Sustainability First

The Smart Electricity Consumer :
realising the electricity demand-side resource

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Views expressed are those of Sustainability First.

Today

1. GB Electricity Demand Project
2. Context : GB electricity demand-side
3. Household demand-side response & and smart-meters
4. Smart markets, smart regulation & smart consumers
5. Questions ?

Sustainability First – GB Electricity Demand Project

- Environment think-tank & charity.
- **Three-year multi-partner project** to assess :
  - GB electricity demand-side resource - across all sectors of the economy.
  - Scope for (1) **demand reduction &** (2) **demand response –** incl role of Distributed Gen.
  - **Economic value** of resource - to both customers & market actors. 10-15 year horizon.

- **Main focus** : customer, consumer, commercial, regulatory and policy.
- **Strong practical focus** : informed by our project partners (incl LCNF smart grid projects).

- **Smart Demand Forum –** project coordination :
  - **Sponsors –** Northern Powergrid, Scottish Power Energy Networks, UK Power Networks, National Grid, British Gas, E.ON UK, EDF-Energy, Elexon, Vodafone, Siemens , BEAMA, Consumer Futures, Ofgem.
  - **Consumer bodies –** Citizens Advice ; National Energy Action; Which ? Energy Intensive Users Group ;
  - **DECC**

- **13 in-depth project papers** – 'GB Electricity Demand' at **www.sustainabilityfirst.org.uk**

Context : GB electricity demand-side

- Benefit = unlock electricity system savings (money, carbon).
- Much detailed work in hand (market actors, DECC, Ofgem, consumer bodies, universities).
- But, many practical challenges :
  - **I&C customers** - demand-side markets starting to develop. (Much DG).
  - **Household demand-side** - perhaps some way off.
- Still many unknowns (market actors, customers)
- **Today's focus : households in 'post-2020' world**.

A top priority : household electricity demand reduction

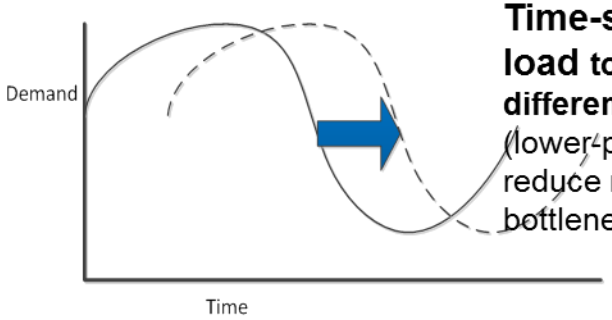
- **Household electricity demand reduction – a clear winner** (system efficiency, customer bills, carbon).

- **Appliance efficiency is central (EU product regulation).** DECC expects **major** electricity bill savings - ~ two-thirds of expected bill-savings by 2020 (Nov 2014 doc). **Non-delivery is therefore a major policy risk** (cost-side largely locked-in already).

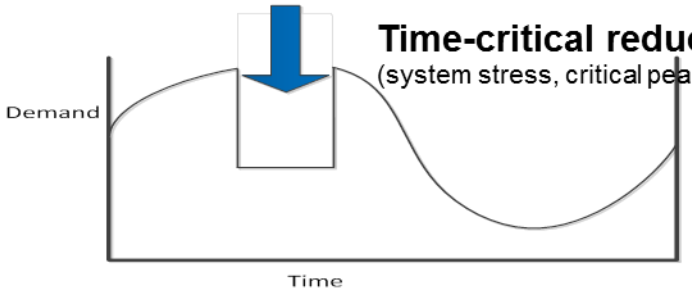
- **Steps to permanently reduce electricity demand *at peak* -** may deliver more **'peak benefit'** than demand-response (DECC studies).

- So, DECC to retain focus on **peak-reductions** :
  - **Targeted household schemes ?** Electricity Demand Reduction Pilot (Capacity Mechanism) – more pro-household ?
  - **Picking 'winners' ?** Lighting efficiency ? fridge-freezer scrappage ?

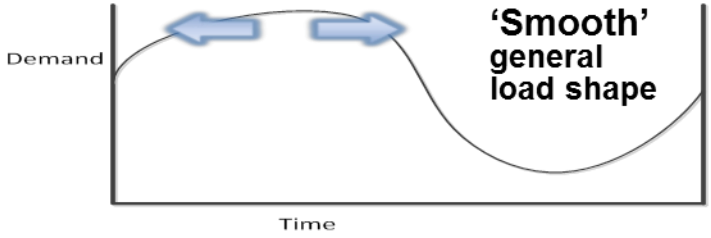
Customer demand-side actions can take many forms



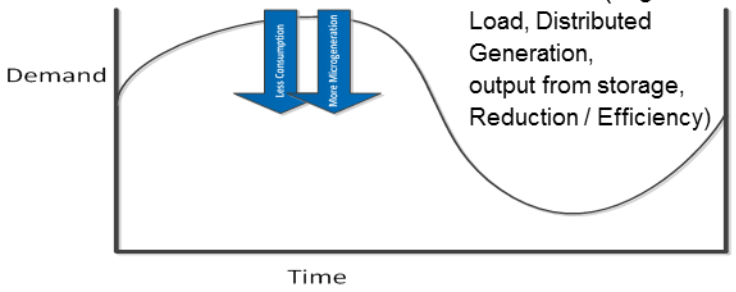
Time-shift load to a different period (lower-priced, reduce network bottleneck)



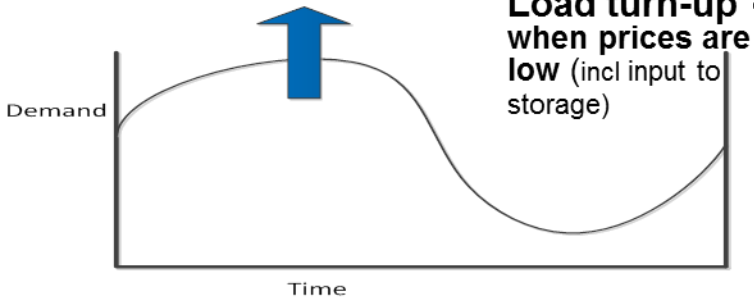
Time-critical reduction (system stress, critical peak)



'Smooth' general load shape



A *net* load turn-down – (Might be from Load, Distributed Generation, output from storage, Reduction / Efficiency)



Load turn-up - when prices are low (incl input to storage)

Source : Adapted from ENA & Energy UK. Discussion paper on Demand Response. 2012

Why customer demand-side actions ?

- **Deliver cost-savings in the electricity system** :
  - **Avoided short-run costs**(operational **-** Balancing. Fuel).
  - **Avoided long-run costs** (capital - Generation ; Networks (T&D))

- **All things being equal, we should look to demand-side solutions to *cost less than supply-side alternatives*** . There are **costs** to demand-side delivery (kit, comms, transaction).
- **Customers need some share of the benefit created** (participating ; non-participating).

- **Reliability -** DSR does **not** imply that customers would entertain a lower level of system reliability overall.

- **Carbon savings** - if fossil-plant displaced.

GB demand-side schemes are on the increase….

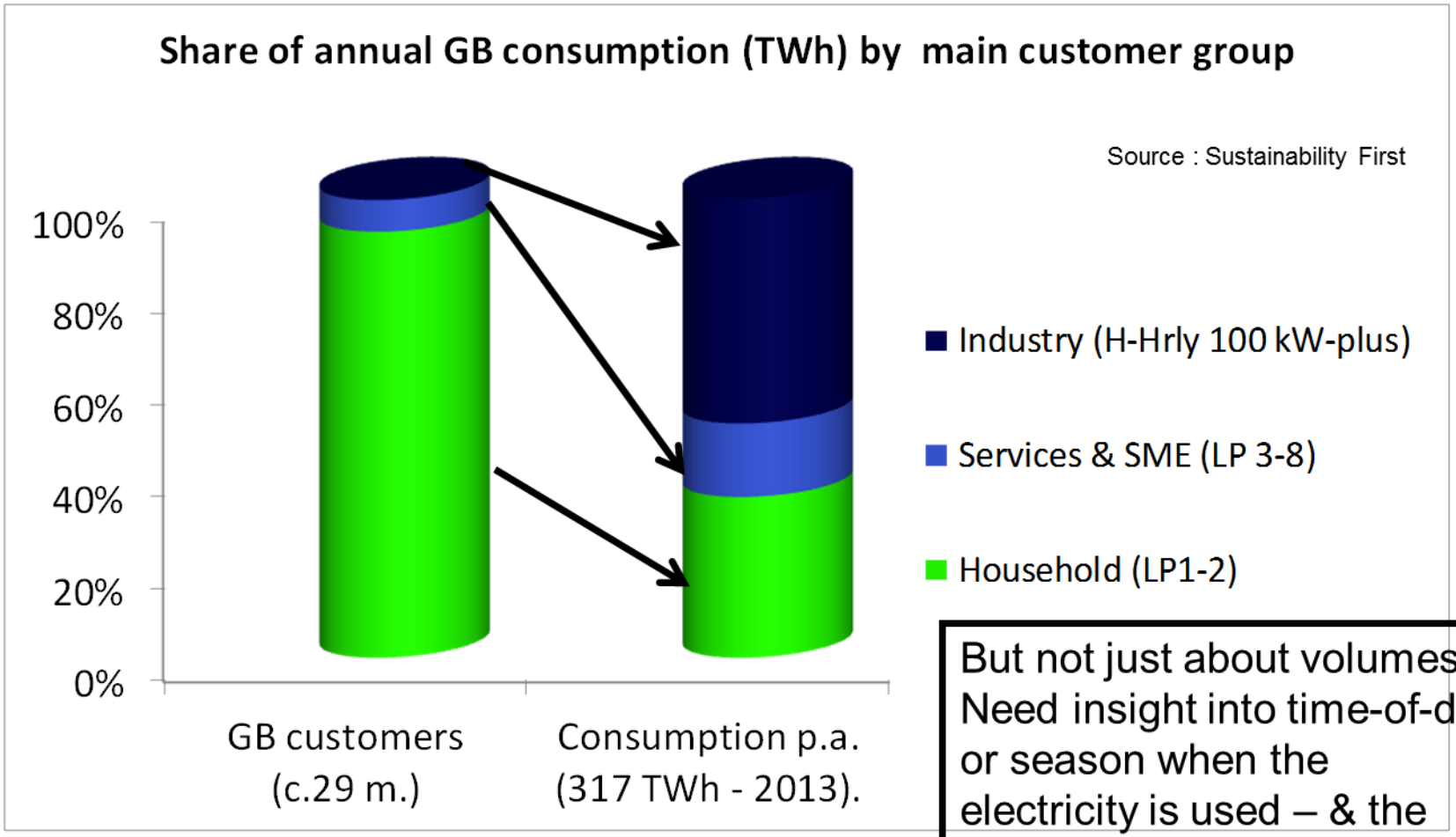
Wholesale Market DSR	**I&C** (ToU tariffs ; Demand management). **Household** (Econ 7)
Balancing Services	**Frequency. Operating Reserve. Demand-Side Balancing Reserve** (new scheme). Much distributed generation.
Transmission (avoided build)	**Established 'turn-down' scheme** at three annual 'critical winter peaks' (**TRIAD**s). I&C load (1-2 GW).
Distribution Networks (fault management).	**I&C customers. Location-specific.** Constraint management in future (peak-load related)
Capacity Market : DSR	To handle **'system stress' events**. Two new DSR schemes (Transition scheme & main Capacity Market).
Capacity Market : Electricity Demand Redn	£10m p.a. for 2 years for permanent peak-related load reduction.
Network / Smart Grid Trials. Distribution (LCNF)	Rich mix - ~£60 m p.a ; I&C ; H/hld ; new low-carbon technologies
Many Other Trials	DECC, Devolved Governments, Research Councils, Innovate UK, ETI, EU schemes
Source : Sustainability First	

Some early efforts at cross-market co-ordination between schemes (technical, commercial)

To realise value in the market from DSR - need a good 'match' – technical, commercial etc

- **A good match :** technical, commercial, market actors & customers, available demand-side schemes.
- **Customers must be able to offer collective 'predictable flexibility' -** in return can expect some benefit / reward.
- **'Needs' of market-actors differ -** speed & duration of response ; capacity (kW) ; energy (kWh) ; location etc.
- **Creating worthwhile customer offers remains a challenge. Split value-chain** (wholesale, balancing, networks).
- **Market actors need to :**
  - **Find ways to *combine* several demand-side revenue streams**. Not readily done.
  - **Offer prices & terms *which will attract consumers***
- **New actors -** need fair access - to markets, to customers.

GB electricity-use today (annual volume TWh)

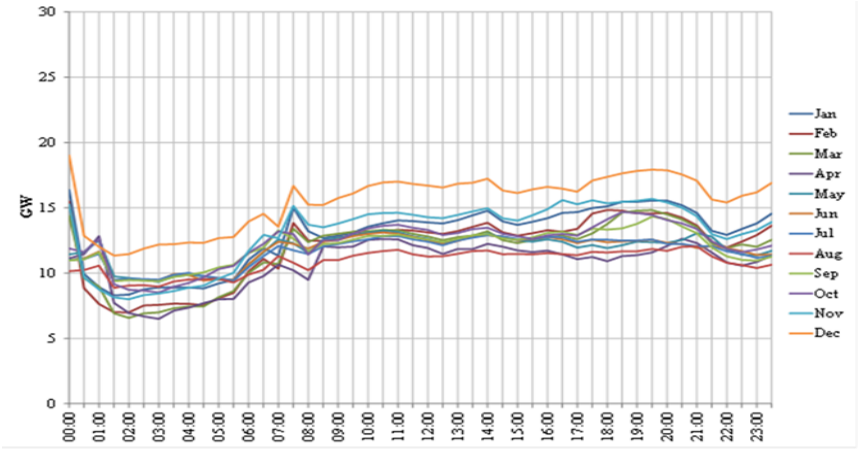


But not just about volumes. Need insight into time-of-day or season when the electricity is used – & the related system costs.

I&C Load

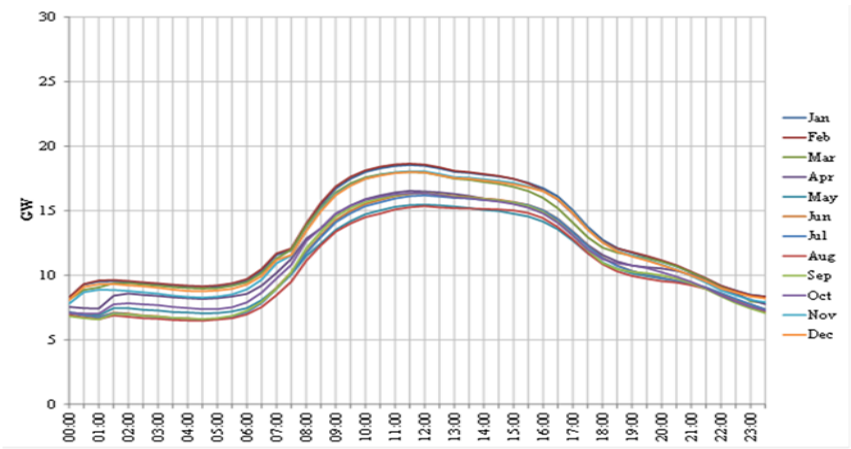
GB daily load profiles – 100kW Industry & Commercial (generic, by month).

Industry - Weekday



Source : Brattle Model. Sustainability First. Paper 2

Commercial - Weekday



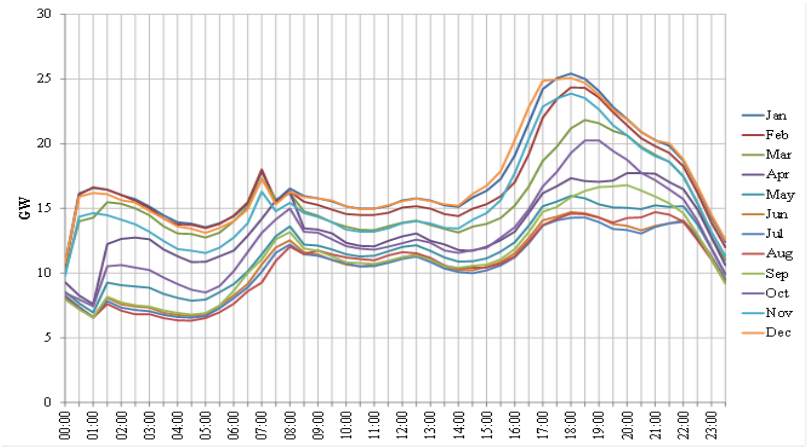
~117,000 half-hourly metered & settled 100 kW-plus Industry customers – 0.0004 % of GB customers consume **around half of total annual electricity**.

~ 2 million customers – ~7% of customers. Consume around 16% of total annual electricity (LP3-8)

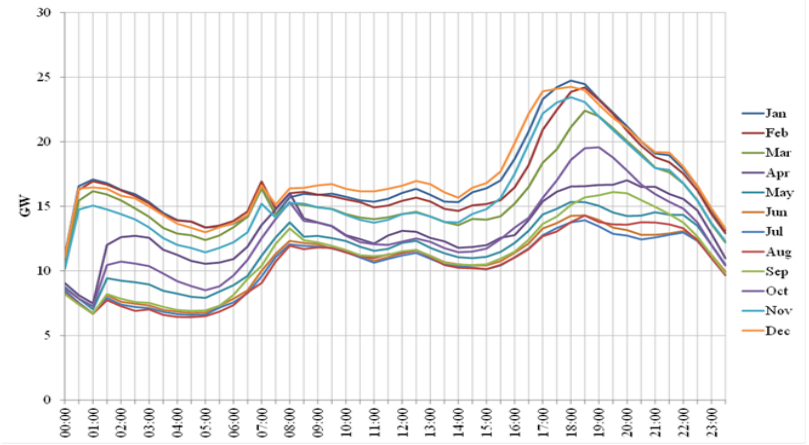
Household Load (24-hour)

GB daily household load profile (generic, by month).

Household - Weekdays



Household - Weekends



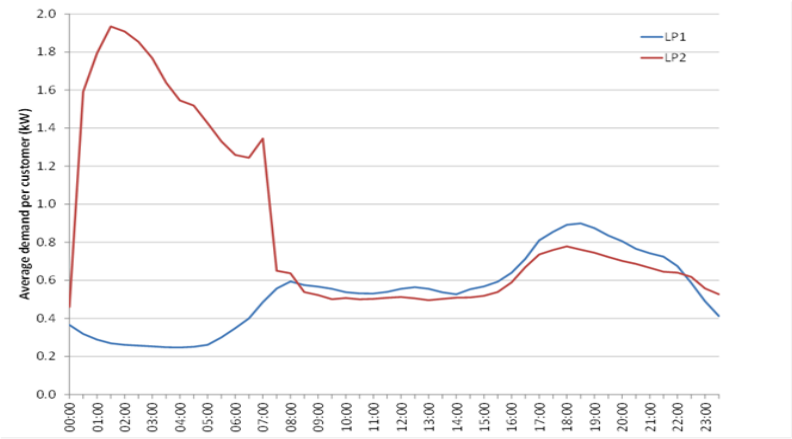
Source : Brattle Model. Sustainability First. GB Electricity Demand project. Paper 2

- **~ 25 million customers** – ~90% of all customers. Distinctive morning & evening peak.
- Consume **~one-third of annual electricity by volume**.
- **Significant contribution to total evening peak (around one-half).**
  = Mostly, lights, cooking, consumer electronics. Some flexibility – but limited.
- **Impact of more new load ?** Heat ? EVs ?

Off-peak household load

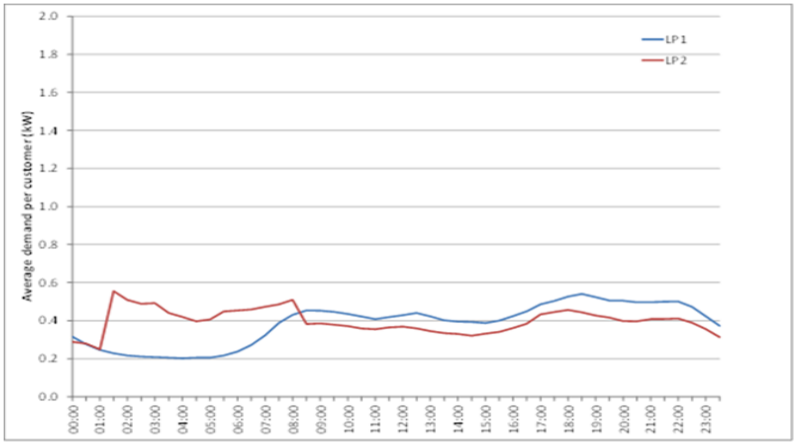
Generic household load profiles -
Economy 7 & 'unrestricted' customers : average kW demand by time-of-day.

Winter Household – Economy 7



Source : Brattle Model. Sustainability First. GB Electricity Demand Project. Paper 2

Summer Household – Economy 7

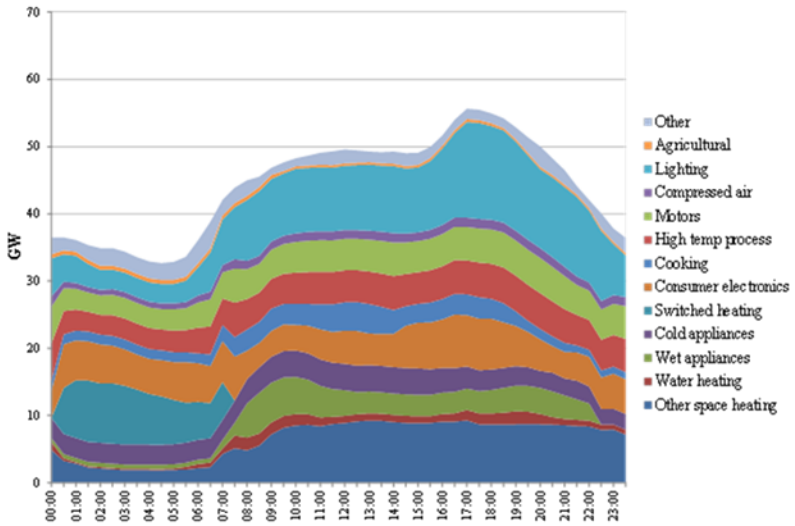


Heat : **How a time-related tariff with automation can shift heat-load**.
Today, only ~2 million households heat with 'old-style' night storage heaters.
(So, <5% of households today).

GB electricity - estimated end-use (2010)

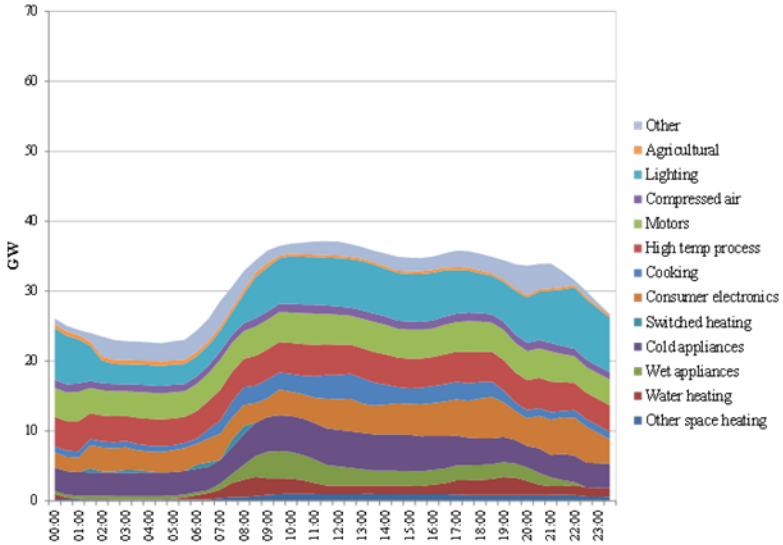
(All sectors, hourly)

Total End-Use – January Weekday



Source : Brattle Model for Sustainability First. Paper 2

Total End-Use – Summer Weekend



For any sector, little knowledge of how power *actually* used. Brattle built an all-sector picture of **estimated** electricity end-use across 24 hrs - winter & summer.

- **Lighting load is significant, year-round : day & night.**
- **Lights & 'On-Peak' Heat : dominate the winter peak.**

Our end-use model assessed the poss. ***technical*** potential to shift & to reduce load *at peak* (~18 GW at average winter evening peak of 54GW). 2010 - & potential in 2025.

Household DSR & smart meters

Are GB electricity demand-side markets open to households ?

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 Councils, DECC			

Source : Sustainability First. GB Electricity Demand project. Paper 12

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

Once smart meters (from 2016) - which record power-use in half-hourly time-blocks - no ***insuperable*** legal or regulatory barriers to household demand-side participation.

Pre-2020 : may see :

- Static Time-of-Use tariffs
- Simple dynamic tariffs (e.g. possibly, critical system peak).

Post-2020 – could see more complex dynamic tariffs (if half-hourly settlement).

Balancing services : need to demonstrate delivery. This may / may not be via the smart meter & settlement.

Where does value lie in household DSR ?

(nb – illustrative !)

Potential cost-savings to the market *overall* from household DSR *in aggregate*

DSR Market	Pre-2020 ?	Post-2020 ?
Wholesale		
Critical peak avoidance – capacity (system stress), TRIADs		
Balancing		
Distribution – peak avoidance (v location specific)		

Source : Sustainability First. GB Electricity Demand project. Paper 12.

Potential benefit available *to the individual customer* if they can offer DSR services

DSR Market	Pre-2020 ?	Post-2020 ?
Wholesale		
Critical peak avoidance – capacity (system stress), TRIADs		
Balancing		
Distribution – peak avoidance (v location specific)		

Source : Sustainability First. GB Electricity Demand project. Paper 12

Indicative annual value – p/kW or p/kWh **Low**  **High**

How to make DSR retail offers 'worthwhile' to households across the value chain ?

GB has the 'technical enablers' for household DSR

'Technical' enablers :

- **Smart meters** : record use by half-hour - and so can enable many tariffs : e.g. ToU (static, dynamic) ; rising block ; a load-limit option (eg 3 kW, 5 kW) ; maximum demand (i.e capacity charges).
- **Supplier software** : to bill for smart tariffs
- **Data access** (with customer consent) : for suppliers ***and*** for third parties (price-info ; 10-sec usage data).
- **Poss universal half-hourly settlement** : will permit a better match between *actual* customer usage and underlying costs of the market.
- **Scope to automate control of load & home appliances** – via
  - **Smart meter-linked auxiliary load control switches / commands** via DCC - & / or
  - Paired **Consumer Access Devices** – & / or
  - **Direct into the home via internet** – & not linked to smart meter (e.g. smart thermostats).

Smart-meter not sole route to customer : a <u>plural</u> GB household DSR market.

Today, GB suppliers have a 'lead-role' in developing household DSR …

- **GB Suppliers :** have direct relationship with their customers (meters, 'critical commands' for appliance control etc) – so may be expected to take lead in household DSR.

- **Unsolved questions on how best to :**
  - **Give *other* actors** fair access to customers. In particular, **access to the smart-meter-led appliance-control.**
  - **Create simple household retail offers for a *mix* of DSR services**.

- **All actors need a better *forward-view*** of how future DSR markets for households may develop in practice. Especially true for :
  - **The innovation supply-chain** (Paper 11 – Sustainability First & Frontier Economics)
  - **Development of retail market arrangements most likely to create *'customer pull'* for demand-side, innovation & low carbon**

But, what about the supplier business case ? (1) wholesale price risk

'Market differentiation' – is today's main driver for suppliers to offer household ToU tariffs & other DSR.

Most suppliers see only limited value in household DSR today. But, from 2016-on, ***commercial drivers*** for suppliers will change :

- **Smart meters** (new customer insight; scope to automate) - ***plus***
- **Supply activity will start to carry more wholesale price-risk :**
  - **Wind** - ***unpredictable*** mix of sustained low-prices - w volatile 'flexibility' prices .
  - **Regulation – new price risks** (Imbalance charges ; Settlement).
  - **Steeper price differences *within-day* (peak / off-peak) ?**

Two key questions :

- **How might this uncertain 'mix' shape a supplier's approach to managing their wholesale price risk ?**
- **How far might suppliers view household DSR as a *meaningful* tool to manage that risk ?**

Hard to know !

Perhaps, whole-sale price risk might prompt suppliers (1) to reduce / smooth peaks and (2) beyond 2020, start to seek more by way of firm ***predictable*** customer response (so, to **de-risk *via* automation).**

But, what about the supplier business case ? (2) network charges & levies

Management of wholesale price-risk – is only **one part** of the supplier DSR story**.**

- **Today, around <u>one-third</u> of our end-bill is made up of charges for <u>networks & levies</u>** (cost-recovery of RO, FITs, CfDs, CM, some social obligations). These cost-elements 'pass-through' into our end-bills.

- **By 2020,** these combined charges **may form ~*<u>one-half</u>* of the end electricity bill** (perhaps *two-thirds* by 2030)**.**

- Broadly today, these cross-industry charges pass-through **to suppliers as a 'flat' socialised charge per customer –** regardless of how much power each customer uses at peak.

A key question :

- If **suppliers were exposed to more cost-reflection in their cross-industry charges -** would ***suppliers*** become more motivated to seek behaviour change and DSR solutions from their customers ?

There are pros- and cons- for greater cost-reflection in supplier charges. Half-hourly settlement could be a game-changer. A discussion is needed. **Especially on poss. impacts for end-customers - which could be major** (winners & losers).

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Smart markets,

smart regulation &

smart consumers

Smart consumers - context

Energy context

- Rising prices (2009-2013 24% increase) and falling standards
- Anxiety – affordability / reliability / complexity
- Levels of consumer trust in the sector are low

Wider social context

- Technological change – the digital revolution
- New consumer pulls - expectations for more responsive, personalised and connected services (social / mobile / local)
- Empowering opportunities – referencing / group switching
- Calls for simplification in complex, inter-dependent world
- Concerns around data protection

Smart markets – reviews

Ofgem's Retail Market Review (RMR) - 2013

- Restricted number of tariffs (4 gas / 4 electricity), simplified tariff structures & introduced 'fairness' license condition

CMA investigation – February 2015 updated issues statement

- Inactive customers
  - A third never considered switching / thought impossible
  - 2012 – 2014 over 95% dual fuel customers could have saved between £158 - £234 p.a by switching tariff / supplier
- *'Since '09..weakening of competition...widening gap…costs & tariffs'*
- RMR Impact questioned
  - Littlechild: restrictions inappropriate for smart world
  - Independent suppliers: a barrier to innovation
- New theory of harm – regulatory framework acts as barrier

Ofgem's Price Control – Current CMA appeals (BGT and NPG)

- What's the appropriate pace of change?

Smart markets – market actors

Suppliers – have kit will play?

Other potential actors

- Digital giants – eg Google
- Appliance manufacturers & automation- the quiet ones to watch?
- Will the ‘internet of things’ more radically reshape the market?
- Scope for joint ventures - but if no business case no ‘value proposition’
- Aggregators and community solutions

‘Straw-man’ : possible retail market models

Model A - Single ‘RMR’ Market

- Retail and flexibility services combined in one market. Consumers have one contract**.** RMR shapes market. Status quo? Most likely option in short / medium term

Model B - Single ‘unconstrained’ market

- Retail and flexibility services combined and consumers have one contract in one fully competitive market. RMR rules are relaxed as market ‘reset’ is seen as success. Possible option in medium/ long term.

Model C - Separate competitive markets for (1) retail supply (flat averaged p/kWh) and (2) for flexibility

- Consumers *can* enter two separate contracts – for supply and for DSR. Either with a single supplier or separate contracts with a supplier and a third-party (DNO or aggregator). Medium / longer term option.

‘Straw-man’ : possible retail market models (continued)

Model D - Separate markets for (1) regulated retail supply (flat averaged p/kWh) *OR* (2) entrepreneurial competitive market for supply and flexibility

- Consumers have one contract for *either* : a ‘regulated’ retail supply for those who cannot / don’t want to engage in DSR *or alternatively* for a *competitive* market which *combines* retail supply and flexibility. More likely in medium to longer term.

Model E - Alternative automated bidding : agents interface with suppliers using software to agree contracts at best price

- Consumers have one contract with one bidding agent such as an autonomous broker who buys on market for them, with each user requesting bids from all suppliers every 30 minutes, for a set number of periods ahead. Suppliers respond with best price and broker agent software agrees contract. Possible in long term?

‘Straw-man’ : possible retail market models & assessment

SF ‘straw-man’ – poss market models	Efficiency	Innovation	Simplicity	Choice	Convenience	Distributional impact
A - Single RMR						
B – Single unconstrained						
C – Separate competitive retail supply and flexibility						
D – Separate regulated retail supply OR compet. Supply & flexibility						
E – Alternative automated bidding	?	?	?	?	?	?

Source : Sustainability First. GB Electricity Demand project. Paper 12.

Poss. Rating ?

Red - Negative
Amber - Neutral
Green - Positive

Smart regulation

Key challenge – how far can you protect both current & future consumers without creating new barriers to entry, efficiency and innovation?

Priority and focus
- Do we need to prepare for incremental or transformative change?
- What is the appropriate pace of change?

Regulatory scope
- Converging markets and regulatory co-operation

Dealing with uncertainty
- **Trials**
  - Incentive structures
  - Regulatory approaches - facilitation
  - Technical and commercial solutions - competitions (LCNF) & prizes
- **Scenarios and modelling**
- **Flexibility** – principles approach eg 'RASP'
  - Reliability
  - Affordability
  - Simplicity
  - Protection / Empowerment

Smart households - DSR trial experience

Do households want DSR?

- Participants generally interested & willing to offer their flexibility
- Some customers are happy to engage (even where bill-benefits are modest)
- Load-shift potential from non-automated 'voluntary' tariff interventions at *average* shift at peak of ~7-10% - albeit a wide range

Questions / issues

- Enough peak-shift to allow DNOs to avoid winter peak network investment?
- Potential for losers (CLNR – 40% of participants would have paid more)
- No major GB household critical-peak trial in the winter and all voluntary

Trials have looked at :

- **Static ToU** eg CLNR; **Dynamic ToU** eg LCL; **Direct Appliance Control** eg nPower CERT fridge trial, So La Bristol (PV to electric battery storage); and **Vulnerable customers** eg UKPN trial

Household automation at scale

Do we understand *time-lines & dependencies ?* As well as smart meters, also likely to need some (or all) of:

- Flexible household load
- Controllable load
- Retail tariffs to incentivise flexibility
- Two way communications
- Data management capability – i.e for validation (household level, & possibly appliance level)
- Individual-level half-hourly settlement (for 'dynamic' DSM).
- Customer over rides and other safeguards
- Metering and communications interoperability

Smart regulation – re-thinking indicators of market health

Market definitions
- Impact of convergence between energy, communications, appliances?

Supply side metrics
- Ensuring entrants from other sectors don't face information asymmetries
- Development of new institutions and systems (eg number of industry codes – 7 in electricity – and code governance)
- Behaviours necessary to enable strategic investment

Demand side
- The power of choice – switching as a metric (Littlechild: switching rates in energy greater than for mobiles, mortgages and current accounts)
- Consumer confidence – should there be a higher hurdle for energy compared to other markets if social license to operate in question?
- Bundled services & staggered contracts for energy / home service offers - consumer protection (joined up redress) & accountability

Smart regulation – protection & empowerment

- Enforcement powers
- Possible safeguards
  - Targeted retail price re-regulation for those that cannot engage with DSR - This could be in the form of a regulated ‘social’ retail tariff
  - Introduction of a regulated benchmark ‘price to beat’
  - Contractual mechanisms - Could include ‘try before you buy’ clauses
  - Limited liability- Losses to the consumer from DSR offers limited to a certain range to protect people from significant bill shock
  - Regulated Next Generation Intermediaries

Smart communities

Local benefits

- Previously excluded communities (eg off-gas) now empowered
- Producers – pro-sumers and local schemes – PV, wind etc
- Storage – electric heating, batteries, electric vehicles - & DSR as an offset to local distributed generation
- Increase diversity and resilience

Questions / issues

- Will smart approaches save communities money or actually increase network constraints and duplication?
- Most DSR 'value' / cost-saving potential - not presently at distribution level
- Distribution cost-saving potential very location specific eg urban / very rural, or congested network hot spots
- Will local solutions lead to a 'death spiral' for existing networks, undermining investment for all?

Way forward

- Location specific test beds for new commercial and institutional approaches
- Need to break down silos between institutional and funding structures

Smart citizens, fair services

- Move from universal ‘one size fits all’ to personalised services means smart can create winners and losers
- Lack of awareness of policy costs – 85% think profits driving prices
- How much greater cost reflectivity is desirable?

Advantages	Disadvantages
• Systems efficiency	• Distributional impacts
• Socialised benefits	• Complexity
• Individual benefits - Lower prices - Tailored services	

- Need to manage distributional impacts and ensure net consumer benefit
- Ensure social protections in place *before* smart markets evolve
- Data privacy and ownership
- Single point failure – business continuity and disaster recovery
- To gain public trust citizens must be involved in smart energy in timely way

In conclusion

GB Household DSR : questions to solve

- **Smart meters by 2020** : first step. But still need active suppliers, 'engaged' customers, time-related tariffs etc.
- **Customer safeguards** : Ofgem, CA and others starting to address
- **Households : only modest flexibility today -** despite a major contribution to winter evening peak load (~50%)
- **How best to deliver many small individual savings** – to unlock 'collective' value of peak-avoidance in wholesale markets ?
- **Back-office** : for suppliers to promote ToU tariffs, how soon to reform settlement ?
- **Automation / remote switching** – eg for electric heat & hot water loads. In the long-run, could make all the difference. **But where is that controllable load ?**
- **Smart App market** – will it truly benefit consumers ?

Household demand side development pre-2020 : six goals

1. **Customer affordability – a main driver.**
   - **Electricity demand reduction** – a concerted drive **– *esp at peak*.**
   - ***where appropriate*** **'upgrade' – insulate & 'smarten' : 0.5 million all-electric 'on-peak' homes - & ~2 million Economy 7 customers.**
2. **Encourage supplier-led 'toe-in-water' for household demand-side** – BUT - 'clear, fair & simple'.
3. **Consider impacts of more cost-reflection longer-term** – both how this might ***incentivise suppliers & customers -*** *&* also create 'winners & losers'.
4. **Manufacturers & supply-chain – encourage an 'early market' in automated controllable household load** . If no large controllable loads by early 2020s, electricity system costs will rise. But, lets be customer-led !
5. **Local energy schemes – continued support.** Important show-case & test-bed for household demand-side.
6. **DECC & Ofgem - to join-up policies, measures & incentives to 'smarten' household electricity -** & *tackle the policy silos* (across efficiency, smart & micro-gen).

GB Electricity Demand project papers (2011-2014) : 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?

GB Electricity Demand project papers (2011-2014) : www.sustainabilityfirst.org.uk

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 w. 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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GB Electricity Demand – *realising the resource*

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