DELTA
Energy & Environment

SMART METER BENEFITS

COST SAVINGS HOUSEHOLDS COULD MAKE WITHIN A SMART ENERGY FUTURE

A DELTA-EE VIEWPOINT

FEBRUARY 2019

Delta-ee are a leading European research and consultancy company providing insights into the downstream "new energy" markets with a strong focus on the customer.

Our focussed research services include Flexibility and energy storage, Electrification of heat, Electric vehicles and electricity, Customer data value, Connected homes, and "New energy" business models. We also provide consultancy for clients including network companies and policy making bodies.

We've been asked to independently explore and communicate how smart meters are a central part of our vision for the energy system of the future, and to demonstrate how households can see these benefits.

A key challenge in portraying the benefits which smart meters can deliver is that the meters and infrastructure themselves are a facilitator which enables a large range of new and innovative energy products and services. They are part of the architecture of this new energy system. To understand the benefits, a broader spectrum of changes in the energy system must be explored and understood.

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Smart meters in our future low carbon energy system

The transition of the energy system to a more flexible, decentralised and decarbonised system is central to the UK reducing its CO_2 emissions whilst providing a reliable, sustainable and cost-effective system for customers now and in the future. The increased complexity of the system and the need to be able to flexibly match supply and demand means that digitalisation is an important part of the transition. Central to digitalisation is the accurate measurement of customer energy demands so the system can provide energy in the most efficient and cost-effective way, and customers can accurately understand how they use energy. For the first time, it will be possible to measure how much energy is being used, where, and when.

The roll out of smart meters will provide the means to measure customers' energy demands, providing the vital information for many of the other changes to happen. A consistent and open approach to capturing consumption data provides access to many innovative supply and services companies to offer customers better propositions whilst enabling the energy system to improve its operational efficiency, reducing infrastructure investment. Any alternative to the national open smart meter roll out will result in a more fragmented market, stifling innovation, artificially creating winners and losers, and ultimately offering poor value to customers and making CO_2 reduction more challenging. This will fundamentally mean higher costs for customers and reduced chances of reaching the UK climate change targets.

Many of the benefits of smart meters are immediately apparent and there are very clear use cases for benefitting customers and the environment. However smart meters are a facilitator for innovation and the majority of benefits they can provide have probably not yet been thought of. In this respect they are very similar to the early versions of the internet or smart phones.

The evidence in this report provides estimates of the savings achieved through smart meters from existing mechanisms, and shorter-term innovations and business models. Longer term, there are likely to be many more benefits and so this report represents a conservative viewpoint, which will probably only get better.

Summary and Highlights

We are seeing that smart meters are already helping many different households reduce their energy bills. With many new and innovative customer centric business models being developed, we predict that these benefits are going to increase and become more widespread as we shift to a new energy system, where customers are at the centre.

The benefits identified in this report represent a current view of the future. As with many other areas of digitalisation, it is likely that many of the future use cases and benefits have not yet been discovered and smart meters will facilitate a far greater range of benefits to customers and the energy system.

Smart meters are part of an energy system of the future. Our energy system is changing, and it's all part of the UK becoming a low carbon economy and doing our part to avoid the worst impacts of climate change. A more flexible energy system will allow for a low carbon energy system at the lowest cost, saving money on household energy bills.

New products and services are emerging. There is a large amount of value available in helping customers use less energy and use energy at times when supply is higher than demand. Our research shows that there is rapid growth in the number of companies offering services which help householders access this value. We predict that these numbers will keep growing, especially as the business models mature and households gain experience and become more familiar with this changing energy market. These split into 3 types of proposition:

1: Being energy-wise could save engaged consumers over £50, and many households with medium to high energy consumption would be able to save £100 or more. Smart meters enable households to better understand their energy use. Consumers who want to be more in control of their energy bill will be better able to understand the costs of using different appliances in their home, know when appliances are left on, and compare their energy usage to similar households. Energy insights based on consumption data are improving and the challenge now is for these learnings to be presented in a way that can be better understood and acted on by consumers.

2: Using energy when it's cheapest could save households around £90 per year. The cost of energy changes hour by hour and energy can be sold at a much lower price at times of low demand and high supply. With increasing low carbon generation and changes in the way we are using energy, matching demand to supply is going to get even more important in the future. Smart meters allow households to take advantage of time varying prices by monitoring consumption in real time and potential for automatically optimising smart appliances.

3: Changing the way we buy energy can currently save households over £200 per year, and smart meters are key to this. Smart meters are part of a transformation in how households will buy energy in the future. Some examples of this are automated switching, peer-to-peer trading and smart pre-payment meters. However, we think this is just the start and we predict that in the future households will buy energy outcomes (such as a warm house and mobility) and it will be up to the supplier to count the kWh of electricity and gas.

Introduction

The UK has committed to 80% reduction of CO_2 emissions by 2050[1] and 57% by 2030[2]. For us to achieve this in the lowest cost way, the energy system will need to radically change.

In the old energy system, predictable energy demand was met by centralised and controllable fossil fuel and nuclear power stations. Conventional "analogue" meters were considered the termination point of the energy system at the point of delivery to "end users".

These "end users" are households for 36% of electricity and 60% of gas[3], and the energy system of the future will have customer households at the centre. We see smart meters as a keystone technology for the system of the future, where we predict that greater focus will be on when energy is used than how much is used. We believe that smart meters are a part of the future of energy system flexibility where significant savings are obtained through optimisation compared to the costs we could incur if we try to decarbonise in a business as usual manner.

In the shorter term, smart meters have a large part to play in increasing households' awareness of the energy they are using, helping households to make changes to stop wasting energy. Longer term the benefits are significant and will continue to grow with new innovations.

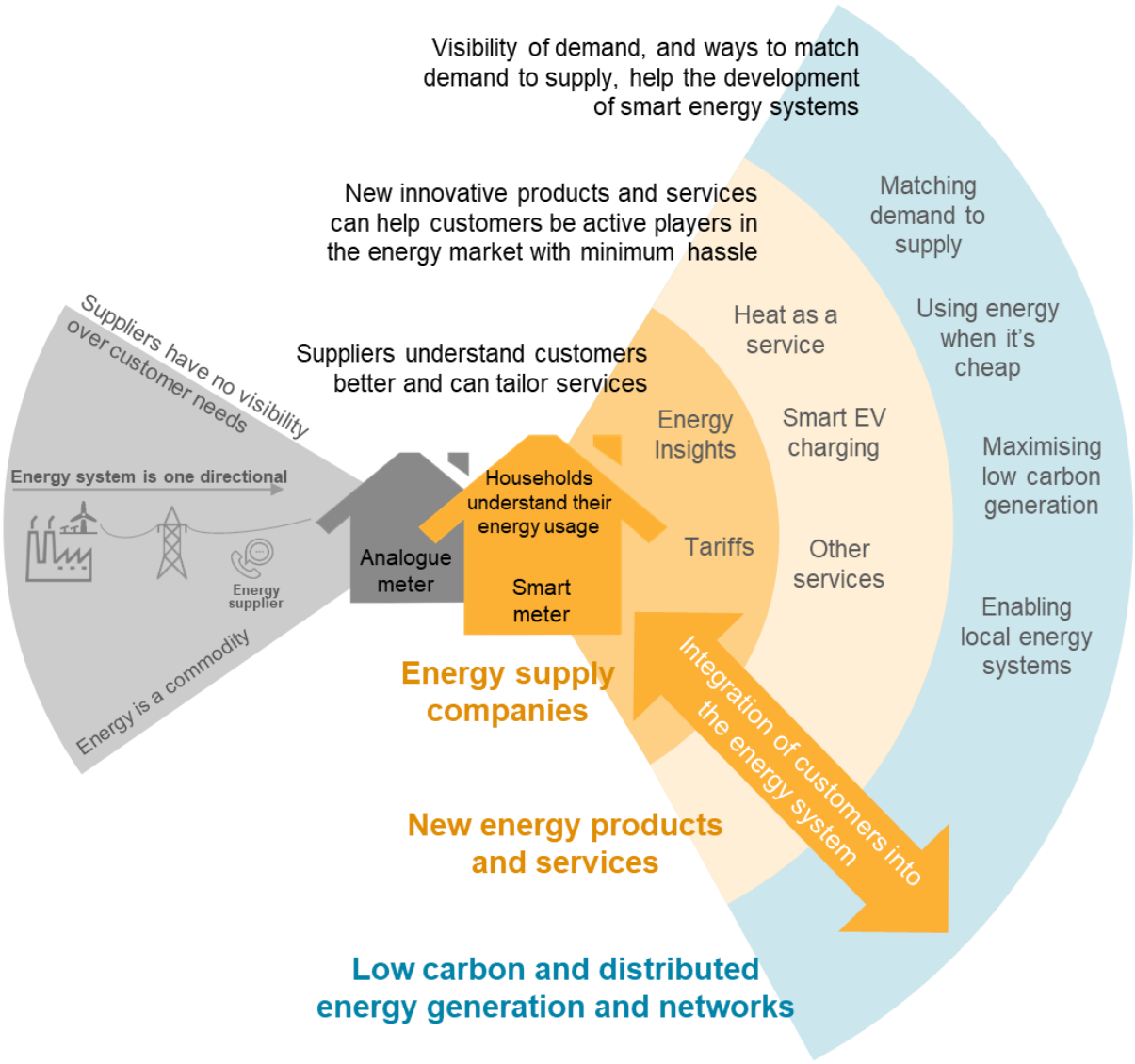
In this report we aim to demonstrate what the benefits can be for households and across the GB energy system. New opportunities are emerging in the form of products and services offered through what we call "new energy business models", and we classify these into 3 types:

1. **Being energy-wise:** Using energy more efficiently, reducing waste (p7)
2. **Using energy when it's cheapest**: Balancing demand to supply (p9)
3. **Changing the way we buy energy:** Consumers being the focus of the market (p11)

In this report, we describe how the new products and services in these 3 categories make use of smart meters. We have researched the savings currently obtained in smart meter equipped homes. We give examples of innovative companies already starting to offer new services to customers; in many cases these are international examples and give a flavour of the types of services UK households could take up in the future.

We've calculated what we think the overall savings are that could be made by a typical engaged household (p13). We then take a broader look at the system level cost savings that are estimated from a smart energy system (p14), and finally we bring the report to a conclusion (p15). Detailed analysis behind the numbers and analysis are given in the appendix (p16), referenced to throughout this report.

Our vision of the New Energy system



1: Being energy-wise

- **Smart meters can allow householders for the first time to understand their home energy usage patterns.**
- **Better information allows more informed decisions to be made around using and saving energy.**
- **Additional data analytic services offered by companies can provide tailored advice to help households to save energy.**
- **Smart meter data could accelerate rates of energy efficiency upgrade to buildings.**

Helping customers reduce their energy consumption and save on their energy bills is far from a new idea. Smart meters provide greater visibility of a household's energy consumption and the in-home-display alone can help households change how they use energy to make cost savings. Services can enhance these insights and broaden engagement.

Real time feedback can help households save 5-15% of their energy consumption, typically equivalent to over £50 per year[4]. Smart meters combined with an in-home-display make the otherwise invisible energy visible by showing in real time the energy consumption in kWh but also translated in a relatable cost of £/day. Smart meters offer easy wins in terms of understanding and visualising energy around the house. Consumers are more likely to replace an old inefficient appliance or care to improve their home's insulation if / when they realise how much it is costing them. Nudges in the form of text notifications or guided decision making can also support the formation of energy habits, for example to check on the week's usage or to pay a bill early.

Organisations who deliver in-home support for vulnerable households, such as Groundwork's Green Doctor program[5], are using smart meter data and in-home-displays to give better tailored advice. These one-to-one services may be crucial for some households to engage[6].

Disaggregated feedback can help an average household save around £40 per year (4.5% energy saving)[7]. Disaggregation means breaking down a home's energy use to show how much each appliance consumes. Advanced algorithms can analyse patterns of usage over time and provide energy insights that give a detailed appliance consumption breakdown for a household.

Comparisons, prompts and games

Data analytics are used to offer tailored energy advice (e.g. around inefficient appliances) or energy budgeting options with examples of European suppliers (e.g. Sowee in France) offering customers options for setting energy bill alerts. Households are also more likely to change their energy behaviour if they compare themselves against their neighbours, similar households or when they set themselves targets and challenges to reduce their energy consumption[8]. This requires accurate and timely feedback which smart meters enable. Making energy savings into a game has also been used in research trials and more recently by energy company looop (see p9) to increase energy savings by challenging individuals or groups of people to use less energy than another group.

Insights that encourage energy efficiency improvements can save over £100 per year for individual measures[9], or up to £300 to reach efficiency levels aimed for by 2035[10].

Smart meter data has the potential to accelerate the rate of energy efficiency improvement in the UK. Better measurement of energy performance[11] could improve the targeting of retrofit support for both home owners and tenants. Improved monitoring and evaluation of energy efficiency improvement work[12] could help improve processes and skills in the sector and improve the certainty of energy savings after upgrades. Lower risk around achievable energy savings could support the growth of green mortgages[13] and other ways of funding energy efficiency improvements without households having to pay upfront.

ONZO UK Data analytics company providing energy insights

Onzo is a UK based software company who provide data analytics to utilities. They specialise in providing advanced energy insights and their algorithms are based on smart meter and sensor data from residential customers. Onzo helps energy companies help their customers use energy more efficiently with:

- Detailed bill breakdowns
- Personalised appliance-level energy advice with actionable tips on how to save energy & money, e.g. “using your washing machine before 7pm will reduce your bill”.
- Early identification of potential appliance faults

Through its partners across Europe, Onzo has already helped more than 1.5m households understand their energy consumption better.

In the future, Onzo aims to improve the energy insights it can offer in order to facilitate demand side management services through disaggregation.

Onzo are working with energy companies across Europe:

SCOTTISHPOWER
Eneco
Fjordkraft
NLE
GREEN CHOICE

Similar business models can be seen across Europe

ECOTAGIOUS
Energy conservation. Worth spreading.

Ecotagious (North America) provide customer energy insights using utility meter data. Their solution includes appliance breakdown, benchmarking against other households and tailored recommendations for end-users. Ecotagious results show that their disaggregation programs have helped households save on average 3% on electricity and 2% on gas during a winter period.

Quby

Quby (owned by Dutch utility Eneco) has added a ‘Waste Checker’ feature in its application for their Toon smart thermostat. This feature uses smart meter data for demand disaggregation and offers personalised customer advice. Insights also highlight the savings available for replacing old inefficient appliances - for a British household, replacing a D rated boiler with a high-efficiency A-rated boiler could save £85 - £110.

EDF

EDF (France) has created an energy insights platform for their customers called e.quilibre. The platform aims to help EDF customers understand and act on their consumption by providing breakdown analysis and encouraging engagement with regular notifications sent to a customer by email or text message. The notifications can help customers engage more to understand and act on their consumption.

2: Using energy when it's cheapest

- **Smart meters will allow for the varying cost of electricity to be passed on to customers in order to promote a shift of demand to when low carbon generation is most available.**
- **Smart meters can promote the automation of high electrical loads to get the best results out of flexible demands.**
- **Recent trial tariffs have shown that engaged households can save around £90 per year from shifting energy use away from peak times[14], and this increases to £130 for households who have an electric car[15].**

In the past, energy demand was predictable and stable generation from fossil fuel and nuclear power stations produced virtually all electricity. As our energy system becomes low carbon, we are moving towards far greater levels of renewable energy generation.

Renewable energy sources can be intermittent and less predictable, and the match between supply and demand from the old system breaks down. This results in highly volatile energy prices depending on whether there is oversupply or constraint. The cost of energy varies hour by hour, but currently most households pay the same price at all times of day. Whilst simple economy 7 and 10 tariffs currently exist, they are inflexible and don't represent the true variation in energy costs.

In the new energy future, we predict that household energy will be benefit from variable costs throughout the day and households will be able to take advantage of cheaper energy periods. Smart meters allow for real time variation in energy price, and the ability for customer's demands to automatically react to prices and save money.

Flexibility with connected home devices

Although some households can and may choose to change the patterns of their energy behaviour, we predict that most flexibility will be through connected smart devices which automatically avoid using energy at expensive times, but in ways that the households can prescribe or won't notice[16]. Smart devices can be connected together and linked to the smart metering signals via home area networks. Even greater flexibility can be achieved with in-home energy storage.

Flexibility with additional electrical loads – heating and transport

Electrification of heating and transport is important for reducing fossil fuel use in the UK. In the future, we predict that there will be even more value available for customers who can shift their electricity demand away from peak times as these additional electrical loads put more pressure on the existing energy system[17]. Eighty percent of electric vehicle owners are predicted to charge their car at home, creating a major new electricity load. Dynamic price signals can specifically benefit these electric vehicle owners if it helps them shift this load to use cheap electricity overnight. Similarly, more extensive introduction of time of use tariffs means that electric heating households can choose to control their heating or heat their electric hot water tanks more efficiently to avoid high electricity bills; a number of companies are already offering this across Europe as shown on the next page.

Agile Time-of-Use Tariff

In February 2018, Octopus Energy launched a time-of-use tariff called Agile. The Agile tariff gave residential customers access to half-hourly energy prices tied to wholesale energy prices and was updated daily.

- 28% of Agile users changed their usage from the evening peak (4-7pm) to off-peak times.
- The most engaged 25% of customers saved £91 compared with the Octopus 12M fixed tariff and £229 compared to a legacy supplier standard variable tariff.
- Households with electric vehicles achieved the highest savings. The most engaged electric vehicle customers reduced their peak demand by 47% saving £132 compared to the Octopus 12M fixed tariff.

Octopus plans for the Agile Tariff to go further with automated control for household appliances to turn on when electricity is cheapest and smart charging for electric vehicle customers to buy and sell electricity with the grid.

Comparison of usage profile before and after shows that Agile customers shifted their electricity use from peak to off-peak times, reducing their burden on the grid

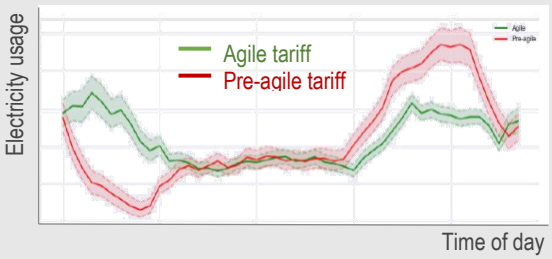


Image taken from Octopus Energy Agile report (2018)[14]

A similar business example

Looop is a Japanese electricity supplier that has partnered with UK software company SMAP Energy to provide a smart meter enabled time of use tariff in a trial with 1000 customers. The results from the trial showed that households had on average 5% savings on their electricity bills with some households saving up to 10%.

This time of use tariff, which was the first of its kind in Japan, managed to show the potential of smart meter data in making smarter tariffs. The extra element of gamification in the trial, where customers compete against others to reduce consumption, is something that could help customers engage more with their energy.

Flexibility with electric heating available across Europe

Voltalis is a French aggregator offering a free electric heating control solution to residential customers in exchange for switching the home's panel heaters on/off in response to price signals. Households can save up to 15% on their energy bills with little to no interruption to their day-to-day usage. As smart meters allow for half-hourly energy measurements, they could provide the metering requirements needed to deliver this service. Voltalis has already started to test its solution in the UK and in the future, it plans to incorporate electric vehicles and battery storage.

The Finnish utility Fortum offers a heat optimisation service which is based on half hourly dynamic tariffs and a hot water heating solution developed by There Corporation. Customers select their comfort temperature level and the system heats up the water at the lowest cost. Fortum's service is particularly useful and can provide significant savings to customers that rely on electricity for their hot water needs.

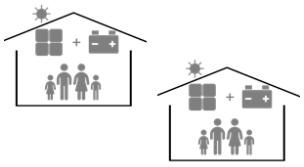
Home energy management specialist GEO has designed Cosy Nordics, a heating management system for electric heating households. GEO's system works out how to heat the home in the cheapest way either by preheating or avoiding expensive periods by combining smart meter data, signals from Norway's spot pricing market (Nordpool) and temperature data. Early trials have shown energy bills savings of up to 25%. GEO is looking to make its solution available to other countries with high penetration of electric heating, such as France.

3: Changing the way we buy energy

- **Greater visibility of energy use opens opportunities for much more sophisticated and innovative business models in the energy market place with more consumer choice.**
- **We think that by 2030 the way that customers interact with the energy market will look very different and give them much more control.**
- **Smart meters enable greater digitalisation and connectivity inside and outside the home.**

Traditionally the only market choice consumers could make with regards to their energy was choosing their supplier. Here, we show three examples of how smart meters are or could disrupt the energy markets, and we think this is only the start.

Tariff auto-switching could open up savings of up to £300 per year[18] to a wider proportion of UK households.



Supplier switching rates in the UK in the past decade have been on average 3-4% of customers, even though typical savings can £200-£300 per year[19]. This shows there is great scope for consumers to engage more in the energy market, but barriers have prevented this from happening.

Auto-switchers simplify the job of switching for households and give them the peace of mind that they are on the right deal year after year without hassle. At the moment just over 100,000 UK households use auto-switchers like Labrador and Flipper[20]. By analysing customers energy use profiles using smart meter data, switchers can choose the lowest cost options for customers.

Smart pre-payment meters are already helping households save of £75 per year[21].

Historically, pre-payment meter (PPM) customers had to pay higher tariffs than credit meter customers. This was justified because PPMs were more expensive for energy companies to supply[22]. Once households have a smart meter, and if they pay for their credit online or through an app, the cost to service is not higher and this is already being reflected in more equal tariffs. With smart meters, we think energy companies will be more likely to offer even better deals to households on smart PPMs.

Peer-to-peer energy trading is still in its infancy, but an emerging example in Germany has shown annual savings of around €150 (~£100 when scaled to UK electricity prices) for a household with solar panels and a battery[23].

Energy trading allows consumers to choose where they want to get their energy from and to trade the excess energy they generate. This requires accurate live energy measurements enabled by smart meters. Peer-to-peer trading platforms give households with solar panel installations or battery storage the opportunity to earn some extra revenue by trading with their local energy community. Peer-to-peer trading also enables a platform for community energy companies where local people can use or buy co-operatively owned energy generation.

Labrador Free auto-switching service

- Labrador is an automatic switching service for gas and electricity with ~5000+ customers to date.
- Customers with a smart meter get a free Consumer Access Device (CAD) – the Retriever – which is self-installed and syncs with the smart meter for more accurate energy monitoring and switching; Labrador have found that cheaper offers can be found for households when using their accurate demand data.
- Labrador's service is free to customers and can be tailored to personal preferences other than price (e.g. green tariffs only).
- The company estimates that customers are typically switched 1 to 3 times a year saving ~£300 on their energy bills.

Piclo, a new peer to peer energy trading platform

Piclo is an online energy trading platforming the UK, created by Good Energy in partnership with Open Utility. Piclo is a marketplace for renewable electricity generation and can match generation and consumption according to preferences and locality.

- Customers require a smart meter for accurate real-time metering of the electricity being put on and taken off the grid.
- Participants can choose who they source or supply their energy from or to
- Customers get direct access to renewable electricity.

The platform is still in early stages but has already achieved proof of concept in a trial with ~1000 commercial and industrial customers of Good Energy and is continuing with trials with residential customers.

We are seeing similar examples across Europe

Powerpeers is a Dutch energy supplier with a peer to peer energy trading platform that enables residential customers and generators (prosumers) to virtually share the energy they generate.

Sonnen is a German battery storage provider who has turned into green energy supplier offering customers the chance to participate in **sonnenCommunity, a virtual energy sharing platform for excess self-generated solar electricity**.

- Sonnen installs a smart meter, and for a monthly subscription, customers can participate in the community
- Energy demand beyond what they generate themselves is available for a low price.
- Savings of €150/year are quoted for a household with solar panels and a battery.
- Sonnen is continuously expanding the range of energy technologies it can incorporate with the recent addition of electric vehicle chargers (sonnenCharger).

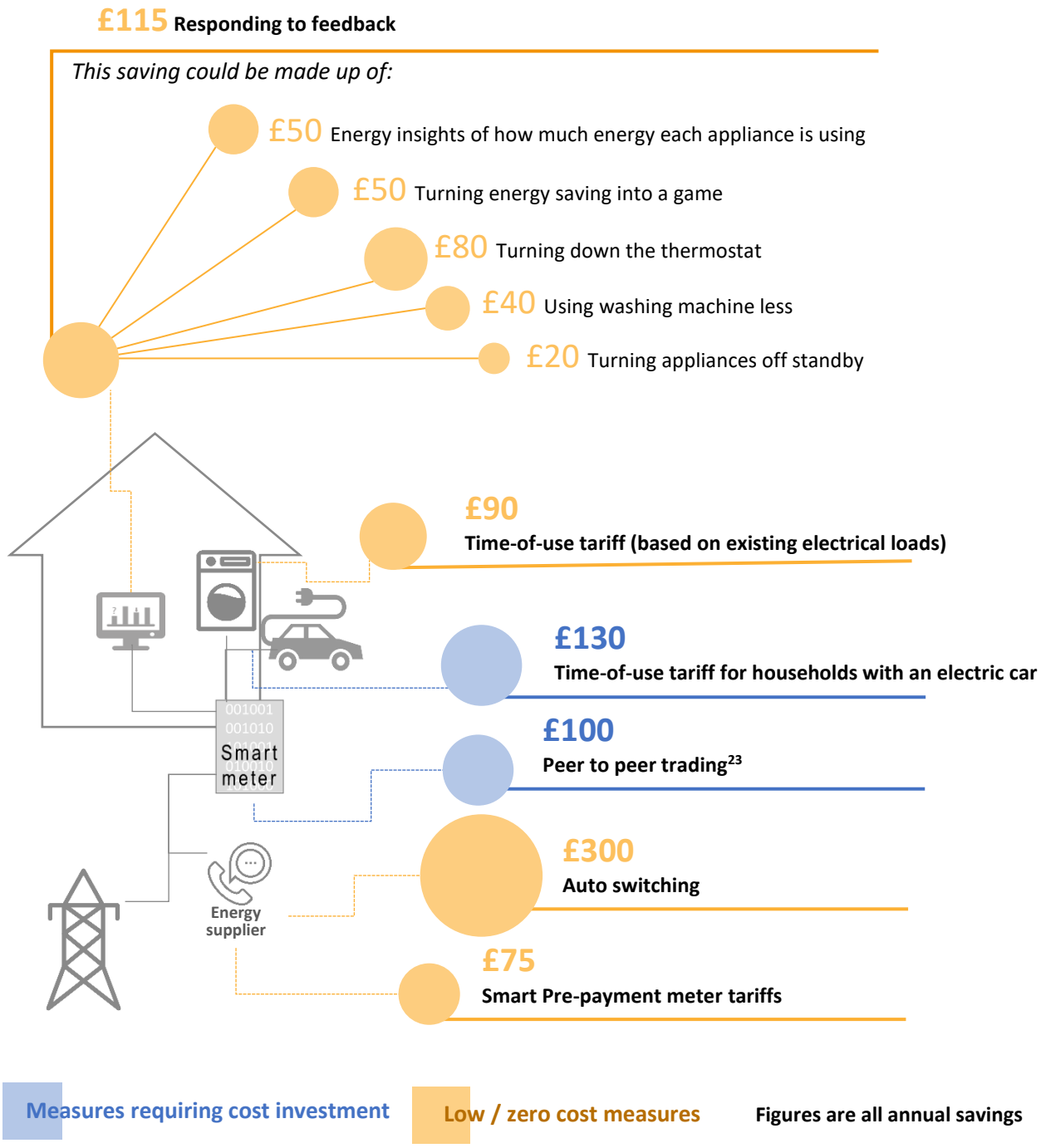
Fairer tariffs for smart pre-payment customers

Ovo Energy has launched Boost, a separate Pay As You Go (PAYG) business, with PAYG+ as their core offering aimed at smart pre-payment customers. Boost Smart PAYG+ gives the opportunity to households with pre-payment meters to get a smart meter and track their top-up needs in real time.

Utilita is the only supplier focusing on pre-payment, or "pay-as-you-go", as their default tariff, and install a smart meter as soon as customers join. Even customers who prefer 'credit mode' will only get the cheapest tariff via 'pre-pay direct debit'.

Smart meters can enable significant cost savings

Across Britain, all households are different, and therefore the expected cost savings are very different too. Here we show the savings that could be available to a typical household. Overall, there are multiple ways that households could save over £100, and by responding to feedback, and taking advantage of new business offering of dynamic time of use tariffs or auto-switching, households could save hundreds of pounds from the opportunities smart meters open up.



Benefits of a flexible system

We recognise that flexibility of the electricity network can save a lot of money at the network level. Estimates of the value of this are up to £8 billion per year in 2030, worth around £300 per household per year[24].

As well as increased flexibility of the system, we are likely to need a change in the cost structure of energy.

We need a more flexible energy system to help integrate intermittent renewables[25] and to avoid the extra cost of accommodating peaks in demand.

Flexibility can come in a number of ways

a. Greater interconnection of our system with mainland Europe
b. Using energy storage – much of which may be through electric vehicles, batteries in homes, or storing electricity in the form of heat
c. Shifting demand away from peaks.

Smart meters are required for (b) and (c), and will mean that the overall cost of the electricity system will be lower.

Network cost savings come from reduced generation, reduced network investment, and reduced reliance on expensive gas peaking plants when demand and supply don't match up.

This £8 billion per year are indirect benefits to households – with lower levels of flexibility, this money would need to be raised through additional network and generation costs on household energy bills or as a centrally funded infrastructure project, with the end cost falling on households.

It isn't yet clear exactly how the cost savings will be passed on to customers. Some of this benefit will be shared across all customers. Some of the benefit will be passed on to customers who engage most in changing their demand times, (either manually or through automated systems), forming an incentive for matching demand to supply, especially for big electrical loads.

A decarbonised energy system is too radically different to the old energy system for the status quo to continue for many more years. The current structure of energy pricing will not be sufficient to reflect the costs in the energy system for much longer. In a high renewables future energy system, energy costs will more strongly reflect the total capacity of the energy networks and expensive backup generation will need to be paid to be on standby to help meet the peak demand[26]. If smart meters can help to reduce peak demand, they will help to reduce the cost of this future energy system.

We believe that an energy tariff (charged pence per kWh) could be replaced by an outcome-based experience for the energy customer. The rise of "energy-as-a-service" type propositions guarantee to deliver customers comfortable temperatures in the home and sufficient mileage to travel as needed. These innovative business models will depend more than ever on having a clear record of when customers are using energy and it will be up to the companies delivering the service to ensure the low carbon energy system of the future can be delivered in the lowest cost way.

Conclusion

In this report we've shown the savings available for households who engage with smart meters and the innovative products they can enable. We predict that this is just the start, and that over the next 5 years there will be lots of other options becoming available, suited to the needs and preferences of different types of people.

Households can benefit though different levels of engagement:

1. **Investigate and understand energy consumption:** use the in-home-display to investigate how much energy is being used and when. This allows households to modify their use of appliances and see direct benefits. By simply understanding their energy consumption better, a typical household could save £115 or more per year at no cost.
2. **Sign up and engage in the market:** services such as auto-switching which use smart meter data allow households to access the best energy tariffs based on their needs, and can save up to £300 per year, especially for households who do not regularly switch suppliers.
3. **Invest in smart technology:** Households who have flexible loads can gain further value by reducing peak loads on the system and buying energy when its cheap. Variable dynamic time of use tariffs allow loads such as smart appliances, battery storage systems and electric vehicles with smart chargers to automatically vary their demands based on tariff information from smart meters. Flexibility could save households £130 or more per year.

In the long term, we expect improved metering will play an important role in the future energy system. Smart meters will facilitate a balance of demand and supply in the electricity system which will be particularly fundamental as we reduce carbon emissions from buildings and road transport. They will also facilitate a change in the way we buy energy and we predict that in the future the energy market will be very different to how it is today.

Without smart meters, the opportunities for innovation and opening up the energy market for customers are limited and we expect that this will make the energy transition more difficult and overall more expensive for the UK to become low carbon.

Appendix

Where possible we have based energy savings figures on measured savings within trials.

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1 The UK Government Climate Change Act (2008) commits the UK to reduce greenhouse gas emissions (including carbon dioxide, methane, nitrous oxide and hydrofluorocarbons) by 80% by 2050compared to a baseline of the year 1990. *www.legislation.gov.uk/ukpga/2008/27/contents*

2 The Committee on Climate Change recommended that the UK's 5th carbon budget is set at 1,765 $MtCO_2e$ per year for the period of 2028 – 2032. This would limit annual emissions to an average 57% below 1990 levels. *CCC (2015). The Fifth Carbon Budget: The next step towards a low-carbon economy. Committee on Climate Change. www.theccc.org.uk/wp-content/uploads/2015/11/Committee-on-Climate-Change-Fifth-Carbon-Budget-Report.pdf.* The UK government adopted the 5th Carbon budget in 2016.

3 Statistics for household use of electricity and gas are taken from BEIS statistics.

4 Savings from real time feedback

Review of trials assessing savings from feedback give varying results of savings available. Generally, energy savings are quoted between 5-15% of energy consumption, with high variation within and between studies.
https://eprints.qut.edu.au/58017/4/2013001547.pdf;
https://aceee.org/files/proceedings/2016/data/papers/12_769.pdf ;
https://www.eea.europa.eu/publications/achieving-energy-efficiency-through-behaviour/file;
https://esmig.eu/sites/default/files/2011.10.12_empower_demand_report_final.pdf;
https://www.researchgate.net/publication/281291249_Case_Study_of_Smart_Meter_and_In-home_Display_for_Residential_Behavior_Change_in_Shanghai_China;
https://www.napier.ac.uk/research-and-innovation/research-search/outputs/energy-behaviour-change-by-coloured-inhome-display
In some trials or reviews the savings are quoted up to 20%
https://www.eea.europa.eu/publications/achieving-energy-efficiency-through-behaviour/file;

There is a differentiation between direct and indirect feedback. Direct feedback is real time, and can be delivered through a smart meter in-home-display. Indirect feedback are insights from data that has been processed. Smart meter data can enable energy suppliers or other advice-giving bodies to provide households specific advice. Direct feedback is generally found to deliver greater savings than indirect feedback, and therefore an engaging in-home-display has been seen as an important offering alongside a smart meter.

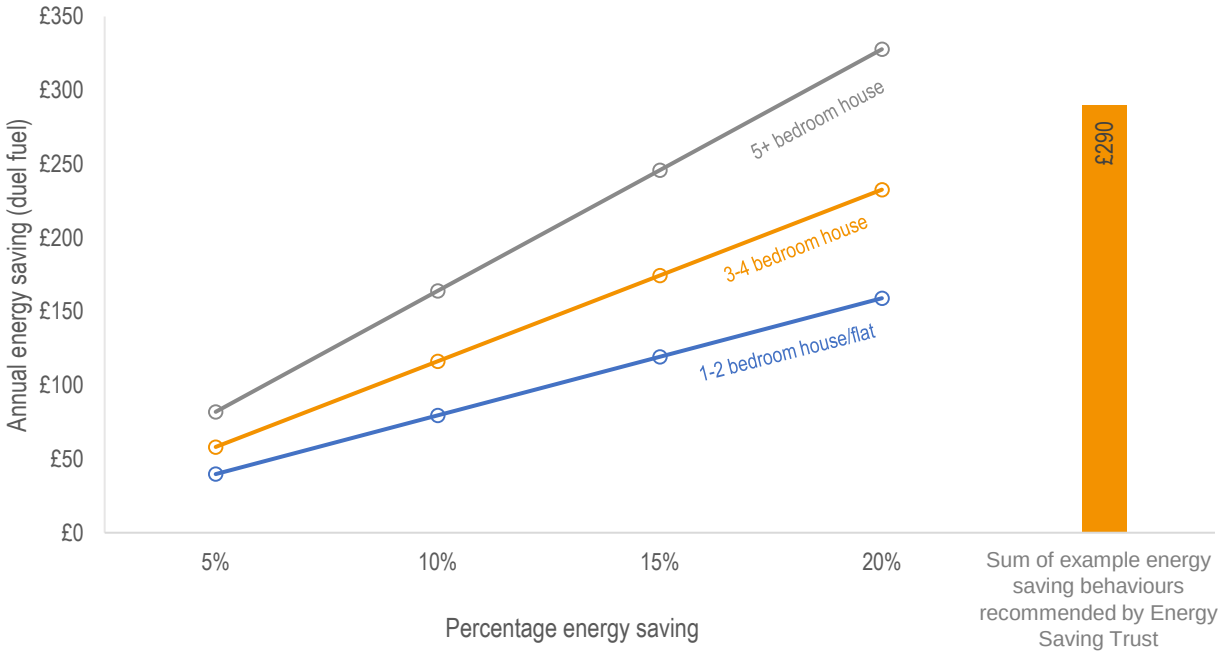
The most successful types of engagement are those that provide immediate feedback, compared to a standard, clear, meaningful and personalised reference. Data visualisations need to go beyond time series analysis, and clear advice needs to accompany the data. For indirect feedback to be engaging, it needs to be delivered in high frequency. For any feedback to stick beyond the initial novelty period, it needs to enable households to develop new habits and practices.

Based on the above range of 5 – 20% of savings, figure A shows what this saving range would mean to households with different energy consumption levels. It compares these savings to the sum total of common energy saving behaviours that are shown to enable cost savings of £290 for a typical three-bedroom house (equivalent to a 25% saving) according to an example from the energy saving trust *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/587331/Zero_cost_saving_energy_-_SmartMeter_Behaviour_LOCKED.pdf*. We don't think that households would necessarily gain all of the individually listed savings in the linked

reference, but it is an indication of how simple behaviour changes can add up and shows where the 5 – 20% of energy savings could come from for a typical household.

We think that any engaged energy consumer could expect to save over £50 per year if they use their in-home-display to identify which appliances are using more energy than they need to, or which appliances are using energy when they're not being used. Those with energy consumption already medium to high should be able to make considerably higher savings, at £100-£150 per year. The actual energy savings which households will make depends on many factors such as their current energy consumption behaviours (whether they are a low, medium or high energy user), their motivation and engagement to save energy. The household situation is also important; if some members of the household require a warmer house or additional electrical devices due to age or illness, it may not be suitable for savings to be aimed at them in the same way. All situations are different and specific help can be sought for vulnerable households. As energy companies develop better ways of presenting energy feedback and engaging currently un-engaged customers, these high levels of energy savings will be available to more households.

Figure A: Plots of the level of energy savings which households could expect from smart meter enabled feedback show that saving over £50 a year should be quite easy for most households



Energy usage based on: 1 - 2 bedroom house/flat - gas usage of 8,000kWh and an electricity usage of 2,000kWh; 3 - 4 bedroom house - gas usage of 12,500kWh and an electricity usage of 3,100kWh; 5+ bedroom house - gas usage of 18,000kWh and an electricity usage of 4,600kWh. https://www.ukpower.co.uk/home_energy/average-energy-bill

5 Groundwork's Green Doctor Programme deliver free in-home energy advice visits to low income and vulnerable households. They are an example of frontline workers who are using smart meter data and insights to improve the tailored support they provide to households.

6 The benefits of smart meter data for providing meaningful energy advice was investigated through the SMART-UP project, led by National Energy Action (NEA) (UK lead partner) and funded by the European Commission. The aim was to understand the impact that tailored energy advice can have on the active use of a smart meter and in-home-display to manage energy consumption in vulnerable households. They found that advice was most effective when given in a combination of direct (enhanced face-to-face advice and telephone aftercare service) and indirect (the provision of written information pack). The report highlights that smart meter engagement can have a knock on effect to further energy rationing behaviour, and that for vulnerable households, support needs to be a combination of financial help for energy efficiency measures, behavioural change advice, alleviation of fuel debt and ensuring that the household is

on the cheapest tariff that is suitable to their needs *www.nea.org.uk/wp-content/uploads/2018/08/SMART-UP-UK-FINAL-REPORT2.pdf*.

7: Savings from feedback trials using disaggregated data

Disaggregation is estimated to reduce energy consumption by 4.5% for engaged energy consumers (based on a 2016 review of academic literature between 2002 and 2016). Across a whole population the energy savings with disaggregation were lower at 0.7% showing that engagement with insights is required to ensure savings are made. *https://arxiv.org/pdf/1605.00962.pdf http://jack-kelly.com/files/writing/jack-kelly-phd-thesis.pdf*.

8 Evidence from comparison and challenge setting

A 2015 review of 9 games with energy saving results suggests gamified energy efficiency programmes can generate energy reduction of 3-6% amongst a 'sizeable number of participants' and that savings over 10% can be achieved in narrowly targeted programmes. The largest sample size game was the San Diego Energy Challenge (run by San Diego Gas & Electric (SDG&E) and Simple Energy) which made use of smart grid data to reward people who used less energy than on a day with similar weather. It involved 42,000 households which achieved 6% savings in the summer, 2% in the winter, and on-peak demand reduction was 2.2%. Not all games are smart meter specific but arguably the availability of smart meter data could improve the accuracy and timeliness of the data behind the challenges and help households to see how their actions are reducing their energy use in real-time. *https://aceee.org/research-report/b1501*
Based on Figure A, a 3 – 6% savings would save households typically around £50 per year.

9 Savings from home efficiency measures could be around £100 for cavity wall insulation, £50 for loft insulation or £110 for a new condensing boiler (per year) for a typical three-bedroom house. Energy saving from loft or cavity wall insulation is estimated from BEIS statistics looking at average numbers over a sample of UK houses (National energy efficiency data-framework Impact of Measures Headline Tables *www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2017*). For cavity wall insulation, the median savings are estimated to be 9.5% of gas consumption and a quarter of households saved more than 24% (sample size 43,240 in both test group and comparator group). For loft insulation, the median savings are estimated to be 4.0% of gas consumption and a quarter of households saved more than 21% (sample size 21,510 in both test group and comparator group).

10 Moving up an energy performance certificate (EPC) band from an E rating to a C rating is estimated from the typical energy usage of each of these bands - saving around £300 per year *www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2017*. This cost saving represents combinations of measures that can improve the overall energy performance of a house to the levels expected by 2035 (EPC rating of C).

11 More accurate energy performance ratings using smart meter data are being investigated (for example, BEIS have launched a smart meter enabled thermal efficiency ratings (SMETER) innovation competition). This could help with robustness of government minimum energy rating targets and help to more confidently allocate resources to where they are needed. They could also give greater confidence to home owners where more tailored and trustworthy advice could prompt households to take up energy efficiency improvements which they are otherwise not convinced are needed or not aware are needed.

12 Improved monitoring and evaluation of retrofit to help improve methods and skills.

In the commercial sector, energy efficiency measures are more commonly paid for in a pay-as-you-save format, delivered by energy service companies. Part of the contract includes verifying that energy efficiency measures deliver energy savings and whether any increase in energy demand comes from extra service taking by the customer or by the poor performance of energy efficiency interventions. A monitoring and verification protocol is commonly used in the commercial sector which allows for the evaluation of energy efficiency improvements *https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp* and this could be adapted to the

domestic sector using smart meter data, enabling for a pay-as-you-save model to be expanded into homes and for broad evaluation of the actual savings being delivered by energy efficiency interventions.

13 Green mortgages A "green mortgage" or "energy efficient mortgage" is a mechanism for incentivising home owners to improve the energy performance of their property or acquire an already energy efficient property by offering more favourable mortgage conditions (either lower interest rates or increased loan amounts). The rational is that the credit risk of the mortgage loan is lower if the energy costs of the house are lower *http://eemap.energyefficientmortgages.eu/roadmap/*. Smart meter data can improve the prospect for green mortgages if they can provide a more rigorous method for measuring building performance and can be used to measure the energy savings which the energy efficiency measures bring. A collaboration between E.ON and BNP Paribas Personal Finance UK are launching a green mortgage pilot in the UK to continue to develop this potential new service offering. *https://www.eonenergy.com/about-eon/media-centre/eon-joins-forces-with-bnp-paribas-personal-finance-to-help-uk-home-owners-unlock-energy-efficiency-potential-through-green-mortgages/*.

14 Results of flexibility trial show that the most engaged 25% of participants saved an average of £91 per year (based on results from the Octopus Agile trial *https://octopus.energy/static/consumer/documents/agile-report.pdf*). Conversely, the least engaged 25% of participants still broke even, but average savings were less than £1. This shows that active engagement is important for this manual-engagement type of time-of-use tariff where households are required to change their behaviour to shift demand from expensive peak times to cheap off-peak times. We expect that in the future, time of use flexibility will be more automated, and would enable households to make savings even if they are not fully engaged.

As a comparator, the Customer Led Network Revolution (CLNR) time of use tariff trial found that the majority of households saved money on their energy bills, with savings between £30 and £350 and electricity demand during the 4 – 8pm evening peak was 10% lower than the control group. *http://www.networkrevolution.co.uk/customer-trials/domestic-customer-trials/%EF%BF%BCtime-of-use-tariffs/*

15 Results of flexibility trial for homes with an electric vehicle show average savings for households who have an electric car were equivalent to £132 per year (based on the above Octopus Agile trial). For an average commuter with an estimated 12,800 km driven per year (1560 kWh of electricity required), with 80% of charging being during off-peak time, this saving is equivalent to off peak electricity being 10.5p cheaper than peak electricity.

16 Automation of demand response will be dependent on aggregators who link many household loads for demand side response (DSR) services. In current innovation trials of residential DSR across Europe, flexibility serves as an additional source of revenue for households through the support they provide to the energy system.

17: Much higher electricity loads are expected in the future With the uptake of electric vehicles and high efficiency smart electric technologies required to meet climate change targets, it is predicted that annual electricity demand could increase by 65% and peak demand could double by 2050 *https://www.auroraer.com/wp-content/uploads/2018/10/Aurora-Report-public-Delivering-net-zero-November-2018-.pdf*

18 Cost savings of £300 per year from auto switching. Are quoted by Labrador including unverified savings of around £100 compared to auto-switching without smart meters data (based on direct conversations and as quoted in press *https://www.theguardian.com/environment/2018/mar/11/labrador-switch-energy-suppliers*). We believe that in the near term, smart meter enabled auto-switching could remove barriers to tariff switching including a lack of trust and understanding of a large number of cheap offers households haven't heard of, and frustration at returning to expensive tariff at the end of the fixed period. Intermediary companies who share risk and who will keep households on the best tariff at end of fixed period could remove these barriers. Given that

currently only around 4% of customers switch tariff and 57% of households are on their supplier's standard tariffs, there is a large potential for savings from helping households switch.

19 Savings attainable by switching tariff. Figures taken from OFGEM research *www.ofgem.gov.uk/publications-and-updates/switching-increases-customers-respond-savings-325*

20 Number of customers currently using auto switching sites taken from newspaper article (The Guardian, 3rd Nov 2018) "Too lazy to switch energy provider? This could be the answer" (original print version titled "Get the best tariffs at the flip of a switch) *https://www.theguardian.com/money/2018/nov/03/energy-bills-tariffs-switch-providers*

21 Smart PPM savings

A price cap has been put in place for a transitional period 2017- 2020, after which it is expected that the roll out of smart meters will allow suppliers to offer more competitive PPM tariffs. The aim is that by 2020, competition rather than the cap will be determining the prices paid by most customers, enabling the more equitable prices to remain *https://www.gov.uk/government/news/cma-puts-300m-saving-in-place-for-prepayment-energy-customers*. The level of the cap was initially set in line with the cheapest prepayment tariff prices in many regions and has changed over time to reflect increases in wholesale price. Calculations at the time of initially setting the price cap found that had it been applied in early 2015, the cap would have reduced prepayment customers' average bills by £75 *a*. Modelling of the cost benefits of more competitive PPM tariffs *https://www.cse.org.uk/downloads/reports-and-publications/fuel-poverty/policy/smart-prepayment-and-fuel-poverty-oct2016.pdf* found that the estimated savings for existing PPM customers would be on average £50 - £100 per year, depending on the extent to which smart PPM tariffs match existing direct debit tariffs. If smart PPM tariffs were equal to existing direct debit tariffs, households on the lowest incomes are predicted to save around £80 per year (lower than the average saving of £100 due to their existing energy expenditure being lower).

Anecdotal evidence from interviews with smart PPM customers *https://www.cse.org.uk/downloads/file/smart-prepay-hh-experiences-report-march16.pdf* shows many customers topping up less each week than they did on their traditional PPM (by over £5 / week, equivalent to over £250 per year), but this being due to both a cheaper tariff and increased energy awareness. The breadth of this research is not sufficient to draw broader conclusions for expected savings across a population but does demonstrate the significant benefits some customers on PPMs have had with moving to smart meters.

Beyond cost savings, smart PPMs are delivering greater benefits in allowing flexible top-up options, availability of different credit options and better access to the meter both for keeping track of credit balance and for topping up credit.

Based on this research, we believe that it is appropriate to quote an annual cost saving of £75 for households currently on pre-payment meters, as these meters are transitioned to smart meters.

22 Justification for higher cost to serve of PPM customers are that PPMs are more expensive to manufacture and install than credit meters. It also covered the cost of the bespoke payment structures required for credit to be bought at local shops and transferred to suppliers, and the higher levels of customer service calls received due to problems in topping up the meters *https://www.ofgem.gov.uk/ofgem-publications/87924/openletterfinalrepublished.pdf*. The roll out of smart meters has narrowed the gap between serving pre-payment and credit meter customers, and the result is that PPM tariffs are lower than they used to be.

23 Savings for peer-to-peer trading are taken from those quoted by Sonnen and scaled down to UK electricity prices (~70% less than German electricity prices, 0.16 £/kWh compared to 0.28 €/kWh) this gives ~£105 in annual savings. These savings are from self-consumption optimisation and reduced tariffs for additional electricity demand. Some peer-to-peer / community energy trading schemes have flat-rate monthly fees in addition to the upfront cost of the system but all of them give reduced tariffs for the additional electricity needed. Savings quoted are in addition to the

savings made from having a standalone solar panels and battery system without the peer-to-peer trading *https://sonnen.de/stromtarife/sonnenflat-home*.

24 **Value of flexibility in the future energy system** has been investigated by Imperial College for the Committee on Climate Change. *https://www.theccc.org.uk/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf*

25 **Renewable electricity generation** was found to dominate the lowest cost energy mix in a future scenario with high flexibility. This compared to an energy mix dominated by nuclear generation and carbon capture and storage technology in a low flexibility future. *https://www.theccc.org.uk/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf*

26 **In the future, the cost structure of energy is expected to be entirely different** to how it is now. Currently, wholesale costs make up over a third of a typical dual fuel bill, but in the future the cost of the energy will be only a small part of the cost of delivering the energy. The biggest costs will be upfront cost of energy generation technologies and network capacity, and these are based on peak demand. More payment will be required to make balancing generation available than to actually use it. *https://www.auroraer.com/wp-content/uploads/2018/10/Aurora-Report-public-Delivering-net-zero-November-2018-.pdf*