costs of new generation. But for an individual customer the greatest individual benefit will come from participation in balancing markets. The disconnects between benefits for customers overall versus individually, and where the value lies for customers versus market actors, leads to the question of how to develop retail propositions which make it worthwhile for households to participate whilst providing benefits to different market actors and to the electricity system overall.

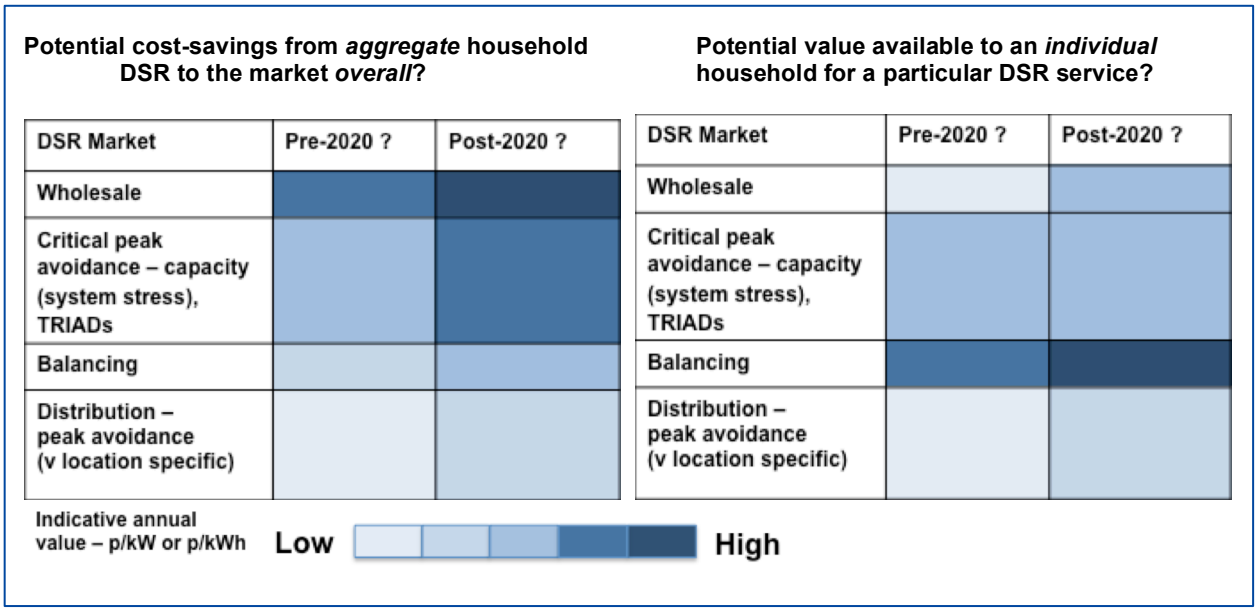

Figure 9: Illustration of where the value lies for household DSR in GB electricity markets – including potential cost-savings for the market overall and individual households pre-2020 and post-2020. Source: Sustainability First Paper 12.

What are the technical enablers for DSR?

Many technical enablers for DSR are already in place or will be by 2020

Many technical enablers for DSR are already in place or will be in place by 2020, including: smart meters; supplier billing software; data access (for suppliers and third parties with customer consent); and potentially universal half-hourly settlement. These steps will enable more dynamic retail tariffs. There is also scope to automate control of load and home appliances, via: smart meter-linked auxiliary load control switches; Consumer Access Devices; and / or direct into the home.

What issues and barriers need to be addressed?

For customers to participate in demand-side schemes there are various barriers that need to be addressed, such as: lack of knowledge of schemes and the ways to participate; size of financial incentives and payback; impact on lifestyle or business operations; and putting the technologies in place to enable automation. Further work is needed to understand what will really motivate customers to participate and overcome barriers – recent innovation trials are providing some helpful early insights.

"We note the large body of work undertaken in the GB Electricity Demand project run by Sustainability First, which has made an important contribution to the understanding of the nature of demand and the potential for industrial and domestic DSR"

House of Lords enquiry on The Resilience of the Electricity System (2015)

The Government and Ofgem have developed various schemes and trials to enable demand-side participation. But work is still needed to ensure a joined-up approach to policy development particularly on schemes to promote demand reduction, end-to-end and integrated demand-side response schemes, energy efficiency and distributed generation. It needs to be clear and simple for customers to engage with the demand-side.

Greater focus is needed on the potential for local matching of supply and demand, including via small-scale storage, to create 'pro-sumers' – but this will involve detailed reform of current administrative silos (especially on feed-in tariff administration) and grappling with current approaches to industry network charges.

What consumer protections are needed?

Need a principles based approach to regulating household DSR markets

As DSR markets develop, it will be important to ensure that appropriate consumer protections are in place, and particularly safeguards for the most vulnerable in society. Other areas for further consideration include: education and information requirements; 'try-before-you-buy' arrangements for time of use and DSR tariffs; reliable comparison information for tariffs; speedy enforcement to penalise license breaches in areas such as mis-selling.

It is critical that DSR schemes and propositions are designed from the customer perspective. But this should not be done prescriptively. We believe it is important to promote innovative and vibrant DSR markets. Therefore we suggest a principles-based approach to provide a stable regulatory rule-set. Below we have set out some principles for assessing the success of DSR markets (see **Figure 10**).

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 10. Principles for judging the DSR market. Source: Sustainability First Paper 8.

Conclusion

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, and potentially critical peak services too. However, one important finding is that, 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.

5 next steps – for the next 5 years

With a focus on household demand-side participation.

1

Focus on customer affordability

Electricity demand reduction is a top priority – need a concerted drive especially at peak. Actively consider LED lighting efficiency schemes & refrigerator scrappage. Support for EU products regulation. Focus on insulating, upgrading and smartening where appropriate the 0.5 million all electric 'on-peak' homes and ~2 million remaining Economy 7 customers.

2

Encourage supplier-led household demand-side

Supplier 'toe-in-water' voluntary ToU tariffs – BUT – adequate customer safeguards – 'clear, fair and simple'. Explore sharper incentives at peak for suppliers on their present cross industry charges.

3

Manufacturers & supply chain to initiate early market in automated controllable household load

Including storage heaters and hot water tanks. If no large controllable loads by early 2020s, system costs will rise without potential for household DSR offset.

4

DECC to join-up policies, measures & incentives to 'smarten' household electricity

This will require a clear focus and silos to be tackled: electricity reduction, insulation, household DSR, low-cost storage (incl. thermal storage), micro-generation. The 'whole' should add up to far more than its parts.

5

Promote local energy schemes

Continued support. Important showcase and test-bed for household demand-side

Project papers

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.

Project partners

The GB Electricity Demand 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 included: BEAMA; British Gas; Consumer Futures; EDF Energy; Elexon; E.ON UK; National Grid; Northern Powergrid; Ofgem; Siemens; Scottish Power Energy Networks; UK Power Networks; and Vodafone.

Work was coordinated through a Smart Demand Forum, whose participants included the sponsor group together with Ofgem, DECC and key consumer bodies: Energy Intensive Users Group, Consumer Futures, Which? and National Energy Action.

We are grateful for the support of our sponsor colleagues who helped to make this major project a reality. The findings, conclusion and recommendations are those of Sustainability First.

Contact

info@sustainabilityfirst.org.uk
www.sustainabilityfirst.org.uk