SEDC
Smart Energy Demand Coalition

Empowering Residential and SME Consumers

White Paper

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This White Paper refers to different examples and case studies to illustrate the arguments made. The selection is not intended to represent an exhaustive overview of the available market offerings.

The views expressed in this document represent the views of the SEDC as an organisation, but not necessarily the position of a specific SEDC member.

Residential & SME Demand-Side Flexibility

Executive summary

With the transition of Europe's energy system, the need for flexibility and in particular, local flexibility, is becoming increasingly important. The role of consumer-empowerment is moving into the foreground as a means to improve services for consumers, while helping to drive competition, integrate variable renewable energy sources, enable the cost-effective uptake of electric vehicles, relieve pressure on electricity networks and allow for a nimble operation of the power system.

Enabling the employment of Demand-Side Flexibility at the residential and SME level will be particularly important to achieve these benefits, but it also comes with specific challenges that have to be overcome.

Making flexibility available

Given the dispersed nature of this flexible resource, the first challenge is to identify its potential and **make it available through smart appliances, or a fully Flexible Home**. Based on the analysis of numerous studies, pilot projects and pioneering commercial offers, this paper recommends a number of concrete steps to achieve this without requiring behaviour changes or negatively affecting the consumer's lifestyle.

In particular, we recommend the **introduction of a Smart Building Certificate** to complement the European Energy Efficiency Certificate for buildings that offers a recognisable and marketable identification of the available Demand Flexibility.

We also recommend that the existing European Energy Efficiency Label for appliances should be complemented with a smartness indicator, in order to show the potential of appliances to respond to external signals to adjust electricity consumption.

To start the market, short-term incentives at national level should be linked with the Smart Building Certificate, for example in the form of tax rebates or financial support. Similar incentives may be applied to smart appliances that have a smartness indicator.

Also, consumers should be able to access all data related to their own use of electricity at all times.

Enabling the market for flexibility

The second, simultaneous challenge, is to enable the market for this flexibility resource to be monetised. Consumers should be able to choose the service offer most suitable for them. This could be a dynamic retail electricity tariff that enables them to make the best use of their local flexibility to save on the electricity bill or it could be working with an aggregator or service provider who sells the flexibility on the consumer's behalf. Finally, they should be able to self-generate electricity if they wish, using demand-side flexibility to enable the cost-effective system integration of their own energy resources.

To make this possible, we recommend a range of measures, including **reinforced smart meter programmes** where a roll-out is not sufficient, **access to market-related dynamic pricing**, unhampered

market **access for demand response aggregators and demand products**, a **market-based approach to deliver network support services to DSOs**, and the **right to self-generate electricity**.

This combination of the "push and pull" strategies is essential to help unlock the demand-side flexibility resource and to enable its overall market-based monetisation. The proposed measures would **put consumers at the heart of demand management** allowing them to become central participants in the electricity market, benefitting from different service offers that are best suited to their own needs and preferences.

Table of Contents

Residential & SME Demand-Side Flexibility 3
Executive summary 3
Table of Contents 5
Introduction 6
Chapter 1 – Motivation and research on Demand-Side Flexibility 8
1.1 The benefits of Residential and SME Demand-Side Flexibility 9
1.2 Research and experience with Demand-Side Flexibility 11
1.3 Consumer needs 15
Chapter 2: Making Flexibility Available 16
2.1 Smart infrastructure in homes and SMEs 18
2.2 Challenges and enablers 21
2.3 Recommendations 23
Chapter 3: Enabling a Market for Flexibility 25
3.1 Implicit Demand-Side Flexibility 26
3.2 Explicit Demand-Side Flexibility 28
3.3 Local optimisation 31
Chapter 4: Overview of Policy Recommendations 34
Reference List 36
Annex 38

Introduction

Consumer Empowerment has become a buzzword in European energy policy for important reasons. Since the liberalisation of the energy sector, significant developments have taken place in Europe's electricity sector, including growing competition and market integration, decreasing wholesale prices, and the enhanced uptake of renewable energy sources. Nevertheless, options and benefits for consumers have so far remained limited.

Today, the energy system is largely driven from the perspective of suppliers and only a few consumers are able to track their energy use or actively participate in the market. While possibilities for larger commercial and industrial consumers have started to develop and active consumer engagement is gaining in relevance, this is not the case today for most residential and SME consumers. Although multiple trials have been conducted demonstrating that demand-side flexibility works, the business-application of these trials has been slow to develop. In practice, it is often difficult or even impossible for small consumers to monetise their flexibility, enhance comfort or save costs. Multiple barriers make it difficult for people to participate in a local energy project or benefit from renewable electricity, smart heating or vehicle charging systems in their building. The lack of retail energy choices is illustrated by the fact that the energy component of retail electricity prices in Europe has gone up slightly, despite the significant decline of wholesale prices.[1,2]

Limited accessibility and choice of energy services not only means that consumers are missing out, but the failure to tap into demand-side resources also means that Europe's energy system is missing out on significant potential for flexibility, system efficiency and sustainability.

A recent study by CE Delft[3] shows that purely the combination of electric boilers, electric vehicles and stationary batteries in homes could reach a technical potential of up to 191 GW in 2030. If only one third of this was actively used, it would already be the size of the UK's entire fossil fuel – based electricity generation capacity[4]. Further technological advancement and uptake of electric vehicles, the coupling of heating and electricity sectors, on-site power generation and residential and SME space energy storage, is expected to increase this capacity even further in the longer run.

Based on modern technologies such as home management systems, this flexibility becomes easily accessible, and premises will have an unprecedented ability to adjust their load profile automatically to a significant level. The activation of these larger residential loads can go hand-in-hand with the inclusion of household devices such as refrigerators, freezers, or dishwashers into demand-side management.

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[1] "*The energy element went up only slightly in the case of households* [on the period 2008-2012]". Cf. Commission Staff Working Document, 'Energy prices and costs report', 2014, p. 16.

[2] "*For the first time since 2008 average electricity prices increased in a few countries in 2015*; however overall prices remained far below 2008 levels". Cf. ACER, 'Wholesale gas prices continue to fall in the EU but electricity prices end their decreasing trend in some countries', Sept. 2016

[3] B. Kampman, M. Afman and J. Blommerde, 'The Potential of Energy Citizens in the European Union', CE Delft, Sept. 2016

[4] Carbonbrief website, 'Mapped: How the UK generates its electricity', Oct. 2015, available at: https://www.carbonbrief.org/mapped-how-the-uk-generates-its-electricity

This flexibility is much needed in a system with aging power plants to be phased out, the increasing demand of electricity driven by a coupling of transport, heating and power sectors, and growing variability brought about by renewable energy sources.

This paper looks into the challenge of unlocking this potential specifically from residential and SME consumers. The primary hypothesis is that the solutions must be attractive for the consumer, where the demand originates. Tenants, home-owners and small businesses need not only "buy-in" to the concept, but to lead and champion it. This requires the availability of economically viable solutions and services for consumers that must be simple to select and effortless to use.

In order to achieve broader consumer adoption, we propose a combination of 'push and pull' strategies. Based on case-studies and extensive literature on demand-side flexibility solutions, consumer preferences and barriers, we propose actionable measures to facilitate and incentivise consumer technology adoption, and to create the regulatory framework. These measures will enable the market to develop and provide a pull-effect for the competitive monetisation of consumers' flexibility, enabling consumers to become a central part of the energy system.

Chapter 1 – Motivation and research on Demand-Side Flexibility

With the transition of Europe's energy system, the need for flexibility and in particular, local flexibility, is becoming increasingly important. The role of consumer-empowerment is moving into the foreground as a means to improve services for consumers, while helping to drive competition, integrate variable renewable energy sources, enable the cost-effective uptake of electric vehicles, relieve pressure on electricity networks and allow for a nimble operation of the power market.

Enabling the employment of Demand-Side Flexibility at the residential and SME level, requires a range of specific steps to address a number of complications and barriers. It is therefore important to emphasise the value of tapping into this resource. This chapter outlines the numerous benefits provided by domestic and small commercial demand-side management and synthesises key findings on opportunities, barriers and consumer preferences from trials, literature and commercial experience.

1.1 The benefits of Residential and SME Demand-Side Flexibility

Households and small and medium-sized businesses have flexibility potential that represents precious resources for the energy sector. Currently devices such as electric boilers, air conditioning systems and many others, represent important potential resources for demand-side flexibility. These can be used to maximise energy use when it is most cost-effective, while reducing consumption at moments when the electricity system is under pressure and a number of our members are starting to exploit this resource.

As technological advancements allow for both the harvesting of flexibility from smaller loads and the storage of energy, domestic and SME Demand-Side Flexibility has increasing value in the marketplace. What is more, and of particular importance, unlocking the full Demand-Side Flexibility potential of this sector will benefit stakeholders across the value chain: consumers, governments, the energy industry, the social and private housing sectors. The section below provides an overview of the main benefits of Demand-Side Flexibility, specific to different stakeholder groups.

Consumer benefits

For small businesses and residential consumers, a major benefit of Demand-Side Flexibility can be the ***financial returns***. Demand-Side Flexibility can provide substantial cost-savings or generate additional revenue when the flexibility is actively sold on the energy market. By saving on energy bills, living becomes more affordable. For SME consumers, successfully employing Demand-Side Flexibility will significantly improve their competitiveness.

For many people, enrolling in a Demand-Side Flexibility program can also have a positive impact on ***lifestyle, comfort and health***. For example, smart applications or home management systems are normally designed to enhance the comfort of living by automatically adjusting to the consumers' preferred settings. They can even adjust humidity and manage ventilation within homes. What is more, people are ***empowered*** to play an active role in the transition towards an efficient and sustainable energy system.

The participation in Demand-Side Flexibility schemes also allows consumers to ***access information*** on their usage. It allows them to increase their insights and awareness regarding energy consumption and environmental footprint, while gaining a sense of control.

Finally, all consumers benefit from the fact that Demand-Side Flexibility can increase the efficiency of the energy system and can thus help ***bring down electricity costs for all consumers***, whether they directly participate or whether they do not engage in the flexible management of their loads themselves.

Benefits to business

While consumers are key actors in demand-side management, they can choose to leave the investment and/or operation of flexibility devices to a third party. When an asset- or property owner is involved, the benefits of Demand-Side Flexibility are usually shared between the owner and the user.

As such, demand-side management has led to the ***emergence of an entire new business sector***, that provides market opportunities for innovative technology companies and smart home product providers as well as for new and existing service providers. New market players like demand response aggregators have entered the field, and existing energy service companies (ESCOs) and retailers have the opportunity

to expand their service packages, adding a new source of revenue and improving customer loyalty and their company image.

Landlords may utilise Demand-Side Flexibility to lower the cost of living, ***making homes more affordable, healthier and more attractive***, especially in the area of social housing. In this way, Demand-Side Flexibility increases the value of their property while residents benefit from lower energy bills.

By engaging in Demand-Side Flexibility, consumers and business generate value to the entire energy sector, by providing ***cost-effective system management resources*** to TSOs, DSOs, and by enabling electricity generators and retailers to **support their balancing activities** in a cost-effective, efficient and sustainable manner.

Societal benefits

Through its local distribution and versatility, demand-side flexibility is optimally placed ***to integrate growing amounts of variable renewable energy resources*** along the entire energy system. At the same time, demand-side flexibility is a ***sustainable resource itself***, replacing the need for polluting back-up generation or new power plants. As such, it can **play a central role in achieving the EU's environmental and climate objectives**.

At the same time, employing Demand-Side Flexibility as an alternative to power generation can significantly reduce Europe's reliance on external energy sources and enhance energy independence.

As mentioned above, Residential and SME Demand-Side Management drives a new business sector, creating new employment fostering innovation. It not only opens up new opportunities for the energy sector, but provides benefits for the economy as a whole. The development of new innovative technology and solutions will create new business opportunities for technology and service providers. The entrance of new offers and players in the market will strengthen competition between electricity suppliers, driving the need for utilities to deliver better and more targeted services and choices to the customers.

1.2 Research and experience with Demand-Side Flexibility

Multiple trials have been conducted in order to measure the potential of Demand-Side Flexibility in the residential and SME sector, and first commercial offers have started to evolve in some European markets. Several pilots tested the technical possibilities and reliability of smart demand-side solutions, while other trials and surveys concentrated on the consumer perspective and examined the participants' response to price signals, their willingness to change behaviour, drivers to partake in the trial projects and their overall experience.

Based on a thorough examination of the studies and market experience, a number of conclusions can be drawn, which are presented in this section.[5]

Technical feasibility

A range of technical solutions have been tested to adjust the electricity consumption of household and SME appliances and energy services based on automation and external signals. Trials and experience gathered through pioneering commercial offers for instance in France, the UK and Finland, demonstrate the reliability and feasibility of Demand-Side solutions on the residential and SME level to respond to market signals and provide important network support services.

While solutions often start with individual devices, the interaction and capabilities of Demand-Side Flexibility services have continued to evolve, as shown for example in the Customer-Led Network Revolution project Northern Powergrid. This trial involving Time of Use tariffs for households, reported an average drop in peak demand of 10%.[6] Similar results were found in trials conducted as part of the Low Carbon London project. The study examines residential consumer response to dynamic pricing and quantifies the effect of Demand-Side Flexibility on the network through assessing the impact of network balancing services such as constraint management.[7] The trial reported a reduction of peak demand of approximately 5-10% across the Time of Use tariff group. In absolute figures, peak hour demand was reduced by up to 0.05 kW/household, which tripled to 0.15 kW/household for the 25% top responders, as compared to the measured after diversity peak demand of 1 kW/household.[8]

Consumer response to price signals

In the majority of cases, consumers respond well to price signals. Several studies testing Time-of-Use tariffs for households reported positive findings on consumer willingness to change behaviour, and demonstrated how 60% to 95% of participants saved money on their energy bills.[9] The size of demand shift varies across different trials. The largest and most reliable shifts in household's demand were delivered by interventions to automate responses where consumers had flexible loads such as heating,

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[5] The reports and trials that were examined for this research paper are listed in annex.

[6] Northern Powergrid, *Customer-Led Network Revolution project*, June 2014.

[7] Balancing method, based on price signals sent to the consumer, used by the grid operator to resolve transmittance issues resulting from network congestion.

[8] Low carbon London, *Residential consumer responsiveness to time-varying pricing*, September 2014.

[9] Low carbon London, *Residential consumer responsiveness to time-varying pricing*, September 2014.
Element Energy, *Further Analysis of Data from the Household Electricity Usage Study: Electricity Price Signals and Demand Response,* 2014.
Northern Powergrid, *Customer-Led Network Revolution project*, June 2014.

ventilation and air conditioning.[10] After automation, the greatest demand response was achieved by a combination of economic incentives and enhanced information.[11]

Consumer drivers

While economic incentives are a key factor in accepting energy management programs, they can also impose barriers, specifically when financial gains are uncertain or unclear and when pay-back periods are long. Another important factor that can negatively impact price incentives is the risk of unequal distribution of benefits. Some studies found that while the larger part of participants saved on their energy bill, another part ended up paying more – especially if automation was limited or excluded. Even if the costs of energy are reduced on average, ''winners and losers'' might be created when only the more engaged consumers can expect to be rewarded for participating in Demand-Side Response. To resolve this problem, the savings need to be passed beyond this consumer group and energy companies.[12] Crucially, the participation in market-related dynamic pricing programmes should be voluntary, maintaining a choice for consumers to opt for a hedged tariff offer.

In today's market, consumer interest in smart products and energy management services goes beyond the traditional, mainly cost-related criteria or energy-purchasing decisions. In other words; price alone will not drive adoption.[13] For this reason, Demand-Side Flexibility programmes become more appealing when they address a range of different benefits. The main non-financial drivers that were reported in trials and surveys include an increased sense of control, reduced impact on the environment, improvements in lifestyle, interest in new technologies and innovative solutions, and supporting the community.[14]

A crucial finding in this respect is that different groups of consumers express different preferences and needs.[15] Various consumer segmentations can be distinguished, based on demographics, interests, priorities, and technical capabilities. For example, seniors and families with young children found it more difficult to adjust their consumption behaviour than other demographic groups. The same issue was observed in the SME community, which is very diverse and whose priorities lie with managing their daily operations rather than managing energy consumption.[16] It is important to understand the different consumer segments in order to target their needs and incentivise them to enrol in energy management

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[10] DECC/Ofgem*, Smart Grid Vision and Routemap*, February 2014.
Frontier Economics and Sustainability First, *Demand Side Response in the domestic sector- a literature review of major trials,* August 2012.
[11] Frontier Economics and Sustainability First, *Demand Side Response in the domestic sector- a literature review of major trials*, August 2012
[12] Citizen's Advice Bureau: Take a walk on the demand side - making electricity demand side response work for domestic and small business consumers, August 2014.
[13] Accenture, *Revealing the Values of the New Energy Consumer,* 2010.
[14] Advanced, *Report with the conclusions of the qualitative survey taking into account the socioeconomic factors,* October 2014.
Accenture, *Understanding Consumer Preferences in Energy Efficiency*, 2011.
[15] Advanced, *Report describing the Actionable Framework for AD*, November 2014.
Accenture, *Revealing the Values of the New Energy Consumer,* 2010.
McKinsey & Company, *The Connected Home Survey*, 2015.
[16] Northern Powergrid Customer-*Led Network Revolution project*, June 2014.

programmes. Automation that **operates in the background** and therefore **minimises the impact on lifestyles** is an essential method that can address these issues.

General conditions for consumer acceptance of energy management

In the majority of the studies, a number of important general conditions were found for consumers to accept automation and allow third party access to data. The first concerns transparency and provision of information. Consumer distrust of service providers can be a valid obstacle for engaging in energy management programmes.[17] In order to overcome this barrier, service providers need to inform consumers on how the data will be used[18], and work on improving customer relations.[19] It is important to note that in a few cases, an abundance of information on user data, in the form of in-home displays, reports, advice and booklets, was observed to negatively impact peak shifting.[20] Furthermore, a multitude of different Demand-Side Flexibility offers can be confusing when they become hard to compare, due to a large amount of variables.[21] **Therefore, information should be simple, easy to comprehend, as well as readily available.**

Another concern often expressed by consumers was the impact of technology on their lifestyle and comfort. Accenture's consumer survey found that ''even where cost was a major motivating factor, many believed they would be unwilling to compromise too much to achieve lower energy costs. For similar reasons, many consumers said that complicated technology could prevent them from participating in Demand-Side Flexibility programmes''.[22] To address this concern, the **technology needs to be easy to use and to install, and consumers need to be well informed on their ability to control and override automated devices to suit their needs**.[23] Furthermore, consumers need to be educated on how automation can improve the level of comfort rather than reduce it.

Preconditions for enabling Demand-Side Flexibility

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[17] Accenture, *Revealing the Values of the New Energy Consumer - Accenture end–consumer observatory on electricity management 2010,* 2010
Advanced, *Report with the conclusions of the qualitative survey taking into account the socioeconomic factors,* October 2014.
[18] Advanced, *Report with the conclusions of the qualitative survey taking into account the socioeconomic factors,* October 2014.
[19] Accenture, *Actionable Insights for the New Energy Consumer,* 2012.
DECC/Ofgem, *Smart Grid Vision and Routemap*, February 2014.
Smart Grid Vision and Routemap,
[20] Element Energy: *Further Analysis of Data from the Household Electricity Usage Study: Electricity Price Signals and Demand Response*,
[21] Citizen's Advice Bureau: Take a walk on the demand side - making electricity demand side response work for domestic and small business consumers
[22] Accenture, *Revealing the Values of the New Energy Consumer - Accenture end–consumer observatory on electricity management 2010,* 2010.
Advanced *Report with the conclusions of the qualitative survey taking into account the socioeconomic factors,*
[23] Accenture, *Revealing the Values of the New Energy Consumer - Accenture end–consumer observatory on electricity management 2010,* 2010.
Advanced *Qualitative survey*,
Citizen's Advice Bureau: *Take a walk on the demand side - making electricity demand side response work for domestic and small business consumers*, August 2014.

The analysed studies identified several pre-conditions that are essential to unlock different Demand-Side Flexibility options. These including the following aspects:

Dynamic pricing should be available

Consumers should have the option to access to dynamic tariffs based on wholesale price signals, enabling them to save money by shifting their energy demand. [24]

Smart home systems are needed

Consumers should have access to "smart" products that are connected to a network, able to inform the user about their status and learn from consumer behaviour, as well as react to utilities or network signals. By using smart products, the consumer retains the ultimate control of his appliance and can override specific modes. [25]

A business case is needed

Consumer acquisition of smart products and enrollment in Demand-Side Flexibility options will become more common when regulations and markets evolve, facilitating the growth of appealing offerings. The development of appealing offerings and effective and consistent communication is essential to create a sense of need and desire.[26] Regulatory and commercial frameworks should facilitate the deployment of smart technologies and smart solutions, incentivise innovation and efficiency and support new commercial arrangements, whilst protecting consumer interests.[27]

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[24] DECC OFGEM, *Smart Grid Vision and Routemap*, February 2014.
Advanced, *Report describing the Actionable Framework for AD*, November 2014.
[25] Advanced, *Report describing the Actionable Framework for AD*, November 2014.
[26] Advanced, Ibid.
DECC/Ofgem, *Smart Grid Vision and Routemap*, February 2014.
[27] DECC/Ofgem, *Smart Grid Vision and Routemap*.

1.3 Consumer needs

Market experience and trials demonstrate that the technology needed to employ Demand-Side Flexibility in the residential and SME sector is progressing apace and continuously opening up new possibilities. Innovative technologies are expected to become commonplace in the near future.

To not miss the opportunities these developments provide, it is vital that the market - in other words, consumer adoption – is ready. While the commercial experience and trials show promising results regarding consumer appeal, large-scale adoption of the available technologies has not yet been achieved. The challenge remains to make these solutions available and attractive to consumers for a broader uptake. Today, the threshold for consumer engagement often appears high.

In the current energy system, electricity is a commodity and its availability is taken for granted. Consumption is largely decoupled in time from access to metering information and the payment of bills. Pilot studies show that raising awareness and providing access to consumption information does have some effect on consumer behaviour in this respect. Furthermore, the trials and commercial experience prove that consumers are willing to respond to price signals and adapt their energy consumption once the application is installed.

In the current market, however, real price signals and service offers are often unavailable to consumers. In addition, depending on the service model, the engagement in Demand-Side Flexibility can require investments in automation and in some countries metering equipment, for which the payback periods can be long. The consequence is that the possibilities and incentives to enroll in a Demand-Side Flexibility programme in real life can be surprisingly weak.

In order to enable residential and SME consumers to make an active choice for Demand-Side Flexibility, engagement options and services need to provide a compelling reason for participation by delivering significant, predictable benefits without requiring too much change in consumers' lifestyle or affect the level of comfort. Unlocking this potential requires an adequate regulatory framework that makes decentralised flexibility available and reveals its value to the consumer whose energy is being managed.

Chapter 2: Making Flexibility Available

Despite the clear potential and pioneering commercial offers, a broader market uptake of Demand-Side Flexibility programmes for residential and SME consumers has not yet taken place in Europe. This is in contrast with the Industrial and Commercial sectors where steady growth in demand management can be observed in those countries where the market conditions allow for it.[28] Among these large energy consumers, significant assets exist that can be managed, metering is in place (including sub-metering and short-term settlement structures) and lastly their scale makes the financial transactions simpler and more direct.

In the Residential and SME market sector in most cases the assets do not exist at scale, where assets are available, they are dispersed, metering is periodic with settlement done after the event on estimated profiles and as a consequence the monetisation mechanism is more challenging, if not impossible.

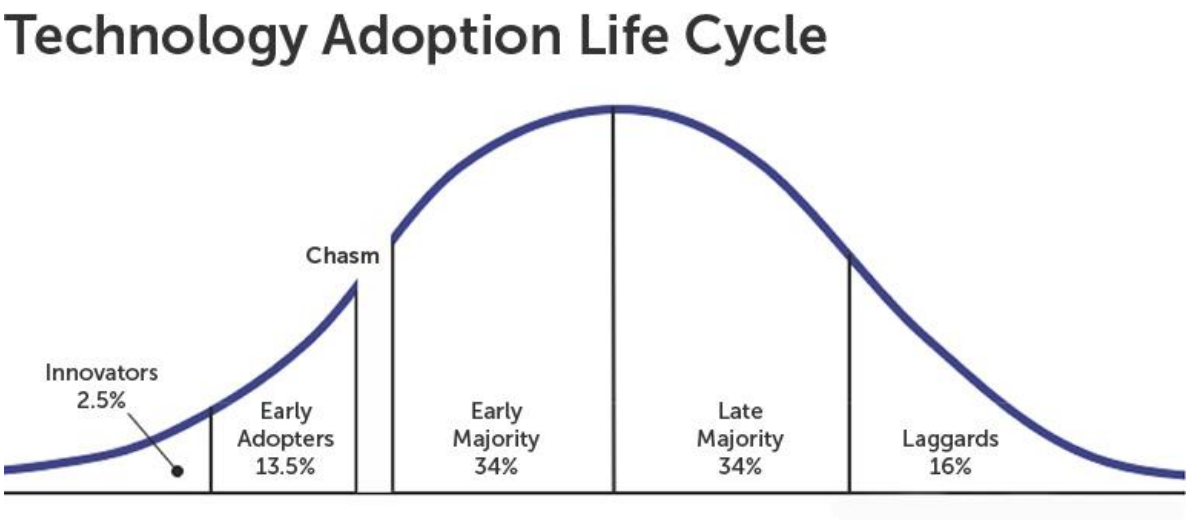
The challenge in the Residential and SME sector therefore lies in making decentralised flexibility available on the one hand, and in enabling the market to monetise this flexibility on the other. This chapter focuses on the former aspect of making flexibility available through technology adoption, in order to allow business models to develop around it.

[28] However, barriers for industrial Demand Response remain across Europe. E.g. market access for Demand Response aggregators or large consumers is limited, aggregated loads are not accepted in all markets and products requirements may be linked to historic generation patterns. For more information on barriers related to explicit Demand Response please see SEDC report: "Mapping Demand Response in Europe Today".

Technology adoption

The main challenge in making flexibility available is not the technology – it is the adoption of this technology by consumers. The general challenge of technology adoption is clearly illustrated in the work of Geoffrey A. Moore's ''Crossing the Chasm''. Moore uses Rogers' Innovation Adaptation Curve to identify a ''chasm'' in technology adoption between the early adopters and the early majority.

Currently, innovative Demand-Side Flexibility technologies mainly appeal to the early adopters, while adoption by the larger, mainstream consumer group has not been achieved. To resolve this problem, the main enabling focus must lie on crossing the chasm.



Source: http://www.theagileelephant.com/

To achieve this Moore advises identifying and focusing on an initial "bridgehead" and not the whole market. By finding a consumer group that can be enabled early on a "role model" is created that will encourage others to follow their example.

A further element that Moore emphasizes is a "whole product" approach. The early majority buyers are very pragmatic and want a product that has a complete established user journey including installation, support, maintenance etc. They do not want "cowboys" installing a unit and then disappearing leaving them with a "pup". The early majority want a professionalized product.

This is particularly relevant to Residential and SME Demand Management where there needs to be a number of moving parts as discussed above. It is not an easy concept for a consumer to grasp and be confident that it will offer *them* value.

In addition, early stage products inevitably have high prices due to low volumes. These initial solutions must therefore target ways that can reduce these costs through market competition, reducing sales and installation costs and concentrating benefits. For example, selling individual solutions separated geographically entails higher sales, installation and support costs rather than concentrating them in a single area – at least, before a geographical installation and support infrastructure can be built up.

The following propositions provide mechanisms for achieving this. The key is simplicity: the consumer needs to receive a turn-key solution offering immediate value.

2.1 Smart infrastructure in homes and SMEs

The electrification of heating and transport combined with the transition towards local decentralised electricity generation are creating significant infrastructure challenges and nowhere more so than at the local distribution network at the sub-station level. Electric vehicles add the equivalent of a new home's demand onto the substation, and make smart management both valuable and inevitable. Similarly, the introduction of heat pumps increases electricity demand significantly. While all these factors illustrate a growing need for flexibility at the local level, the introduction of these new loads also increases the potential for flexibility in homes and businesses.

Different options exist to access flexibility in consumers' homes and work-places. The entry point for flexibility can be from an individual automated appliance, a combination of appliances, or a fully automated Flexible Home.

The benefit of all these approaches is that they require no behaviour change, but can run autonomously, via a smart management system, or operated by an aggregator. They create significant demand response capacity and bring the Residential and SME segment in line with the Industrial and Commercial Sector by **creating the asset base** that can be accessed to provide flexibility services.

Managing current appliances

A number of potential flexibility assets are already installed in some homes and businesses: e.g. hot water storage tanks, night storage heaters and heavy loads such as air conditioning, electric heating systems etc. A small number of market players are actively addressing this market, particularly where the resources can be accessed with minimal intervention.

As appliances are typically not equipped with built-in communication technology, their operation usually requires the investment in additional smart management equipment by the consumer or service provider.

Future appliances

Further attractive flexibility potential could become available with increasing electrification of the transport and heating sectors, growth in energy storage and when old appliances are replaced with new ones that have demand management functionality built in to them. The larger the electrical load the appliance takes the more attractive this option is. Indeed, the first electric vehicle charging points, heating equipment, and appliances are beginning to appear with demand management controls built in to them.

As the number of controllable appliances in a building increases, it is important that the different appliances can operate through standardised data taxonomies to enable a coordinated management approach.

The Flexible Home

A Flexible Home is a home that combines traditional and modern ways of powering a residence together with a range of other smart technologies to deliver greater energy efficiency, reduced running costs and a better living experience. Through automation, the flexible home is run by the technology which can be installed as part of the building.

There are different means of making a home flexible. It could use a combination of some or all of these products: smart metering, smart thermostats, heat storage, battery storage, solar PV, electric vehicle charging, smart appliances, lighting controls, and it could even incorporate a direct current main ring.

The heart of this solution is that the system operates on its own in the background optimizing energy management using off-peak electricity plus, where available, solar generation. This "home-led" approach lends itself to new builds and is identified as a bridgehead for "crossing the chasm" as it offers the following benefits:

- It professionalises the market entry as the solution will be designed and managed by professional house builders.
- It reduces the cost of sales as this will be done through competitive procurement on estate volumes rather than individual sales to home owners.
- It reduces the cost of installation and maintenance as the system will be designed at the outset and installed in volume.
- It reduces other site energy distribution infrastructure costs.
- It enhances the capacity for solar PV and electric vehicle installations.
- It concentrates the demand management benefits.
- In the private market, it simplifies the consumer purchasing decision: the system is another fixture and fitting that comes with the house and is therefore bought on the mortgage.

As such it will provide an excellent role model that will encourage other homes to follow suite thus opening up and enabling the market. The Flexible Home model can also add value to social housing and the affordable homes concept, as they will crucially become affordable to run and affordable to buy.

Over time, the primarily appliances-driven approach and the Flexible Home are expected to converge as various aspects of the building interact through an IoT-enabled approach.

Smart meters & thermostats

In recent years there has been significant interest in the market for smart meters and thermostats. The investment into smart technology has resulted in the creation of devices that learn from customer behaviour and automatically adjust to preferred temperature settings, thereby increasing consumer comfort and energy efficiency. These products are easy to use and automatically help save money when consumers are enrolled in a dynamic pricing programme with their energy supplier, securing energy savings of 10-15%.

In the United States where already more than 10 million smart thermostats from different providers have been installed, Demand Response is also possible, through 'Rush Hour Rewards' style programs, where the energy company pays consumers to help reduce the load on the grid during rush hour periods. Programmes like this have so far helped achieve a 55% reduction in energy use during peak times.

While smart home controls systems in Europe are not usually linked with such Demand Response activities today, devices are available on the market that have the same capabilities and are likely to include Demand Side Response services in their offering as real-time pricing offers or Explicit Demand Side Response service become more accessible.

The smart control devices are typically compatible with almost all heating system and include a display (temperature controller and also provides local controls) and a mobile app (used to set daily temperature profiles and control the heating remotely). Some providers enable consumers not only to monitor but also compare their consumption, inspiring them to become more efficient.

Alongside the evolution of smart thermostats, Demand Response service providers and device manufacturers have started to offer heat pumps and other domestic climate systems that directly include smart control technology. Smart appliances help consumers to optimize energy consumption and energy cost savings, increase energy efficiency and system costs reductions, improve consumer choice and empower them to have ultimate control over their appliances, and create new services for end customers.

Smart appliances communication standardisation

Different projects and networks of different market players from energy, telecommunications, electronics and automatisation sectors have emerged in Europe to ensure the interoperability of the different solutions. In other words, these project focus on defining the ability of appliances and devices to connect and interact between themselves and with the energy system, based on and identical understanding of messages and data that are exchanged between the respective markets and devices.

These important initiatives should eventually lead to European and global universal standards to support the consumer-friendly and efficient digitalisation of energy solutions.

2.2 Challenges and enablers

While the examples above provide practicable models to start off the market, a number of challenges remain that hinder broader implementation.

Information and comparability

Today, awareness levels of demand response options and services are low. Consumers often have no way of knowing the demand management potential of their homes and appliances, and no comparable labelling or certification schemes exist so far. To bridge this gap, complementary labelling for both appliances and buildings will be essential.

People also have no guidance to take the potential into account in their buying and renting decisions for properties and devices. Efforts are still required in educating and convincing users that the expense for a smart appliance is worthwhile and preferential to a non-smart version.

Payment gap

The payment gap refers to the time-lag between consumer acquisition of a technology and the financial remuneration collected by demand response payments. As seen in Chapter 1, engagement in many types of Demand-Side Flexibility requires investments in automation or metering equipment. For example, where smart metering is already in place and where the domestic heating and cooling systems include significant storage potential, a smart thermostat will unlock important flexibility potential for a typical cost of 200-300 euros.

A fully flexible home that integrates individual propositions to maximise their effectiveness could add approximately 1-2% to the cost of a home at the early bridgehead stage of the market. This would make the pay-back at current electricity prices well over 15 years and therefore unattractive to most purchasers or home providers. However, with time-limited investment incentives, as have been implemented for electric vehicles in different countries, a flexible home could become a highly attractive purchase/rental proposition that would contribute significantly to the cost-effective management of the energy system as discussed in Chapter 3.

Standardisation/ Open protocols

Interoperability remains a significant challenge in an emergent market. The appliance-led approach currently depends on individual systems talking to the internet and being integrated “in the cloud”. Therefore, a reliable internet connection is a pre-requisite for the system to function as a system.

The flexible home approach starts from an integrated energy management system in the home that accesses implicit demand management services (Time of Use tariffs). A number of these are emerging and consist of a fairly sophisticated hub in the home with multiple Home Area Networks to interface with smart meters, electric vehicle connections, solar panels, appliances plus the “middleware” required to integrate them. Occupiers can then choose to further enhance their benefits and functionality, for example, managing their homes remotely, by accessing the intranet and using the services of an aggregator to deliver explicit demand management payments.

While the market does not depend on first having standardization across open protocols (of which there are many), universal standardization of communication protocols would enhance interoperability, facilitate the switching of service providers, and drive down costs.

Data access

The efficacy of the home-led solution as with the appliance-led solution will be greatly enhanced by local access to live energy consumption and tariff information. Whilst this can and is provided through the internet, this should be seen as possible complementary service not as a requirement driven by inadequacies of the metering solution provided. Local, live data enables automation: It also simplifies the settlement process.

Based on the evidenced trials collected, the provision of information is among the main elements in empowering energy consumers. Access to data enables consumers to better understand and manage their usage. Key data includes consumption and billing, as well as the results of data analytics such as comparisons to average customers or estimated consumption of major appliances. Important policy and implementation areas include what data is available, where consumers can view it, data exchange standards, customer authorization of parties to receive their data, timing of data collection from the meter, timing of data availability, different models for sharing data between market participants (i.e. data hubs and DSO-centric models), data security, and others.

2.3 Recommendations

To address these challenges and facilitate a 'push' for market take-off, we propose a set of enablers that would ensure developers start to build smarter products and flexible homes so that owners are able to recover the higher costs of their homes when they sell them.

Smart building certificate and a "smartness" indicator on the Energy Label

The European Energy Efficiency Certificate for buildings should be complemented with a Smart Building Certificate that offers a standardised identification of the available demand management capacity of a building measured simply in terms of load (KWp) and capacity (KWh). Also, the European Energy Efficiency Label for appliances should be complemented by introducing an indicator for the smartness of an appliance, in order to show its potential to respond to external signals to adjust electricity consumption using the same units.

Such a certification of buildings, and a smartness indicator for devices could be easily recognised by consumers, and by all relevant market actors – including construction firms and financial funds, as well as demand-side flexibility service providers and energy retailers.

Short-term incentives to close the funding gap

To create a bridgehead to start the market and address the funding gap, short-term incentives at the national level should be linked with the Smart Building Certificate of the building. While the European Energy Performance of Buildings Directive currently provides for incentives for investments in static energy efficiency, such incentives should encompass also the flexibility and connectivity capabilities of a building. The measures are required for the early phases of market uptake of flexible energy buildings. This could include tax rebates (for instance, tax adjustments to compensate buyers for the increased cost of the house) or investment incentives for newly equipped buildings. Similar incentives may be applied to smart appliances that have a smartness indicator.

These measures should be proportionate to the certificate of the building and time-limited to the early phases of market uptake of active energy buildings. As the demand management market matures and consumers are enabled to market their flexibility through a service provider or retailer, the direct incentives will no longer be required.

Planning stipulations

To further encourage developers to build flexible homes the planning system should be encouraged/ required to meet certain EPBD performance levels.

Data Access and Standardisation

Consumers should be enabled to access smart meter data locally and all data related to their own use of energy at all times. At the same time, consumers should be enabled to have control of their own data privacy and security. Each energy consumer should have the full right to decide which market player(s)

will be allowed to access specific – standardised and machine-readable - data relating to their own consumption, including new service providers.[29]

More than anything else, these measures would **put consumers at the heart of demand management.** They would re-vitalise the electricity market and set the direction for meeting the challenges of electrification of heating and transport and the energy trilemma.

[29] For more information on this topic, please refer to the SEDC Position Paper on Data Access in the Electricity Market, September 2016

Chapter 3: Enabling a Market for Flexibility

In order to enable the marketing and use of the Demand-Side Flexibility and help it become viable at large scale, it is essential to complement the 'push' with a 'pull' approach. This means that a competitive market environment must enable the development of service offers that allow for the monetisation of demand-side flexibility.

Depending on the consumer's flexibility potential and preferences, different approaches are possible to monetise residential and SME consumer engagement in Demand-Side Flexibility. Three central models can be distinguished in this respect:

(1) **Implicit Demand-Side Flexibility,** where the consumer can save on the energy bill by adjusting energy consumption to variable market-price signals,
(2) **Explicit Demand-Side Flexibility**, where the consumer sells local consumption and possibly generation flexibility via an aggregator, and
(3) **Local optimisation** where a consumer is connected to a local power generator or engages in self-generation of electricity, e.g. through a solar system. By combining variable electricity output with dynamic demand management, local consumption can be optimised to save on electricity purchases and to support the grid system.

These approaches usually go along with services and automation, optimising the convenience and comfort for the consumers. The services can also be part of integrated offers, connecting solutions for electricity use, heating, air-conditioning and ventilation, transport, security or health and safety.

3.1 Implicit Demand-Side Flexibility

In an implicit Demand-Side Flexibility scheme, a consumer chooses a dynamic market-based pricing option that can – depending on the choice - lead to limited or full exposure to market price fluctuations. This is usually combined with the automated steering of consumption from certain devices.

A number of service providers offer this form of Demand-Side Flexibility in Europe today.

Automated appliance optimisation through hourly pricing

In different European countries, first retail offers have emerged that combine the automation of devices with attractive market-related price offerings for consumers.

For example, in the UK and Germany, individual retailers have started to offer their customers more competitive tariffs in combination with the automation of their appliances. Different financial models are possible, where either the retailer or the consumers makes the investment in automation solutions. Real-time price monitoring allows the retailers to obtain energy at the lowest price, while the automated adjustment of the devices enables the customers to provide flexibility without having to actively adjust their behaviour.

In Finland, consumers can choose hourly electricity pricing from a retailer, combined with smart controls on electric heating devices (electric radiators or heat pumps). With this offer, consumers are able to heat their homes using cheapest hours in electricity markets avoiding the most expensive ones.

The consumer may opt for this model to save electricity costs. Flat electricity prices or simple day-night tariffs are the standard model for most residential and SME consumers today. These usually include hedging margins that suppliers charge to ensure that consumers can receive the same price when wholesale prices are higher. If the consumer chooses a flexible tariff with smart consumption, he will maximise the consumption when power prices are low, while consuming less at times of price peaks. This will allow him to pay less than the average electricity price, which is calculated on the basis of a non-flexible consumption profile. In participating in the dynamic market-based pricing, the consumer will also require less hedging from the retailer, which further decreases the electricity bill.

In addition to the financial benefit, consumers may engage in this model as it allows for increased transparency and information on consumption patterns, especially if complemented with relevant information from the retailer or service provider. Further drivers include the participation in the energy transition with positive effects for the environment or society in general.

It is important to note that in a fully competitive market, prices for consumers remaining with flat electricity tariffs will not be negatively affected by those opting for a dynamic approach. This is because the retailers' sourcing costs for a unit of electricity for consumers with a flat tariff structure will remain stable or even become lower in a market with higher participation of Demand-Side Flexibility. Consumers engaging in Demand-Side Flexibility thus compete with electricity generation technologies, but not with consumers who do not have the possibility to engage.

The market offer and barriers today

The incentive for retailers to offer market-related dynamic pricing schemes derive from the reduced need for balancing and hedging on the energy markets. However, only a few retailers offer market-based short-

term pricing to their residential and SME customers in Europe today. The reason for the slow uptake can be found in market barriers, regulatory conditions and limited metering functionalities.

Established retailers may initially be wary to move to dynamic pricing as their profit margins could be reduced in line with lower hedging requirements and a possible net reduction of electricity use. However, in a competitive environment where customer loyalty is gaining in relevance and smart solutions are easily available, market-related short-term pricing schemes with good consumer services can be expected to gain importance.

Preconditions for Implicit Demand-Side Flexibility include the availability of short-term, market-related tariffs, the availability of short interval metering, as well as the automation of consumption. These conditions are currently not met in many European markets today. The automation equipment and access to relevant metering or tracking devices can be part of the retailer's dynamic pricing offer, but it can also be provided by an independent service provider or based on off-the-shelf technology controlled by the consumer. Devices can be leased or privately owned by the consumer. The engagement will become simpler as buildings and household appliances are increasingly equipped with smart management options as standard solutions, supported by certification and incentive structures as described in Chapter 2.

Depending on the uptake of Implicit Demand Response, the granularity of real-time pricing signals may impose the risk that load synchronisation will lead to increased pressure on the grid. To resolve this issue, Implicit Demand Response is sometimes combined with Explicit Demand Response options or critical peak network tariffs, signalling when it is more valuable for the consumer to react to system constraints.

Regulatory recommendations specific to Implicit Demand-Side Flexibility

To enable the uptake of implicit Demand-Side Flexibility, it is critical that the necessary pre-conditions are met and regulatory barriers are removed.

In particular, every consumer should have the right to a smart meter with the necessary functionalities to support dynamic pricing offers.

At the same time, every consumer should have the opportunity to choose short-term market-related electricity pricing. In line with this requirement, the balance responsibility of the energy retailer should be set up in a way that is aligned with the actual load profile of the consumer. This requires an adaptation of the settlement processes, which should be enabled also by the involved DSOs and TSOs.

More generally, competitive wholesale markets with effective price signals will be important to realise the full value of Demand-Side Flexibility.[30]

[30] For more details on this topic, please refer to the SEDC Position Paper on Price Signals in Electricity Markets, July 2016

3.2 Explicit Demand-Side Flexibility

Consumers' flexibility can also be directly monetised through so-called Explicit Demand-Side Flexibility. By partnering up with an aggregator – be it an independent service provider or a retailer – residential and SME energy users can sell their flexibility to Transmission System Operators, Distribution System Operators or other market participants requiring balancing or system support services.

Explicit Demand-Side Flexibility is usually traded before the actual activation of the flexibility – through increased or decreased use of electricity at a certain time. As such, the consumer – through the aggregator - makes a commitment on the volume and timely availability of the resource.

The market for residential and SME demand aggregation is still very small. A selection of various examples of aggregating domestic and small commercial loads within Europe are described below.

Home battery automation

In the Netherlands, home battery automation has been advanced by a major electricity supplier. In exchange for a discounted home-battery, the consumer agrees to let them use 30% of the battery capacity. The aggregated capacity is then used to spread over its consumer portfolio to create a virtual power plant providing balancing services to the grid.

On the top of a discounted battery, the consumer receives an annual payment of 450 € guaranteed for 5 years. The 70% limit in storage capacity only has a very limited impact on the consumer's use of the battery.

HVAC hardware on site

Independent Demand Response aggregators have been active in providing technology to residential consumers in order to connect appliances so as to aggregate their flexibilities. For instance, one European aggregator uses a wireless transmitter and electricity modulator provided to consumers, installed and operated without charges, to connect appliances such as electrical heaters, air conditioners, heat pumps and water boilers in homes, commercial buildings and offices. The aggregated flexibilities are sold to the grid operator for balancing and safety purposes, and on a daily basis to all players through wholesale markets. Approximately 100,000 members are currently participating in this real-time DR programme, annually saving 10-15% on electricity bills according to the aggregator's information.

Another European aggregator has recently announced a cooperation with a manufacturer of heating devices to directly include control technology into the devices, enabling consumers to participate in Explicit Demand Response offers without further investments costs for the consumer or the aggregator.

Transactive energy management solutions

The market for energy management solutions has also been developing on pace. An aggregator active in Europe accumulates transactive loads such as electric thermal storage heaters, hot water heaters, ice-based air conditioning, compressed air storage, and electric vehicles into a grid asset (Virtual Power Plant), to deliver ancillary services to grid operators. They also monitor real time price variation and purchase electricity when it is cheapest. Through the combination of savings from arbitrage with profits from ancillary services, they provide low-cost ancillary services to grid operators and reduce the cost of heating for consumers. According to the aggregator's information, a homeowner can typically save 25% on the cost of heating their home.

Depending on the business model and market conditions, customers signing up to an explicit Demand-Side Flexibility programme could receive a number of benefits. In today's market, the main benefit is free

information on energy efficiency and increased control of their energy consumption, combined with a financial incentive. In order to participate in explicit Demand-Side Flexibility programmes, consumers require a central device or interactive appliances in their home to connect loads to an aggregation platform.

The market offer and barriers today

As load aggregation is an essential precondition to effectively market domestic and SME flexibility through the explicit Demand-Side Flexibility model, it is mainly this type of Demand management that creates new market opportunities for third party aggregators to enter the market and for existing electricity providers to extend the scope of their services. By offering modern, innovative and economically attractive offers, combined with the provision of extra information and a modern customer service platform, businesses increase customer satisfaction and loyalty, providing them with a competitive edge.

While there are different aggregators in Europe actively trading industrial and large commercial loads in flexibility markets, only few players have expanded their services to residential loads, as they have so far been costly to access. The market for Explicit Demand-Side Flexibility thus remains small. However, as smart technology becomes more broadly available as described in Chapter 2, the residential segment is likely to become more attractive for existing aggregators. More players are likely to emerge in the form of both new start-ups (e.g. control- and software companies) and utilities or ESCOs, adding aggregation to their service packages.

Today, a number of barriers hinder further developments in this area. In many countries, independent Demand-Side Flexibility aggregators are hindered from entering the market, and a clear regulatory framework is missing. Also, many flexibility markets are closed for demand products, as outlined in the SEDC Demand Response Map, as well as the SEDC White Paper on Demand Response at DSO level.

Another possible concern stems from market conditions pressing the value of flexibility. Many European markets run over-capacity, leading to low balancing prices that make the conditions for service providers unfavourable. However, this situation is expected to change as over-capacities are reduced, while growing shares of variable generation increase the demand for flexibility.

Regulatory recommendations specific to Explicit Demand-Side Flexibility

In order to allow Explicit Demand-Side flexibility to realise its potential, important amendments to the regulatory context are essential. Although the access to the flexibility resource will differ, the market requirements are identical for residential, commercial and industrial applications.

As a first condition, Demand-Side Flexibility should have access to all energy markets on an equal footing with generation. While European provisions for this exist in principle, they are currently not sufficiently enforced in a number of European countries and Demand-Side Flexibility is still excluded from important markets for grid and system services.

Also, product definitions in all markets, including for grid services and hedging or capacity products should allow for all flexibility technologies to participate, including demand response, storage and decentralised generation.

Crucially, third party Demand-Side Flexibility Aggregators must be able to access all markets without prior agreement of the respective customer's energy retailer/Balance Responsible Party. A clear regulatory

framework should be put in place, defining the roles and responsibilities and putting in place standardised processes for information flows on a need to know basis, as well as volume and financial settlements between the different market parties, with a view to avoiding any significant distortive impacts on the retailers/BRPs.

In order to allow for the best use of Demand-Side Flexibility to support the distribution system, the regulatory framework should be adjusted for Distribution System Operators, to encourage them to source flexibility services on a market-basis when it can be a cost-effective alternative to network investments.[31]

More generally, as is the case for implicit Demand-Side Flexibility, competitive wholesale markets with effective price signals will be important to realise the full value of Demand-Side Flexibility.[32]

[31] For more details on this topic, please refer to the SEDC White Paper on Demand Response at DSO level, April 2016

[32] For more details on this topic, please refer to the SEDC Position Paper on Price Signals in Electricity Markets, July 2016

3.3 Local optimisation

The third approach for monetising Demand-Side Flexibility is through the optimisation of demand with local generation. In this scheme, the consumer is connected to a local power generator or engages in self-generation of electricity, for instance through a solar system. By combining variable electricity output with dynamic demand management, local consumption can be optimised to support the grid system and to save on electricity expenses from the grid.

Consumption and self-generation optimisation
A service provider in France controls the -on and -off switch of home appliances to synchronise local production and local consumption, while maintaining consumer comfort. In addition, they provide an app with real-time analytics that allows them consume to control appliances remotely. In fact, it is estimated that this solution offers 20% energy efficiency and self-consumption optimised to cover up to 50% of electricity needs without using a battery.

Self-generation and storage optimisation
A supplier in Germany offers installation and management of self-consumption devices. It includes the installation and optimisation of solar panels, home batteries and electric car charging stations. Recently, they also introduced an offer for green electricity based on a monthly flat rate for consumers' electricity use.
Through this offer, the consumer can optimise the use of self-generated electricity, including through a remote control app. The complete offer is lastly accompanied with a long term guarantee.

Self-generation optimization integrated with supply of green electricity
A green energy company in Europe supplies private and business customers with certificated green energy directly from CHPs, solar installation and energy markets. Through a distributed energy optimisation software, customers are integrated into a complete smart grid offer. They not only receive certified green electricity, but the application also helps customers to optimise their local power plants and storage, including by receiving the financial benefits from grid support.

Consumers that choose to optimize their energy use, often do so to optimize the financial benefits of their own electricity generation system. Synchronisation of local demand to local generation can maximise the value of self-generation and self-consumption, shortening the payback period for initial investments. Combining this with implicit or explicit Demand-Side Flexibility options to react to price signals from the energy system, can further improve the investment case.

In addition, customers are informed and know the source of the energy they consume, and even have the potential to become energy autonomous. Through this, consumers gain a sense of control on their ecological footprint.

The market offer and barriers today

Service providers offering local optimisation programmes collect revenue from the consumer, which can be done through offering a leasing model on smart local management solutions, by collecting a service fee in return for the consumer's monthly savings on their bill, or through the introduction of innovative package deals for the consumer's monthly energy supply. If the local optimization model is combined with an implicit or explicit Demand-Side Flexibility engagement, additional revenue can be collected as described for the models above.

Today, grid parity for self-generation of photovoltaic electricity has been reached in certain markets, meaning that it is cheaper to consume self-generated electricity when it is available, than to buy electricity at retail prices from a grid. While this has driven the market uptake of residential approaches for local optimization in some countries, regulatory barriers or uncertainties hamper or prohibit self-generation in others. In some European countries, local generation is not allowed or has only recently been introduced. While general policy trends are in support of local generation and decentralization, much still depends on regulatory and tax structures.

The main risk concerns the allocation of taxes and grid charges for local generation. For example, in Germany, the renewable energy surcharge that is usually added to electricity retail prices, is also charged in parts on self-generated electricity. While such a re-distribution of taxes and charges can be expected to increase across Europe, transparency and regulatory foresight are essential to enable consumers to calculate their investment case.

Local projects for self-consumption and optimization that go beyond an individual household or building could be very attractive in principle, but are practically impossible in most situations today. Regulations for Distribution System Operators and rules on network access and charges currently do not foresee the possibility for local cooperation beyond the consumer's meter.

Regulatory recommendations specific to Explicit Demand-Side Flexibility

To enable and encourage the further development of sustainable decentralised resources for the energy system, consumers should be enabled to self-generate their own electricity or participate in local projects. Long-term regulatory certainty and transparency on taxes, levies and grid charges will be essential to enable and safeguard investments.

In order to enable prosumers to actively participate in the energy market and monetise their flexibility for the benefit of the electricity system, it is important that they have the possibility to engage in Explicit and/or Implicit Demand-Side Flexibility as described above.

Adding value to flexibility by bundling services

A trend in today's energy market is energy retailers and energy service companies looking to add value to their offerings by bundling technology and services with additional services such as building control and security, health services, efficiency or providing added value to building upgrades. This development could lead to a further diversification and competitiveness of offers for technology investments and energy services across different business models.

Integrated offerings currently mainly exist in the form of building automation systems for larger commercial enterprises.

Energy controls, automated energy efficiency and demand response

Different examples exist in particular in the US, where energy service companies provide building automation management solutions for commercial buildings, automatically controlling the building management system (BMS) accounting for the learning models for the building's thermal behaviour, BMS capabilities, and tenant comfort. The services often include real-time usage information to monitor energy consumption as well as other conditions such as lightning, air quality, security and humidity. The energy management offers are typically completed by providing demand response services.

European experiences in energy management and demand response for commercial buildings

Several European companies are trialling similar services:

- One specific instance is the partnership between a consultant engineering firm, together with a major global energy management player and a service company, who experimented integrating lightning, temperature and ventilation controls in a commercial building in Denmark.
- Another major energy management player has been experimenting with integrated energy efficiency and energy control services together with demand response services in their commercial office in the UK.

Chapter 4: Overview of Policy Recommendations

To help unlock the potential of residential demand-side flexibility and enable business models described, important regulatory adjustments are necessary to overcome persisting barriers. A competitive market with effective price signals and fair access for new market actors and solutions will be essential for demand-side solutions to develop. Especially in the early phases, specific supporting measures can drive the necessary technology push that will complement an evolving market pull.

Making flexibility available

- The **European Energy Efficiency Certificate for buildings should be complemented with a Smart Building Certificate t**hat offers a recognizable and marketable identification of the available Demand Management Capacity of a building.

- Also, the **European Energy Efficiency Label for appliances should be complemented by introducing an indicator for the smartness of an appliance**, indicating the potential to respond to external signals to adjust electricity consumption.

- **To start the market, short-term incentives for the energy performance of buildings at the national level should be linked with the smart building certificate described before.** While the European Energy Performance of Buildings Directive currently provides for incentives for investments in static energy efficiency, such incentives should encompass also the flexibility and connectivity capabilities of a building. The measures are required for the early phases of market uptake of flexible energy buildings. These types of incentives could include tax rebates or investment incentives for new home owners. Energy-efficiency mortgages could be related explicitly to the Smart Building Certificate with tax-incentives passed to mortgage providers to encourage their uptake. Similar incentives may be applied to smart appliances that have a smartness indicator.

- **Consumers should be enabled to access all data related to their own use of electricity at all times**. At the same time, consumers should be enabled to have control on their own data privacy and security. Each energy consumer should have the full right to decide which market player(s) will be allowed to access specific – standardised and machine-readable - data relating to the consumer's own consumption, including new service providers.[33]

Enabling the market for flexibility

- **Smart meter programmes** need to be implemented as soon as possible and every consumer should have the right to a smart meter, providing life consumption and tariff data so that in-home energy management can be automated both in the cloud and in the home.

[33] For more information on this topic, please refer to the SEDC Position Paper on Data Access in the Electricity Market, September 2016

- Consumers should be enabled to **have control on their own data privacy** and security. Each energy consumer should have the full right to decide which market player(s) will be allowed to access specific – standardised and machine-readable - data relating to the consumer's own consumption, including new service providers.[34]

- **Any consumer should have the right to choose short-term market-related pricing** and the retailer/BRP should be settled accordingly.

- **Third party aggregators must be able to access all markets without prior agreement of the respective customer's energy retailer/Balance Responsible Party.** A clear regulatory framework should be put in place, defining the roles and responsibilities and putting in place standardised processes for information flows on a need to know basis, as well as volume and financial settlements between the different market parties, with a view to avoiding any significant distortive impacts on the retailers/BRPs.

- **EU rules providing access for demand-side flexibility to all energy markets** (wholesale, balancing, ancillary services and capacity) on an equal footing with generation exist in principle (Energy Efficiency Directive, Article 15.8), but need to be further specified to capture the structural advantages that demand-side resources deliver.

- **Product definitions of all markets should allow for all applicable of technologies to participate, including demand-side resources, distributed generation and storage.** They should reflect the real needs of the electricity system, instead of being designed around the capabilities of traditional generation technologies.

- **The regulatory framework for Distribution System Operators should be adjusted to encourage them to source flexibility services on a market-basis**, where it represents a cost-effective alternative to network investments.

- **Consumers should be enabled to self-generate their own electricity or participate in local energy projects**. Long-term regulatory certainty and transparency on taxes, levies and grid charges will be essential to enable and safeguard investments.

[34] For more information on this topic, please refer to the SEDC Position Paper on Data Access in the Electricity Market, September 2016

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Annex

This annex contains the trials and research reports that were examined for this research paper. Included are references to the sources and an overview of the main findings and conclusions.

ADVANCED (Active Demand Value ANd Consumers Experience Discovery)

Report with the conclusions of the qualitative survey taking into account socioeconomic factors, October 2014.[35] *Deliverable from the Advanced FP7 project: A qualitative research report based on in-depth interviews with 88 consumers who have participated in DSM and energy efficiency programmes (Active Demand or AD in report).*

Drivers to Participate in Pilot

- Greater personal control of energy consumption / Short and long term energy cost savings.
- Being part of a project focused on energy consumption (individual goals / wider energy issues / need to use energy more efficiently).
- Being part of an innovative energy initiative / Access to new technology to control consumption.
- Supporting the community.

Barriers

- Distrust of providers: Established distrust of providers (mainly the case in Italy and France) or generalised skepticism.
    - *Solution:* Organising local events, relying on word of mouth and the support of Government may work in certain areas.
- Concerns about the impact of installation.
    - *Solution*: Installation needs to be seen as efficient and causing minimal disruption, consumers need to be presented with information and demonstrations and need to be ensured that the installation will be easy to use.
- Impact on comfort of reducing energy consumption: participants were willing to reduce energy consumption to reduce costs, but agreed it should not be at the expense of household comfort
    - *Solution:* Inform consumers on user control over the devices or the ability for consumers to override the devices and appliances to suit their needs.
- Privacy of data: (minor) Issue related to distrust of the project and providers.
    - *Solution:* provide participants with information and reassurances about how data will be used (but not to unnecessarily raise concerns or even trigger the issue).

Conclusions

- Before the project, consumers saw energy as an abstract concept surrounded by complex factors. DR is a new concept that does not fit easily into existing consumer frameworks.
- Providing feedback on consumption data caused a majority of consumers to think more consciously about their usage and energy consumption, increased the sense of responsibility

[35] Report available at: http://www.advancedfp7.eu/getattachment/a6b6196b-ebfb-4e19-8504 d069a81d2695/ADVANCED-D3-2-Qualitative-analysis.aspx

toward energy usage and raised awareness of the need to moderate consumption and use energy more efficiently.

- **Education and information** are key conditions for behavioural change on both the driver and barrier side, as it raises motivation to meet environmental/sustainability goals, increases understanding of their environmental impact, helps to understand consumption and consumption data, what and how to adjust their use, and how to use energy management systems.

Differences between consumers' situation

- SME's were interested as they have more to gain from saving costs than households, but they are also less flexible in their energy use (especially bar owners).
- For people in more comfortable economic circumstances, the cost of energy was less important and they were much less likely to be motivated by cost factors.
- Some people (albeit a small minority) who were not very motivated to consider reducing their energy consumption either due to the cost or environmental/sustainability issues.
- Differences between markets: more awareness in Germany (due to energiewende), more distrust of providers in Italy.

ADVANCED (Active Demand Value ANd Consumers Experience Discovery)

Report describing the Actionable Framework for AD, November 2014.[36] *Deliverable from the FP7 project. Focusing specifically on residential consumers, the report considers the drivers and barriers facing active consumer participation in AD. The report proposes a large number of regulatory and non-regulatory actions, corresponding to associated drivers and barriers, explained in detail.*

Drivers

- **Consumer knowledge through education and feedback.** Consumers lack an understanding of their consumption, for instance their impact on the environment or how much they can do to help the environment through their own AD related actions. Through education, environmental issues will become a higher priority issue for consumers; The focus must be on the degree of benefits that come from different types of action. **Consumption feedback (i.e. monitoring) is therefore an essential part of knowledge**. Customers need to relate their behaviour to their consumption.
- **Trust and relationship through experience**. Customers need to be impacted by positive experiences and both the image of the sector and satisfaction with individual service providers must be improved, so that consumer trust improves, and subsequently consumers' willingness to accept supplier management increases.
- **Consumer Journey, one step at a time**. Consumers must be guided through the process to remain engaged in and accept increasing levels of AD, gradually increasing their trust in the AD supplier and in their energy consumption being increasingly controlled by that supplier.
- **Support when it is needed**. AD requires support in many forms: pre-education, technical support, advice and suggestions. Consumers who do not receive sufficient support (e.g. in the form of a hotline) are likely to not become active, give up, or simply not benefit from the full potential of AD.
- **Comfort and confidence with technology**. The use of simple technical solutions and education prior to use of technologies makes AD appealing to more consumers.
- **Opportunity, need and desire**. AD will become increasingly appealing as consumers have more to gain through the use of AD in coordination with the synergies afforded by e.g. roof-top solar, storage and electric vehicles. It will become more common when regulations and markets evolve, facilitating the growth of appealing AD offerings. The development of appealing offerings and effective and consistent communication is essential for this sense of need and desire.
- **Spreading the word**. AD can become a more prominent topic of social discussion.
- **Conforming and competing**. Consumers are driven by the norms around them, the knowledge of how they compare to other consumers and their own track record. As AD becomes more common, it will also become a more prominent and powerful driver of behavioural energy efficiency. AD therefore, to some extent, drives itself.
- **Right consumers, right message, right time**. Some consumers are more suited to AD or more likely to be early adopters. Different consumers are driven by different motives, want different things and therefore need to be offered differentiated offerings. Timing: The relevance of active

[36] Report available at: http://www.advancedfp7.eu/getattachment/17c8c322-492c-472b-91db-98417c5ef4ef/ADVANCED-D5-2-Actonable-Framework.aspx

consumer participation in AD is very heavily context specific. AD is relevant for instance when the consumer has the opportunity, when the offerings are good enough, when energy prices are high, offering costs low enough, regulation appropriate, and when the consumer knows enough, has sufficient experience and trusts enough; the level of participation will increase as all of these factors evolve and as the consumer grows, shares her/his experiences and as AD becomes part of the norms of energy consumer behaviour.

- **The success** of active consumer participation in AD is therefore **highly dependent on offering the right service to the right consumer at the right time**. Segmentation is therefore essential to the successful adoption of AD by consumers.

Barriers

- **Lack of access to data / smart meter & in-home feedback and AD infrastructure and follow through.** Consumption monitoring tools and services appear heavily reliant on the mandating of infrastructure, specifications, standards and technical solutions for data communication, access and control (incl. mandating technical access to data). Regulators tend to shy away from such mandates.
- **Appliances (including smart appliances) are rarely 'AD ready'; Insufficient controllability of appliances (including also EVs).** Too few people have distributed generation or AD ready smart appliances. Some smart appliances fail to provide the controllability required for AD, either because they have the wrong interfaces, protocols, communications or otherwise.
- **Tariff and Billing inflexibility (lack of enablement of dynamic prices).** Dynamic tariffs are often not allowed in markets. Regulations to ensure tariff simplicity and comparability can be at the expense of variable tariffs or the innovation of more effective (and desirable) variable tariffs.
- **National needs for AD not always sufficient to drive policy.** National needs for capacity, network congestion problems, need to integrate renewables are often not yet severe enough to induce the policy actions needed to encourage AD participation. In some markets the climate may just not be suitable.
- **Market arenas under-developed.** The market arenas necessary for the proliferation of appealing AD services are not yet fully developed in Europe. New business models are needed in the market. For this, potential players need access to data and market value; equal connection rights with non-AD substitutes such as distributed generation; and many more structural and technical conditions need to be fulfilled.
- **Energy companies do not know their customers well enough.** Building AD services to accommodate customers' needs requires contact, or a marketing strategy capable of attracting the right customers to specific services. Energy companies need to do far more research into their consumer bases.
- **Lack of competition.** Existing players in energy markets should not be relied upon as the sole source of innovativeness in solutions and new business models relating to AD. New market entrants such as aggregators, are also needed. Energy markets are, however characterised by major barriers to entry.
- **AD not yet social norm.** Consumers do not yet have role models and certainly do not have any sense of coercion or pressure to engage in AD activities.
- **Technology centricity.** Simplicity and usability of technology needs to be enhanced. Solutions should not only be appealing to early adopters, those who feel comfortable with technology.

- **Lack of choice.** In order to engage in AD a consumer needs to be able to select a service that suits their needs, preferences and capabilities. The choice is currently extremely small.
- **Not enough consumers have been impacted by a positive AD experience.** A lack of experience to date, a lack of a concept by consumers of what AD really is, a lack of trust by consumers of the energy industry, and an absent track record of the energy industry with new innovative services, means that consumers need to be impacted by positive experiences of AD in one form or another so that they can comprehend them and spread positive word to others. Small pilots do not result in many consumers being affected.
- **Lack of trust and relationship (including readiness to accept supplier management / trust in capability of the AD service).** Few energy companies have a relationship with their customers and customers often have issue with the way the industry (in their perception) behaves (e.g. price rises, high profits, salaries, sales practices etc.). Stronger, more trusting relationships are therefore needed to convince consumers that the negative connotations with the energy industry are not associated with AD service offerings.
- **Incorrect use of opt-in/ opt-out.** Opt-in is usually considered the best option. This is not always the case though. The fact is that the wrong option is often chosen and or wrongly applied, leading to missed engagement potentials or public relations issues.
- **Consumer's knowledge shortfall.** The importance of education and information provided to consumers before and during offerings is often underestimated. Most consumers want to save energy, but the knowledge and awareness of the average consumer is presently far too low to facilitate the mass participation of the public in AD.
- **Insufficient appeal (including cost of solutions) and usability of offerings.** Offerings to date have generally been too little too soon. For the most part they have simply not been appealing enough, relevant enough, simple enough, or cost-effective enough.
- **Appropriateness of marketing and communication.** AD programmes are often simplistic in terms of the motives they address and the messages they use to address them. There is little segmentation or customization. Communication and offerings should be more sophisticated to capture the diverse attention and interest of a mass market audience. Energy companies often lack experience with this type of marketing. AD providers will need to become experts in social media, crowdsourcing and other channels of sharing as well as understanding the psychological and sociological dynamics.
- **Contradictory messages** in the debate about CO2 reduction and energy efficiency.
- **Insufficient proof and guarantees.** Consumers are typically not given enough proof and guarantees of the benefits of involvement in AD.
- **Few realistic offerings / availability of AD offerings.** In order to engage in AD a consumer needs the opportunity to engage in AD, through being able to access a realistic and convenient service. Existing and new entrant player AD offerings therefore need to develop in the market.
- **Consumers need to feel more in control of the development of AD.** Customers do not have much choice in AD services. Automated control not is always a good solution. Consumers often do not want to be pushed too fast into being controlled and automation without behavioural AD taking place first, which can lead to lower consumer knowledge levels.
- **Better consumer support will need to be developed.** Good consumer support for services and technologies (call centres, online assistance), will be essential.

- **Modest savings and savings significance potentials.** Financial savings need to be more appealing to capitalise on consumers' main motive and ensure that the perceived cost (including financial cost, effort and risk) of AD is not greater than the perceived benefits.
- **Not enough journey (one step at a time).** There is lack of visionary business models for the future and strong hooks to get customers started on the journey, as suppliers lack knowledge about consumer identity and segmentation, a sufficient relationship with their customers and, consequently, customer trust and loyalty. Furthermore, the current regulation of energy markets presents restrictions to a new method of pricing and due to issues concerning data privacy.
- **Issues of data privacy and customer protection.** The debate over data privacy is still not solved in the minds of customers and regulatory restrictions on data can inhibit AD services.

Conclusions

Regulatory Action

- Critical measures: Provide market signal, smart meters, access to metering data, consumer access to consumption information.
- **Ensure availability of residential interval metering and dynamic pricing:** When feasible, consumers should be offered dynamic pricing tariffs – time-of-use, hourly, critical peak, or peak time rebates – that communicate prevailing wholesale price signals and offer the opportunity to save money by utilizing lower-cost, off-peak power, to be used by consumers on an entirely voluntary basis.

Non-Regulatory actions

- Devices should be turned into “smart” products that are connected to a network, aware of how they are being used, able to inform the user about their status, to react to utilities signal, and able to be controlled by end users anywhere-anytime remotely. The availability of appliances that can be remotely controlled is key for DR programs
- **Mass market AD ready smart appliances:** smart appliances and enabling infrastructure significantly improve the responsiveness of consumers to dynamic price signals as they allow consumers to automatically respond to external signals. Using these products, the consumer retains the ultimate control of its appliance and can override specific modes. **Challenges:** manufacturers of appliances should invest to upgrade their products to smart ones, forcing consumers to buy a more expensive product. The introduction of technologies that enable greater demand side involvement must be accompanied by a commercial framework for service providers to facilitate consumer involvement, and necessary standardisation of business procedures.
- **Higher return on investment** (ROI) of AD solutions: Unless market participants (DSOs, suppliers, vendors, other AD service providers, investors) see a profit from AD, few will enter the AD market. Some will provide AD for reasons of consumer loyalty, image or as part of the journey towards the smart future. Others will simply try it out with optimism. Ultimately however, there need to be business cases if the interest of these participants is to be maintained and developed. At the moment, there are few proven business cases and there is a risk that the market will stall before it has really begun. Various research has indicated significant ROI from various smart grid activities, but smart home / home energy management services for instance have not yet made any profit for those providing the services and DR is (as explained in the regulation section of this report) heavily restricted by inappropriate regulation.

Accenture, Understanding Consumer Preferences in Energy Efficiency

Accenture end–consumer observatory on electricity management, 2011.[37] *Global survey based on in-depth interviews with 9,108 individuals in 17 countries. Accenture set out to understand consumer opinions and preferences toward electricity management programs by answering six core questions:*

1. Do consumers have a clear understanding of the impact of electricity consumption on the environment?
2. Do they understand how they can optimize their electricity consumption?
3. Do they feel social pressure to do so?
4. Which organizations do they trust to inform them about actions they can take to optimize their electricity consumption?
5. Are they aware of electricity management programs?
6. What are the drivers and barriers to adoption of electricity management programs?

Key Findings

- There is a significant contradiction between consumer perceptions and their actual knowledge of energy efficiency.
- Consumers' first instinct is to contact utilities/electricity providers for energy-efficiency activities, but providers still need to build trust and credibility.
- While price remains a key factor to adoption, the extent of the utilities'/ electricity providers' control over energy use has emerged as a potential barrier.
- Channels and contact points for utilities/electricity providers to communicate with consumers are diverse.
- Adoption of electricity management programs is influenced by fragmented and nontraditional consumer preferences.

Six consumer segments, by analysing and grouping the importance that consumers attach to the various aspects of electricity management programs, six distinct consumer segments are identified, each with its own differentiated preferences and behaviors, reflecting the attitudes of each grouping toward electricity management programs:

Proactives

- Highest willingness to take action to reduce the use of major appliances in their home
- Lowest interest in the reduction of their impact on the environment
- Higher preference for in-person contact at their home to get general information about electricity management programs
- Higher proportion of electricity used to heat their home

Ecorationals

- Highest interest in the reduction of their impact on the environment
- Higher impact of social pressure to drive them to take action
- Highest positive perception of a person having enrolled in an electricity management program
- Higher willingness to decrease level of comfort but remain sensitive to savings in their electricity bill

[37] Original source available at: https://www.accenture.com/t20160105T033228__w__/us-en/_acnmedia/Accenture/next-gen/insight-unlocking-value-of-digital-consumer/PDF/Accenture-Understanding-Consumer-Preferences-Energy-Efficiency-10-0229-Mar-11.pdf

- Higher interest in energy-efficiency products and services such as smart meters, solar panels, renewable energy, home-energy packages, loyalty programs or technology recycling
- More often women
- Often seek advice before purchasing and are ready to pay more for quality products

Cost conscious

- Highest sensitivity to electricity bill savings
- Higher impact of social pressure to drive them to take action
- Higher positive perception of a person having enrolled in an electricity management program
- More likely to be discouraged from adopting an electricity management programs if their bill was more complicated or if it required more time to manage their electricity usage
- Higher level of trust toward utilities/electricity providers
- More often women

Pragmatics:

- Lower acceptance of utility control
- Higher sensitivity to electricity bill savings
- More ready to switch products and brands
- Less prompt in adopting new technologies
- More often men

Skepticals:

- Lowest acceptance of utility control
- Lowest trust toward utilities/electricity providers
- Lower sensitivity to electricity bill savings
- Lowest sensitivity to social pressure
- More likely to seek advice with consumer associations to get some information about electricity management programs
- Higher income / Higher proportion use natural gas to heat their home

Indifferents:

- Lowest willingness to take action to reduce the use of major appliances in their home
- Higher acceptance of utility control
- Lower proportion believe electricity has a negative impact on the environment
- Lower proportion think they understand enough about the actions they can take to optimize their electricity consumption
- Potential inhibitors would be the bill complexity and time commitment
- More often men / Below 24 years old / Lower income / highest proportion of early adopters of new technologies and new trends in this segment

Drivers

- Decrease in energy bill
- Decrease in personal environmental impact
- More control over the heating and cooling at home

- Less time required to manage electricity use
- Social pressure - reported in nearly all segments (see next paragraph), except skeptical respondents, higher opinion of someone with smart management system

Barriers

- Consumers are strongly aware of climate change, but they still do not fully equate electricity usage with its environmental impact.
- Consumers don't know much about electricity management programs that help optimise their electricity consumption – or whether their provider offers one.
- Providers need to build trust and credibility.
- Extent of the utilities'/ electricity providers' control over energy use.
- Consumers fear that AD might increase electricity bills.
- Most consumers are not willing to change behaviour if the energy they save is sold by their utilities/electricity providers for a profit.
- Consumers are more likely to sign up for a program where utilities/electricity providers cannot remotely limit the use of any home appliances.
- Consumers are more likely to sign up if they retain some control over their home appliances. Also, when consumers are provided with some control over their home appliances, they are more likely to respond to the incentive of saving money.

Conclusions

- To enable broad adoption, energy-efficiency programs will need to deliver unique value propositions for each segment. Programs that enable efficient use of energy will need to be simple, convenient, intuitive and accurate
- Providers should create a consumer-centric organisation: Differentiating services and capabilities to better meet a more active consumer base and diverse consumer preferences

Accenture, Revealing the Values of the New Energy Consumer

Accenture end–consumer observatory on electricity management, 2010.[38] *Research study among more than 10,000 end consumers worldwide to explore their preferences, opinions and priorities toward the value they perceive in beyond-the-meter products and services.*

Key Findings

Consumer preferences, a wide array of consumer preferences is driving the need for differentiated propositions and experiences. The report describes six core consumer segments, as evolved from the preceding report:

Self-reliants—13% "I prefer to manage my electricity consumption on my own"

Demographics: higher proportion of women, higher proportion of 55+

- Highest willingness to manually manage their appliances based on real-time pricing information.
- Higher interest in monitoring and adjusting their electricity usage through an existing device.
- More uncomfortable than the average consumer about sharing data with a third party for commercial purposes,
- Higher readiness to purchase energy-efficient products from online sites.

Social independents—18%"I like testing new technologies"

Demographics: higher proportion of men, all ages and levels of income.

- Highest interest in personally setting up their in-home device,
- More interested than other consumers in monitoring and adjusting their electricity usage through a new device.
- Highest interest in receiving their device, information and pricing program from multiple providers.
- Uncomfortable about sharing data with a third party to make a program work,
- Lowest interest in loyalty rewards, but would value electronics/computer rewards.
- More likely to be dissatisfied about poor communication of changes to the program.
- Value a program that allows them to connect with a community and share experiences, and like the idea that a program would be regarded as "trendy" by family and friends

Cost-sensitives—22 percent "I look above all for the best financial rewards"

Demographics: higher proportion of women, relatively high proportion of consumers between 25 - 34 years old. Higher than average share of lower-income consumers.

- Highest level of interest in loyalty rewards, especially loyalty rewards.
- Highest sensitivity to a program that would reduce their bill.
- An increase in their bill is likely to act as a catalyst to make them eager to learn about a program,
- Especially interested in programs that can be customized to their personal needs and usage.

[38] Original report available at:
https://www.accenture.com/t20160105T033228__w__/us-en/_acnmedia/Accenture/next-gen/insight-unlocking-value-of-digital-consumer/PDF/Accenture-Revealing-Values-New-Energy-Consumer.pdf

Service-centrics—18 percent "I want the best service for my family and me."
Demographics: higher proportion of women, all ages and income levels.

- Most interested in full set-up of the device and assistance by a certified technician,
- Highest sensitivity for a program that would allow them to better control the heating/cooling of their home.
- Their interest in learning about a program is more likely to be stimulated by moving into a new home.
- They are more likely to be dissatisfied by a program with poor customer support and poor product installation,
- Highest preference for dealing with their utilities/electricity providers.
- Higher interest in a program that is easy to use for the whole family, and in an in-home device display installed at no cost.

Traditionalists—15 percent "I prefer a familiar experience"
Demographics: divided equally between the genders and levels of income, higher proportion of 55+

- Highest interest in receiving their device, information and pricing program from a single provider,
- Most likely to purchase energy efficient products from their utilities/ electricity providers.
- Lower readiness to go to a retailer, telephone/cable provider or online site to purchase electricity, energy efficient products, and/or related services.
- More likely to be interested in learning about a program when they are renovating their home.

Tech-savvys—14 percent "I value convenience and efficiency"
Demographic: higher proportion of men. relatively high proportions of consumers who are 25 - 34 years old and who are high-income earners.

- Highest interest in automatic management of their appliances by a device,
- More interested in full set-up of the device and assistance by a certified technician.
- Most likely to install a "SetAndForget" program that switches their devices on and off automatically,
- Highest interest in monitoring their consumption on their mobile telephone or another personal electronic device.
- Highest readiness to consider online sites for purchasing electricity, energy-efficient products and/or related services.
- More likely to choose a program that simplifies their life.

Non-traditional/unconventional drivers
Consumers will respond to programs that consider their full spectrum of values and preferences. Tailored solutions should therefore include a broad set of unconventional values and preferences, many of which are more emotional in nature than practical or financial.

Examples of these values and preferences:

- Ability of program to simplify consumers' life
- Easy to use for the whole family
- Customized to personal needs and usage.

- Fun to use
- Including the latest technology
- Enabling sharing of experience and tips with a community.
- Regarded as “trendy” by friends and family, (underlining the potential power of strong brands in this space)

Drivers

- Reduced electricity bill
- Greater control over domestic heating and cooling
- Noncash incentives: free technology installation and loyalty rewards that can be spent in a store, electronics and computer rewards
- Price is the pivotal factor in the acceptance of electricity management programs, but price alone will not drive adoption

Barriers

Possible barriers are found in **utilities monitoring or controlling energy use and third-party access to information**. Some findings on this topic:

- Many consumers prefer to maintain ultimate control over their home and require the ability to override any external control factors.
- Some consumers may “opt-in” to allow third-party providers access to personal usage information if they perceive value.
- 63 percent say that the prospect of approved third parties gaining access to their usage data under an electricity management program to make the program work would not prevent them from signing up for it.
- A higher proportion of younger respondents and low-income earners would be reluctant to give access to a third party.
- Consumers in emerging markets are relatively less willing than those in developed countries to allow third-party access.
- 48 percent of consumers state that third party access to their personal information for the purposes of offering additional services to help them save on their electricity bill would not prevent them from signing up for an electricity management program.
- As before, a higher proportion of younger respondents, low-income earners and consumers in emerging markets would be reluctant to give access to third parties under these circumstances.
- Many consumers want the comfort and reassurance of face-to-face contact with a person, prefer to interact with a staff member to buy a program or products, whether in a store location or at home.

Conclusions

- Consumers will opt-in and share personal usage information when they first trust their electricity provider and when the utility can clearly explain and alleviate concerns related to the level of control implicit in the program offer. (p.32)

Solutions from utilities/electricity providers' perspective

- **Make information the new currency -** Focus on analytics to gain a deeper understanding of consumers: **Customer segmentation is critical.** Providers will need the ability to understand their customers, develop tailored products and services and bundle these with value propositions that will resonate with their target consumer segments.
- **Innovation needs to fuel product and service development to create consumer value.** Use an analytics-driven understanding of consumer segments to develop tailored products and services. Use new insight on consumer values to develop and deliver energy products and services that meet those consumer requirements. Successful innovation can develop products and services that will achieve the desired levels of adoption.
- **Address the service and channel requirements of all consumer segments.**
  Consumers' choices of energy management programs are influenced not only by their preferences toward the composition of products and services, but also by how those products and services are acquired and delivered. To prepare for the future, providers need to create or partner with third parties to develop a network of retail outlets and field agents that can educate consumers and encourage adoption of energy management programs.
- **Rethink traditional business models to maximise value.**
- **Collaborate to accelerate.**
  As the marketplace opens up to new players (commercial providers), utilities/ electricity providers will have to reevaluate their go-to market strategies to deal with intensified competition.
- **Utilities/electricity providers will require bold and sweeping changes to realize the true value of the evolving energy marketplace.**
  Dynamic business models are emerging and leading providers will assess or reevaluate their approach to their markets and consumer.

Accenture and the New Energy Consumer

Actionable Insights for the New Energy Consumer, 2012.[39] *The report focuses on developing actionable insights and tactical implications for providers. Recognizing that smart technology represents just one of the trends creating opportunities and challenges for providers, Accenture explores consumer preferences and behaviors that define the operational considerations for addressing the new energy consumer and explores questions such as:*
1. What energy and non-energy-related products and services are consumers interested in receiving from their providers?
2. How do consumers want to interact with providers and what expectations are there for self-service, social media and other nontraditional channels?
3. What opportunities exist to better balance cost-to-serve with consumer expectations?
4. How can utilities differentiate themselves to more effectively acquire and retain consumers or increase participation in specific programs?
5. What are the preferences and behaviors of the next generation of energy consumers?

Key Findings

Customer choice: Consumers will opt for products and services that align with their evolving values.

- **Offer the "right" mix of products and services**. Consumers are increasingly interested in receiving additional energy and non-energy-related products and services from electricity providers.
- **Maximize consumer willingness to pay**. When it comes to paying a premium, consumers are more attracted to differentiated products than services.
- Maximize consumer desire to save. The majority of consumers would forgo customer service in return for price discounts.

Create a value proposition with bundles. Consumers are interested in bundled packages that better suit their lifestyles and needs, particularly when they deliver savings, convenience or ease of use.

- **Customer connection**: Changes in technology and the continued consumer move online are shifting the traditional preferences for interactions.
- **Optimize the value of self-serve**. Low-touch channels and self-service have reached a tipping point where consumers prefer these options for most transactional interactions.
- **Unlock social media**. Consumers in many geographies are interested in engaging with their electricity providers through social media, in particular, for service convenience.

Customer loyalty: Engaging consumers and understanding the drivers of loyalty and satisfaction are critical to ongoing success.

- **Manage consumer engagement**. Satisfaction and engagement actually decrease based on the length of time consumers interact with their providers.
- **Understand churn**. In competitive markets, while switching decisions are largely price driven, loyalty rewards are emerging as an effective motivator for consumers to stay with their current provider.
- **Engage the next generation**. Younger consumers can offer a paradox: they prefer a complex mix of high-touch interactions, self-service and social media engagement.

[39] Available at:
https://www.accenture.com/_acnmedia/Accenture/next-gen/insight-unlocking-value-of-digital-consumer/PDF/Accenture-Actionable-Insights-New-Energy-Consumer.pdf

Kergrid, 2014

France's first smart grid-ready office building. The Kergrid project is validating the reliability and cost benefits of local green energy production and storage.[40]

Schneider Electric has been entrusted by energy union SDEM to design and implement a unique experiment named 'Kergrid'. Kergrid is a network of smart electricity distribution implemented in the new 3,300 square meter SDEM headquarters, with the objective "To adapt to the constraints of the electric britton network." Through automated energy management and storage, energy expenditure will be anticipated and controlled, particularly during peak consumption.

Key Findings

- An electrical energy storage system (EESS) is installed, linked to onsite RES from solar PV and wind, controlled by an energy management system.
- The Kergrid building's 850 square meters of roof mounted photovoltaic panels produce up to 126 kW of electrical power. Additionally, two small wind turbines are each capable of producing 2.5 kW. Energy is stored in the EESS. The buildings 56 kWh capacity can supply the building's entire energy needs for up to two hours.
- A power management system controls energy flow between all energy sources, energy storage, and loads, including electric vehicle charging stations. A building management system monitors and controls lighting, heating, cooling, and ventilation. Cloud-based StruxureWare Energy Operation software provides detailed analysis and reporting.
- The system will automatically arbitrate between selling stored energy to the grid or auto-consuming it to supply the building.
- Self-consumption of renewable energy will be maximised, while stored energy will optimise participation in demand response programs.
- The building will have the ability to operate autonomously for 2 hours.

[40] Sources: http://morbihan-energies.fr/kergrid/
http://www.construction21.org/case-studies/fr/kergrid.html

McKinsey & Company

The Connected Home Survey, 2015.[41] *In this survey, approximately 2,000 U.S. households were asked for their views on the connected home, revealing distinct customer segments and key issues that need to be tackled in order to unlock this growth.*

Key Findings

Family First Consumers:

Income: ~$40K per year
Age: 25–44 years old
Channel Preference: Service providers/online retailers
Home Structure: Single family with 1-2 kids, suburban

Leading Attitudes:
- Average tech adopter
- Budget conscious
- Does not plan on moving
- Cares about family well-being

Interests: Security 32% Wellness 19% Entertainment 17%
Top devices: Remote Video Feed Connected Lock Connected Smoke Detector

Social Climber Consumers:

Income: $100K per year
Age: 25–44 years old
Channel Preference: Direct from manufacturer website
Home Structure: Single family with 1-2 kids, urban/suburban

Leading Attitudes:
- Early tech adopter
- Invests in home
- Image conscious
- Cares about family well-being
- Considers themselves "green"
- Willing to pay more for "green" products

Interests: **Utilities 40%** Security 39% Wellness 32%
Top devices: **Connected Thermostat**, Connected Lock, Remote Video Feed

Affluent Nester Consumers:

Income: ~$75K per year
Age: 45–64 years old
Channel Preference: Home improvement/service providers
Home Structure: Single family with 1-2 kids, urban/suburban

Leading Attitudes:
- Late tech adopter
- Invests in home

[41] Source available at: http://www.mckinsey.com/spContent/connected_homes/index.html

Does not plan on moving
Willing to pay more for "green" products

Interests: Security 27% **Utilities 24%** Wellness 19%
Top devices: Connected Thermostat, Energy Tracking, Connected Smoke Detector

Traditionalist Consumers:
Income: ~$35K per year
Age: 45–64 years old
Channel Preference: Big box/home improvement stores
Home Structure: Single family with no children, suburban/rural

Leading Attitudes:
Late tech adopter
Budget conscious
Does not plan on moving

Interests: Security 18%, **Utilities 10%,** Entertainment 3%
Top devices: Connected Thermostat, Lighting, Connected Smoke Detector

Urban Dweller Consumers:
Income: ~$40K per year
Age: 25–34 years old
Channel Preference: Service providers/online retailers

Home Structure: Single/married with no children, urban

Leading Attitudes:
Average tech adopter
Budget conscious
Will likely move within 5 years
Willing to pay more for "green" products

Interests: Security 30%, Utilities 26%, Wellness 26%
Top devices: Connected Thermostat, Energy Tracking, Connected Smoke Detector

Interested Non-Users' Reasons for Not Purchasing: Value Proposition Not Fully Understood, Despite Clear Needs (% rating as a top 3 reason)

- 66% Too expensive
- 39% Not sure how well it works
- 37% Technology is still developing
- 27% Concerned about privacy
- 24% (energy management) Not a big concern

Drivers

Non-Users Frequently Exhibit Behaviors That Indicate Latent Demand for Connected Solutions

- 51% accidentally leave lights on.
- 41% accidentally leave televisions/appliances on.

- 36% wonder what's happening at home while away.
- 35% leave A/C running (even when it's comfortable).
- 31% can't remember if they locked doors/windows.
- 51% accidentally leave lights on.
- 41% accidentally leave televisions/appliances on.
- 36% wonder what's happening at home while away.
- 35% leave A/C running (even when it's comfortable).
- 31% can't remember if they locked doors/windows.

Barriers

- Family First Consumer Group → Most concerned that devices will be difficult to install and use, High concerns over price.
- Social Climber → Most likely to believe that technology is still developing, Concerned about product setup and usage
- Affluent Nester → Lack recognition of need for products, Believe technology is still developing, Concerned over privacy and hacking
- Traditionalist → Lowest awareness of any segment, Most deterred by price, Concerned over setup and usability, Concerned over privacy and hacking
- Urban Dweller → Skeptical that products work well, High concerns over price, Deterred by current suite of available products

Conclusion

''The connected home market is poised for large growth—however, market players will need to communicate their value proposition more effectively to realise their market ambitions. ''

Citizen's Advice Bureau

Take a walk on the demand side - making electricity demand side response work for domestic and small business consumers, August 2014.[42] *This report presents a discussion from a consumer perspective, referencing several trials and other reports.*

Drivers

Potential benefits of DSR for the electricity system

- Less need to switch on expensive and carbon-intensive back-up power plants at peak times.
- Less need to build new power plants.
- Less need to reinforce or extend existing distribution networks.
- Better outage management when a network fails.
- Easier connection and use of small-scale, intermittent renewable energy sources like wind farms.
- More efficient balancing of the grid on a local and national level.

What DSR means for the consumer

- If DSR can produce at least some of the above outcomes, it should help to create an electricity system that is more sustainable, more secure and more affordable. However, some uncertainties and barriers need to be addressed.

Barriers

Financial

- The overall financial benefit from DSR is hard to predict and depends to a large extent on how DSR is managed at the early stage
- **Fear/risk of increased prices / creating winners and losers of DSR:**
    - Even if the net effect is a reduction in bills, DSR could mean that consumers end up paying more, depending on the way incentives are structured and the clarity of DSR offers. Trials have shown this is a real risk. (British Gas and Northern Powergrid study on ToU tariffs: 60% of participants benefited, other 40% paid more than normally.)

Too much complexity in the energy market.

- A multitude of DSR offers can create confusion, especially when they are difficult to compare due to a large number of variables.
- DSR may introduce certain risks: Consumers' behaviour change, new incentive mechanisms, and the new arrangements needed to make these possible could all result in unforeseen problems.
- Automation in any form will pose serious questions in terms of risk, accountability and control.
- Too little engagement with consumers less likely to benefit (low income families, elderly)

Conclusions

Needs of domestic and SME consumers in the DSR market.

1: An accessible market for DSR, Consumers considering whether to take part would benefit from a more objective source of information to clarify some basic points such as:

- How DSR works and what the benefits are.

[42] Source available at: https://www.citizensadvice.org.uk/Global/Migrated_Documents/corporate/take-a-walk-on-the-demand-side-final-2.pdf

- The range of DSR options available, and guidance on which kind might suit consumers according to their situation.
- Ideas for how to shift usage, and linked to this, approximate potential benefit of doing so.
- The risks of signing up to a DSR scheme.
- Consumer rights regarding DSR.
- A guide to what further information and resources are available.

A unified and well-explained approach is needed to communicate the specific challenges posed by DSR. **It is necessary to gain further experience through introducing DSR to consumers -based on trials-, to obtain more information on areas including:**

- Best practices for consumer engagement and continued communications.
- Understanding winners and losers in different consumer segments.
- The level of savings available and behaviour changes required.
- Appliances and devices needed to affect that change, and their costs.
- Unforeseen problems and opportunities.

Industry parties should be active and thorough in sharing consumer-related findings from trials of DSR and should continue to work together through the Smart Grid Forum to agree which form of DSR has the most immediate potential for shared benefit.

Adopting a shared strategy (either agreed between industry parties or formalised by the regulator) to save consumers unnecessary confusion, while new and innovative options could still be explored on a small scale trial basis before being introduced nationally.

Clarity of DSR offers
Consumers will need a framework in place to ensure that clear and comprehensive information is provided at the point of sale and subsequently on bills (openness on all tariffs, including those of competing providers, and recommendations on adjusting energy use based on the bill).

Comparing offers
''In addition to ensuring that clear information is provided with DSR offers and that the number of possible tariffs does not become overwhelming, it should be made as easy as possible to compare offers. If rival DSR offers are not comparable, competition will not function effectively in setting a price for a given shift of usage, causing individual consumers to lose out and potentially stalling the development of the DSR market.'' (p.15)

Ofgem, industry parties, price comparison sites and other stakeholders should work together to adapt the Tariff Comparison Rate to time-of-use tariffs and consider what other steps might aid comparison between DSR offers, such as standardising time bands.

2: Safe DSR Protections, DSR may introduce certain risks. To allow consumers to engage in DSR with confidence, existing protections may become more important or need to be adapted, and new ones may need to be introduced. Putting in place **strong, clear protections** will help build a DSR system that works better for all parties. (p.19)

Automation and load limiting
While risk of confusion or higher bills can be predicted and mitigated, introducing protection that is

adequate for schemes based not on price but on active intervention by the energy company is more challenging. These schemes could take the form of:

- Load limiting – smart meters have the ability to restrict the maximum load allowed to flow through them, and to disable supply until further notice, if exceeded. In the context of DSR, this could be used to ensure that participants do not exceed a given usage during peak times.
- Direct control – smart meters and smart appliance technology may make it possible for energy companies to control a consumer's household appliances remotely, for example by turning down a fridge or freezer at a time of high demand.

Automation in any form will pose serious questions in terms of risk, accountability and control.

''Automation could perhaps enable a significant layer of efficiency savings, but the ***benefit to consumers is still to be proven****. It is also unclear what level of financial incentive would need to be embedded in a tariff to overcome consumer concerns about automation and direct control, what unintended consequences may result (such as the impact of noisy appliances in properties with poor sound insulation, for example), and whether the level of shifting will be sufficient to deliver the savings across the supply chain and consumer base necessary to make such a move worthwhile.''* (p.21)

''A ***key protection will be the provision of an override function*** *that is easy to identify and use, and can be used at the consumer's discretion without incurring a financial penalty other than forgoing the incentive to use off-peak power. Automating without an override function or with one that the user might feel unable to activate would not only be very off-putting for consumers, but could also in some cases pose serious risks to health and wellbeing.''*

Automation could also pose Health and safety risks, argues home safety expert from the Chief Fire Officers' Association: 'Every year we have numerous fires caused by dishwashers, washing machines and tumble driers. We would strongly advise people not to put them on when they go to bed, or before they leave the house.''

Product standards should also ensure that any automated appliance is safety tested, has an easy to use, free override and is clearly labelled with running costs and an estimate of possible savings.

Energy services

The combined factors of ESCOs and automation playing an increasing part in DSR may pose a risk to accountability, if consumers enter into arrangements with multiple parties for their DSR services. Clear lines of accountability need to be drawn in these situations, from a legal, operational and communications perspective. If for example a smart appliance manufacturer provides a fridge through partnership with a supplier, and it is automated by an aggregator according to calls for DSR from a DNO, then:

- It should be clear to the consumer who to contact in the event of a malfunction or billing query (ideally a single point of contact).
- It should be agreed between all parties who will be responsible for each eventuality of fault repair and maintenance.
- There may be a legal question of liability if, for example, an error somewhere along the chain leads the fridge to be turned up instead of down when prices are high, to be turned off and not turned on again, or to have its life shortened.

It is impossible to foresee the full range of complex contractual situations that may arise. The regulator will need to consider in detail the balance of costs and benefits, and the risks and opportunities for all parties. This is preferred over having a system that might take much longer to untangle at a later stage, at a cost to consumers.

Ofgem should implement an accreditation scheme for third party DSR providers and consider a framework for accountability when multiple parties are involved in a consumer's DSR.

Limits on liability

Some forms of DSR might expose consumers to high financial risk. **It should be possible to limit the financial liability faced by participants who fail to shift their load sufficiently** (particularly with critical peak pricing).

Options for limiting liability could include:

- Capping bills, and possibly shifting consumers to a different tariff if the cap is exceeded.
- Setting a maximum differential between high and low prices rates.
- Introducing financial incentives at peak times as a rebate rather than a charge.
- Having a contract for flexibility separate from the main supply contract, so that the consumer is rewarded for their response relative to a baseline load.
- 'Shadow billing', as in the ToU trial in the Customer-Led Network Revolution, where consumers in effect pay either a ToU rate or a non-ToU rate in each period, whichever is lower.

Switching and interoperability

Consumers will need to have the ability to explore the unknown territory of new kinds of tariff freely and with confidence. New complexities of DSR (technical or a commercial basis) could pose barriers to switching (e.g. suppliers could have an incentive to make switching difficult, to secure a shift in load even if contrary to consumers' preferences).
If locked in to a tariff customers might end up having to shift usage even if they decide the resulting savings are not worth it – which would benefit the supplier, but be a detriment to the consumer and to DSR's reputation in the long term.

As such, we need to **ensure consumers are not locked into DSR schemes** by bundled appliance offers or interoperability issues.

Fair distribution of benefits

Initially, only more engaged consumers can expect to be rewarded for the efforts in DSR. If savings are never passed beyond this group and the energy companies, DSR could lead to a two-tier electricity market, where those with the time and resources to take part pay less and the rest end up paying more.

Distributional impact of DSR

In the US, the Smart Grids Consumer Collaborative published a report on the smart grid's impact on low income consumers. Findings were that those with low incomes received substantially less benefit from the smart grid and associated offers, due to:

- A lack of educational outreach.
- Too much reliance on engagement through the internet, which not all consumers are happy to use or have access to.

- Too little consideration to the disproportionately high number of low income consumers (here as in the US) in rented accommodation, which may impede them from adopting the energy efficient products or services that might be a part of some DSR offers.
- Too little engagement with older people

Priorities:
1: Protect vulnerable consumers from unsuitable DSR offers
2: Enable different groups of vulnerable consumers to take advantage of DSR such as:

- Older people.
- Low-income and fuel poor households.
- People with disabilities.
- People who do not use the internet.
- People who speak little or no English.
- Renters.
- Families with young children.

Ofgem should **complete a distributional impact assessment of DSR** to examine what measures are needed for vulnerable consumers' groups engaging in DSR.

Delivering benefits
Savings from DSR should be passed on to consumers, but the commercial details are hard to foresee. It is unclear when savings would start to appear, what their scale would be, and how they would be split between those consumers who were directly rewarded for participating in DSR and those who were not. This process will operate differently depending on which party turns out to be best placed to realise DSR's potential savings.
If it is suppliers, competition should mean that savings would be passed through as cheaper tariffs, but there is no guarantee that this would extend beyond the participants – who in any case would need rebalanced tariffs to incentivise their behaviour to change in the first place. One way to achieve this would be through a supplier-led version of DSR; savings in the wholesale price of energy would be used to incentivise participants while savings from avoided generation costs would be passed on to all customers, but such an assumption still needs to be tested If it is networks or the system operator, savings should be captured by the price control, but it is unclear whether they would be passed through in the current or the next price control period, nor what would set an appropriate margin for the networks. A price signal would still be needed for participating consumers. Avoided costs might be highly regionally specific, but it would be unfair if this accentuated a postcode lottery for network charges.
Industry parties should explore forms of DSR with clear and immediate benefits to consumers based on existing thermal storage and energy efficiency initiatives.

Left-behind consumers
Suppliers removing all non-DSR tariffs might be problematic →consumers feeling forced into DSR, remove a useful point of comparison: 'normal', flat-rate, evergreen tariff, could be benchmarked to compare DSR offers and suppliers. Monitoring the impact of DSR for nonparticipating consumers and considering a requirement that suppliers maintain at least one non-ToU evergreen tariff is necessary for this to work.

UK Power networks, Low Carbon London

Residential consumer attitudes to time-varying pricing, September 2014. [43]*A residential dynamic time-of-use (dTOU) tariff was trialed with the aim of measuring consumer's willingness to engage with dynamic electricity pricing. Over 1100 households in the London Power Networks area were placed onto a three-rate dynamic tariff with day-ahead notification and monthly feedback. Half-hourly smart meter consumption data was collected from these households and compared to 4500 households on a standard rate tariff. This is the first trial of a dynamic time-of-use electricity tariff with UK households. It looks at how responsiveness is achieved and how households experience this novel tariff. In doing so it relies heavily on trialists self-reports from interviews and surveys.*

Key Findings

Overall

- Analyses show a large majority of households on the trail modified their consumption behaviour in response to the dynamic pricing signals and also made financial savings over the 12-month trial period.
- Findings shed light on the potential of dynamic pricing for wind-following and how such tariffs might be delivered and supported with appropriate technology to maximize take up, engagement, consumer benefit, and so can help to inform future trials and energy policy.

Specific main findings

- Very positive trialist reaction to dTOU, who were not necessarily pre-disposed in favour of dTOU at the outset.
- One of the most impressive findings was the very high rate of endorsement of the item (91%) which indicates strong potential support for cost-reflective pricing which is viewed as fairer and/or promoting efficiency.
- dTOU was not cited as complex. Findings suggest that greater consumer engagement supports greater acceptance of, or even an appetite for, some types of complexity and the two need to be seen in tandem.

Conclusions

- The characteristic of dTOU for supply following that distinguishes it from fixed TOU is that the times of rate changes are unpredictable. A potentially serious issue of having more predictable time of rate changes was the most commonly endorsed suggestion of things that might help households respond better in the future. 68% reported that they would be more likely to sign-up to dTOU if the rate changes were more predictable.
- The schedule of rate changes on the dTOU trial was unpredictable; trialists reported irritation with the schedule and its lack of transparency and suspicion that the rate changes were scheduled to benefit the supplier.
- A strong piece of learning from the trial is that consumers are likely to engage more with dTOU if the reasons and rationale for the tariff design, rate change events etc. are explained clearly.

[43] Source available at: http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/Project-Documents/LCL%20Learning%20Report%20-%20A2%20-%20Residential%20consumer%20attitudes%20to%20time%20varying%20pricing.pdf

UK Power networks, Low Carbon London

Residential consumer responsiveness to time-varying pricing, September 2014.[44] *Trial with dTOU investigating the potential value of residential demand response to the Supplier, e.g. for system balancing or integrating low carbon generation, and to the DNO, where it may be used for network Constraint Management (CM), displacing or deferring network reinforcement costs, while providing rewards to consumers for services provided.*

Key Findings

Methodology

- 5,533 households with smart meters were recruited onto the trial from the London Power Networks (LPN) area.
- All households agreed to have their half-hourly consumption data analysed, and a subset of 1,119 households additionally signed up to receive a dTOU tariff.
- At the end of the trial, valid data for the 2013 calendar year was available for 922 households on the dTOU tariff and 2,327 households on the non-time-of-use (nonTOU) tariff.
- The dTOU tariff contained three different price bands, deliberately chosen to have a strong high to low price ration, though still designed so that an average consumers bill would be the same on the flat rate tariff of the nonTOU group should there be no change in consumption profile.

Results

- Consumers were incentivized to change their electricity consumption in reaction to changes in the electricity tariff, which was designed to be cost-neutral for households with average consumption levels.
- Over the trial year, 95% of households saved money relative to what they would have spent had they been on the standard flat tariff of the nonTOU group.
- As expected, highly engaged households tend to decrease their consumption in response to high price signals and increase their consumption in response to low price signals, and the magnitude of the response generally decreases with increasing rank index.
- Households responded to high price signals with decreases in consumption levels that were much larger during the colder and darker winter months than in the peak of summer.
- The ability of households to increase power consumption was only very slightly affected by the time of year.

[44] Report available at: http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/Project-Documents/LCL%20Learning%20Report%20-%20A3%20-%20Residential%20consumer%20responsiveness%20to%20time%20varying%20pricing.pdf

Frontier Economics and Sustainability First (UK gov, energy & climate change department)

Demand Side Response in the domestic sector- a literature review of major trials, August 2012.[45] *This report considers two types of DSR: DSR aimed at delivering a reduction in electricity use at peak time on a day-in day-out basis. This type of DSR involves a habitual change in consumer behaviour during the daily peak period. DSR aimed at delivering a reduction during exceptional, 'critical peaks' in electricity demand. This type of DSR involves occasional reductions in consumer demand at times of exceptionally high electricity supply costs. This report reviews 30 DSR trials in the domestic electricity sector. The initiatives covered a range of countries, seasons, appliance uses, and market arrangements. Some trials included in this review focused on economic incentives such as time of use tariffs while others included non-economic signals, such as the provision of information. Most trials tested more than one DSR measure (for example different types of tariffs or different combinations of economic measures and automation technologies).*

Key Findings

Key finding 1: Consumers do shift demand in response to economic incentives even if the incentives are accompanied by only basic information, however the size of the shift varies significantly across tariff types and trials (p.13). Economic incentives are effective in changing consumer behaviour. Consumers respond to static time of use (ToU), Critical Peak Pricing (CPP) and Critical Peak Rebate (CPR) price signals by reducing their electricity demand at peak periods. There were stronger responses to CPP tariffs, but it may be due to the following:

- Consumers may find rebates more difficult to understand than higher prices, since rebates are calculated relative to a consumer's notional baseline demand (what their electricity demand would have been expected to be during the critical peak, in the absence of a critical peak tariff). **This may make it difficult for consumers to estimate the savings they make from shifting demand away from the peak**.
- Consumers may be loss averse. That is, they may care more about the additional costs that they incur with CPP tariffs than about the additional gains they may make with CPR tariffs. Loss aversion has been observed by behavioural economists in other contexts. (p.21)
- Consumers may become less responsive to economic signals as the duration of the peak period increases. Most trials included a peak period covering around 5 hours. The CL&P Pilot included an 8-hour peak period and found only a small peak period demand reduction of 23%, despite trialing the highest peak to off-peak differential of the trials reviewed. **In consumer feedback after this trial, the length of the peak period was considered by some respondents to be a barrier to shifting demand**. (p.21)

(p. 78: ToU participants felt 12pm—8pm was too long for a peak period, and that the peak/off-peak price differential was too small)

Key finding 2: Interventions to automate responses deliver the greatest and most sustained household shifts in demand, where consumers have certain flexible loads such as air conditioners and electric heaters. The key behavioural issues relate to the extent to which they accept the scheme in the first place and remain on it, and the extent to which they override the signal, where this is possible.

[45] Report available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48552/5756-demand-side-response-in-the-domestic-sector-a-lit.pdf

The limited evidence suggests that consumers generally accepted automation and direct control. The results of some trials suggest that initial doubt about participation can be mitigated by providing consumers with the options to override any automated response.

A study of consumer acceptance of smart appliances provides further evidence on consumer attitudes to automation and direct control. Sample demographics: high share of males, middle-aged people with higher education, a technical background and high ecological awareness, with the majority living in a house without children (about 60%).

Consumer acceptance of smart appliances was high among this group, averaging over 90%. The degree of demand shifting that was acceptable varied across household appliances:

- 77% of consumers would accept a shift of three hours for washing machines and tumble dryers, but they were concerned about leaving laundry for a longer time as it might go moldy or become creased.
- For dishwashers, 77% would accept a shift of at least three hours, and the main concern about smart operation was noise during the night.
- There were some objections to smart operation of fridges and freezers due to concerns about safety and the potential for a reduction in food quality.
- Reported willingness to accept automation was highest for the interventions affecting fridges and freezers and lowest for those affecting cookers.

Key finding 3: After automation, a combination of economic incentives and enhanced information generally delivers the greatest demand response. (p. 29)
All trials using economic incentives need to provide basic information on tariff levels to trial participants, for example through bill inserts or fridge magnets. Some trials also provided more sophisticated information alongside economic incentives, including:

- Additional bespoke information, such as enhanced billing that breaks consumption down into the different tariff periods.
- Accessories that provided more interactive real-time information, such as In-Home Displays (IHDs) and Energy Orbs.

Limited evidence on **bespoke information** provision suggests that it **can improve the response to economic signals**. Trials provided real-time-information to consumers through in-home displays (IHDs) that show current energy use and billing information or through devices such as Energy Orbs that serve as a real-time visual reminder of peak periods to consumers. In most international trials, the provision of real-time information led to a small additional reduction in peak demand.

Key finding 4: Consumer feedback on tariffs and interventions aimed at incentivising DSR was generally positive (p. 32). 78% of 298 survey respondents from the Ontario Smart Price Pilot said they would recommend the ToU tariff to a friend. The top 3 reasons given for satisfaction were:

- Awareness of how to reduce bill
- Greater control over electricity costs
- Environmental benefits

Low income consumers, Low-income consumers in the US do respond to incentives to shift load tend to be smaller than the responses for average consumers. (However, evidence is mixed -some trials found no difference)

US studies have found a number of possible reasons for different peak use reductions:

- **Lower overall electricity use**
- **Flatter load shapes**
- **Other consumer characteristics.**
- **Smaller economic incentives**. If low-income consumers receive a discount on the price they pay for electricity, the impact of the price differential with a ToU or CPP tariff may be limited
- **Response to automation and information.** Consumers responded differently to non-economic incentives according to their income.

Real-time pricing

Four of the studies examined in this report used domestic sector real-time pricing. The limited available evidence suggests that domestic consumers do respond to real-time price signals.

The PowerCentsDC Trial included an hourly pricing tariff for households where consumer prices were based on the day-ahead price in wholesale markets. Consumers were notified a day in advance by phone, email or text message if prices were going to exceed a high price threshold. Information on hourly prices was available in real-time on smart thermostats, online, and at a free telephone number. However, the results of this trial were inconclusive. Wholesale prices fell over the trial period. This made it difficult to separate out the demand shifting effect resulting from the pricing structure from changes in consumption resulting from the overall fall in price.

The Norway EFFLOCOM Trial91 also included tariffs that partially depended on the hourly wholesale electricity spot price92. This found larger peak demand reductions for consumers where the tariff depended on the spot price compared to those on the tariff that did not. However, the number of consumers with hourly variation in their prices was too small to provide statistically significant results.

In the Illinois Real-Time Pricing Trial93, domestic electricity prices were based on day-ahead wholesale prices. Consumers were notified the day before by phone or email when the price went above a threshold, and the overall hourly price was capped. Prices were available, after 5pm a day in advance, on the programme website or by phone. On the day with the highest price, consumers on real-time tariffs reduced their overall consumption by 15% compared to consumers on standard tariffs94. The trial also found that consumers' responsiveness was greatest when the electricity price was above the high price threshold.

The Pacific Northwest GridWise Project95 found that consumers respond less to real-time price signals than to ToU and CPP signals. During this trial, the domestic electricity price was adjusted every five minutes. The reduction in peak period demand for consumers on this tariff was 15-17%, compared to 20% for the group on ToU/CPP tariffs

DECC/Ofgem, Smart Grid Vision and Routemap

February 2014.[46] *A paper published by UK's DECC/Ofgem looking at the Smart Grid. One section addresses the progress and actions required to enable customer participation in DSR. it shows how small the ambition is and that consumers are not really considered a key part of the Smart grid in many people's minds.*

Key Findings

Commercial and Regulatory Frameworks

The challenge is to ensure that regulatory and commercial frameworks facilitate the deployment of smart technologies and smart solutions. These frameworks must incentivise innovation and efficiency and support new commercial arrangements, whilst protecting consumer and customer interests.

The system is becoming much more complex as the need to balance supply and demand at local levels intensifies and there is a need for technologies that enable the intelligent control of the network, including a much greater role for storage. Investment will be required in the short-term to develop these systems in order to start preparing for the projected take-up of low carbon technologies:
''Existing regulatory and commercial frameworks need to evolve to incentivise this investment, while at the same time, ensure that all stakeholders (network operators, suppliers, generators and consumers) are able to participate fully in the deployment of smart grids and that benefits are fairly distributed along the value chain. They need to enable the introduction of new consumer incentives, for example, time of use tariffs, which encourage consumers to use energy at times of the day when it is cheaper to do so (e.g. off-peak).'' (p.34)

Customer Participation

''The challenge is to ensure that the Government, Ofgem and the electricity industry communicate effectively the benefits that will accrue to customers and the energy system more generally, through the adoption of smart grids, changing market structures and engaging willing consumers in active management of their demand or distributed generation. '' (p.38)

Barriers

- Smart grids are a major shift from the way the industry operates today. Whilst most industry stakeholders are familiar with the changes, few residential or business customers are.
- Most customers have relatively passive relationships with their electricity consumption today.
- Studies show consumers appreciate automated load shifting systems and tend to shift more energy when control systems are provided that respond to price signals to delay energy usage. Consequently, it is expected that automated appliances (e.g. washing machines, dishwashers) and heating systems will appear on the market that respond automatically to price signals to help decrease bills. There are considerable challenges of integrating these into the smart grid network using industry standards and in a manner that is acceptable to the consumer.

Conclusions

- It is necessary to create new and adapting existing regulatory and commercial frameworks.

[46] Source available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

- Establish new or different relationships with customers.
- Customer participation is strongly influenced by the structure of the electricity and gas markets. Changes to market structure could therefore be beneficial as the technology develops. For example, the use of the smart grids could enable much finer granularity of pricing to be achieved. Locational pricing might reflect the availability of locally generated power or difficulties of pinch-points in the distribution network.

Progress to date

- A Central Delivery Body (CDB) has been established by suppliers to centralise consumer engagement activity; build awareness, understanding and willingness for the smart meter rollout amongst consumers, including vulnerable groups and microbusinesses; as well as to act as a channel for communicating the wider benefits of the Smart Grid.
- Smart Grid GB has published "Smart Grid: A great consumer opportunity" which outlines customer benefits and best practice for engaging consumers. The report also describes the future role and responsibilities of customers, and barriers for industry stakeholders in engaging customers in more active roles.

Work underway

Industry stakeholders have acknowledged the importance of customer engagement and many activities are underway to explore how customers can be part of Smart Grid solutions in future:

- A number of the Low Carbon Network Fund trials are addressing the role of different stakeholders in identifying, recruiting and rewarding customers to actively manage their energy use, through behaviour change and control technologies.
- In addition to the smart meter rollout, many UK energy suppliers are trialing and deploying 'smart home' energy technologies. Through this work suppliers are learning about customers' willingness to engage with automation technologies and the incentives that may be most appropriate.
- The ENA is developing the necessary systems and processes to ensure data privacy and security that can be accommodated through appropriate aggregation of consumption data provided by smart meters. These plans for data aggregation are subject to Government approval. This work will help provide the correct balance between enabling network operators to use data to support DSR and the protection of consumer privacy.
- There are a number of research projects underway exploring the potential of customer involvement in demand side management and engagement techniques which will help us to understand how to engage customers. For example, Sustainability First31 is leading a major three-year project to understand the potential of the GB electricity DSR across all sectors of the economy until 2025. The project has a strong practical focus on policy, regulatory, commercial and consumer issues and its work is coordinated through a multi-partner Smart Demand Forum. The Energy Technologies Institute is developing Smart Systems and Heat capability with the ambition to create future-proof and economic local heating solutions for the UK.

Gaps and further actions

- Need to engage customers in a dialogue to understand their requirements and potential issues. This includes consideration of disadvantaged consumers to ensure that the benefits of smart grids are widely dispersed. Combined with this is the need to learn how best to engage with customers.

Smart Grid Forum will work toward

- Improving understanding about who is best placed to understand, engage and inform consumers to help them participate in different aspects of new smart electricity markets. Potential actors include suppliers, DNOs, aggregators, local authorities, product retailers, electric heating installers, electric vehicle or heat pump retailers, and potentially, future Distribution Service Operators. This will help build credibility and trust.
- Understanding how best to balance benefits amongst active customers, through direct rewards or cost-reflective tariffs, and the customer base as a whole through lower Distribution Use of System (DUoS) or wholesale charges. This is important to ensure that not only the active or those with the greatest means or interest, benefit.
- Furthering our understanding about factors which influence consumer behaviour, such as cost, carbon reduction, convenience, new technology, as well as social attitudes and context, and what incentives are needed, to achieve lasting change to ensure consumers offers are tailored to customer needs, which will help take-up.
- Exploring in the near-term the opportunities to articulate the wider benefits of smart grids alongside the roll-out of smart meters with the Smart Meter Central Delivery Body. This could provide a key opportunity for dialogue with customers.
- Ofgem and DECC to consider the role of multiple tariffs in encouraging DSR in the context of the simplification of household tariffs delivered by Ofgem's Retail Market Reform.

Element Energy: Analysis of Data from the HEUS Electricity Price Signals and Demand Response 2014.[47] *This Report, prepared for the Department of Energy and Climate Change and Department for the Environment Food and Rural Affairs (UK), examines the capacity of 250 homes to shift loads and reviews TOU Trials conducted between 2003 and 2014. It presents barriers and recommendations, many of which call for further research.*

Key Findings

- Comparing the actual amount of demand shifted in the four ToUT trials to the maximum technical potentials reveals that, in most cases, UK households engage well with ToUTs and are even willing to shift loads that involve some element of lifestyle change.
- That is to say, in addition to washing, drying and water heating loads (which can be shifted with minimal lifestyle impact via timers etc.) **there is emerging evidence that some cooking consumption and other loads closely linked to lifestyle patterns are being shifted in response to ToUTs.** This is a promising finding pointing to high levels of efficiency for this type of domestic demand side response intervention in the UK.
- The number of interventions implemented in conjunction with a ToUT (e.g. energy advice booklets, monthly consumption reports, real-time displays, online consumption data and complementary financial incentives) can have a strong bearing on the level of demand shifting achieved. **Cases in which more than two interventions were implemented, in addition to the ToUT, were observed to negatively impact peak shifting – possibly due to an interference effect in which consumers were overwhelmed by an abundance of information**. In the SSE trials, the optimal effect was observed for two interventions in support of the ToUT.
- The Energy Demand Research Project EDF trials showed that the **peak demand shifting effect of a ToUT was, on average, negligible for households with more than three occupants (aged 16-64).** This may be due to demand shifting constraints specific to large households, or perhaps it is linked to a "dilution" of actively participating household members – i.e. the household member(s) who signed up to the trial.
- Both the SSE and EDF Energy Demand Research Project trials revealed a generally superior demand shifting response to ToUTs on weekends relative to weekdays. While it is not possible to determine the causes of this difference from the data available, it is conceivable that **many households have an increased degree of demand flexibility on weekends when daytime constraints from work and school are typically lower**.
- The Customer-Led Network Revolution trial results exhibit, in addition to a strong shift in peak demand, a distinct demand peak at the beginning of the night-time tariff rate following the evening high tariff period. This behaviour points to a significant challenge for network operators and policy makers identified in our earlier HEUS report, Correlation of Consumption with Low Carbon Technologies, which relates to large new loads from emerging low carbon technologies (such as heat pumps and electric vehicles). As these technologies are adopted in greater volumes by UK households and automated to preferentially operate during low-tariff periods, the peak observed in the CLNR trials at the beginning of low-tariff periods will be greatly accentuated. This is a problem related to consumption diversity and can be addressed as such –

[47] Source available at: http://www.element-energy.co.uk/wordpress/wp content/uploads/2014/07/HEUS_Electricity_Price_Signals_and_Demand_Response_Final_Report_04_04_14.pdf

i.e. by staggering time-of-use tariff periods at the local and national level or implementing a range of demand side response mechanisms.

- The Northern Ireland Keypad Meters study, which encompassed a **high proportion of low-income households (since it was a pre-paid meter trial), showed the highest demand shifting response of all the trials examined in this report**. This raises important questions regarding the role of demographic factors in demand response, particularly in the context of the fuel poor.

Conclusions

- Gather further data on the types of lifestyle changes, particularly around cooking appliances (which contribute to approximately 20% of evening peak loads), that UK consumers are willing to adopt under modern ToUT interventions.
- Limit the number of demand shifting interventions implemented alongside ToUTs (e.g. energy advice booklets, monthly consumption reports, real-time displays, online consumption data and complementary financial incentives) to around two per household.
- Further research is required into the drivers behind poor ToUT response in high occupancy households and to better understand the load shifting constraints specific to these households.
- Further studies into the drivers behind the higher levels of demand shifting observed on weekends relative to weekdays could provide valuable insights for the optimisation of domestic demand side response interventions in the UK
- Further research the effect of locally staggering time-of-use tariff bandings on network loads and consumption diversity. Similarly, further testing is required to understand the effectiveness of applying multiple demand side response interventions to maintain consumption diversity while reducing peak time loads in the UK domestic sector.
- Further studies are required to explore the significance of household demographics (particularly household income and fuel poverty) in responsiveness to load shifting interventions such as time-of-use tariffs.