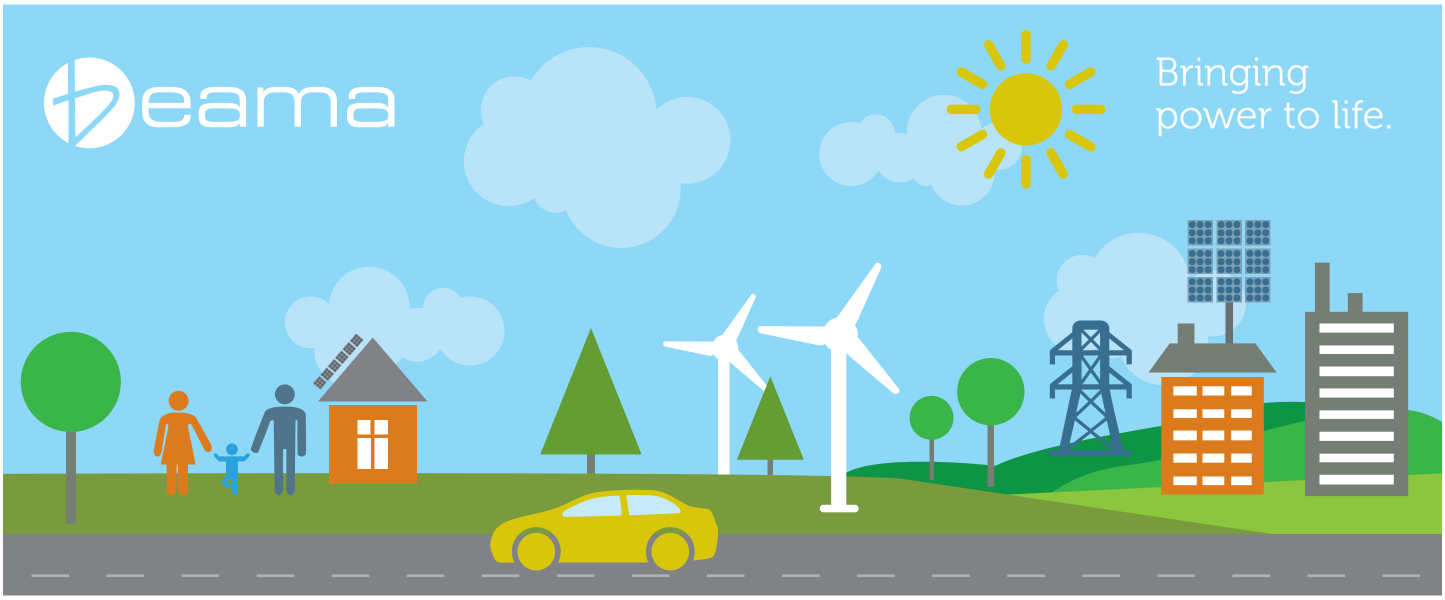
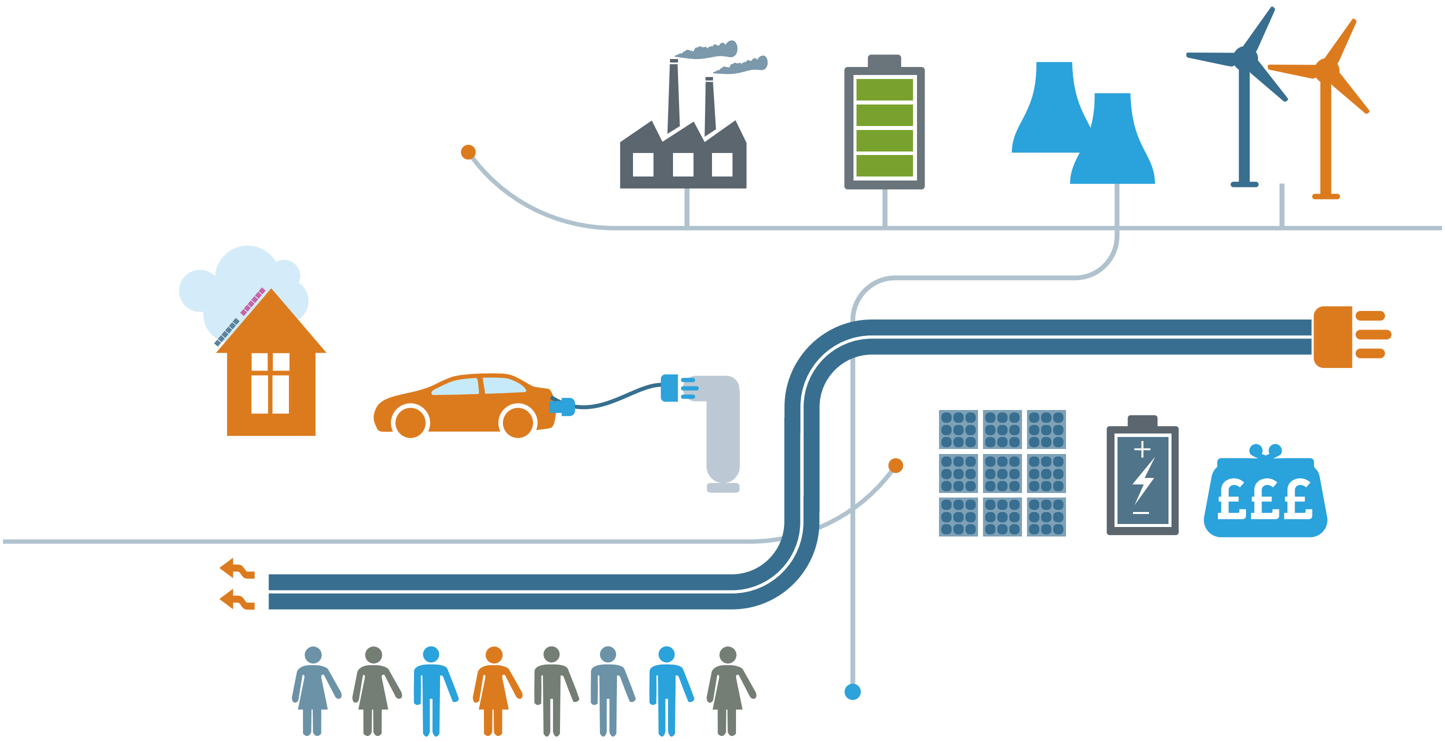


ENERGY STORAGE BY DESIGN

REALISING THE BENEFITS OF ENERGY STORAGE IN BUILDINGS



May 2018

Electrification by Design Series - Report No.2: Energy Storage

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BEAMA Electrification by Design Series

In December 2017 BEAMA published a report, Electrification by Design[1], exploring simple policy and market mechanisms to promote deployment of low-carbon electric systems. In it we identify critical enablers of a flexible and efficient low-carbon energy system. These include consumer engagement with energy use, energy storage, transport, automated energy management in buildings, and demand-side energy management.

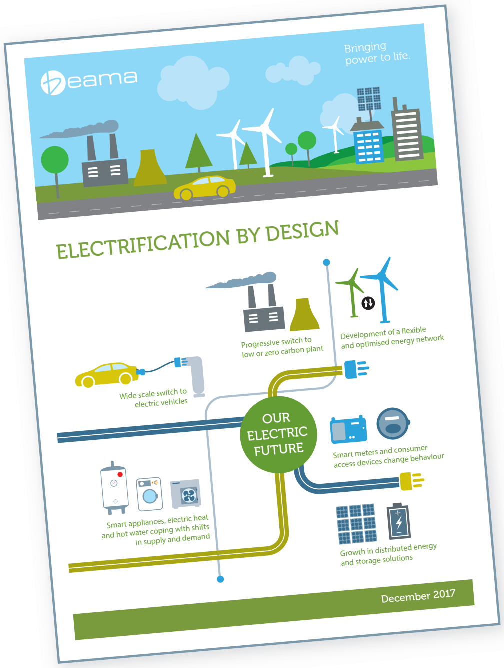
We also made recommendations for how Government, Industry, consumers and other stakeholders can work together to enable and maintain the market for smart products and to maximise benefits to the consumer and to the electricity transmission and distribution networks. This short paper provides some more detail of BEAMA's view of Building Energy Storage products, what these benefits could be and how to realise them.

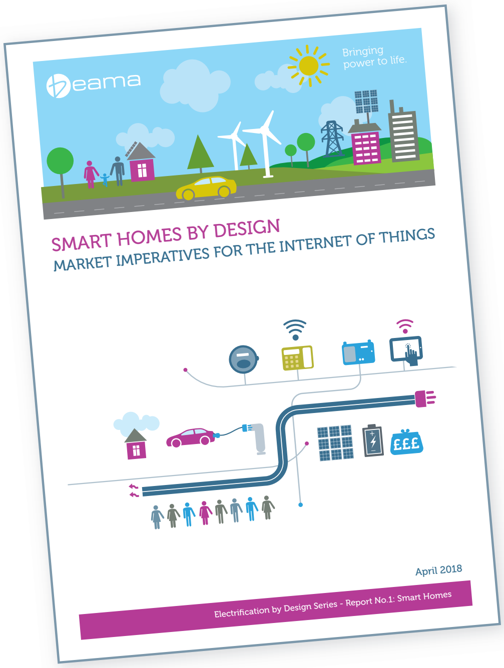
[1] The report can be found here: http://www.beama.org.uk/resourceLibrary/electrification-by-design-pdf.html

CONTENTS

INTRODUCTION

Our need for affordable, secure, reliable and decarbonised energy will lead to an increasing proportion of generation coming from renewable sources. These sources are often intermittent in nature when compared to large base load power such as nuclear and more carbon-intensive generation. The system will need to become more flexible to accommodate the mismatch between peaks and troughs of energy supply and demand. Some financial, regulatory and cultural change will help to smooth energy demand, and improvements in system efficiency will help as well, but these will not be sufficient on their own. The system will need ways of storing energy, in networks and in buildings, for times when demand is high and renewable generation low. Storage is therefore a key flexibility asset, and a crucial enabler of a smart system.





ENERGY STORAGE DEVICES: AN OVERVIEW

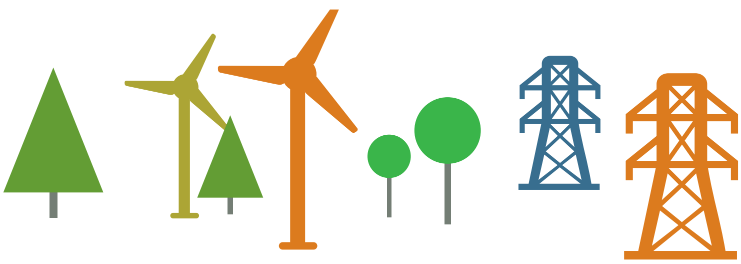
Energy storage devices store energy when there is an excess available, for example at times of low grid load or at times of high power output from renewable generators such as wind and solar. The stored energy can then be released at a later time and in a controlled manner. Storage systems range in scale from very large battery banks connected directly to the network to provide network services such as frequency control, network resilience and peak demand management, down to small residential home systems to maximise the benefit of solar PV systems and, in some cases, maintain power during supply interruptions. Reductions in cost and improvements in technology have helped make energy storage a commercially and technically viable solution.

Unlike generation connections, storage connections often require both import and export capability. The connection characteristics vary depending on the use, size and location of the connection. Whilst this is true for network storage solutions (large or small), that use imported electrical energy to store energy in another form (e.g. conversion from AC to DC for battery storage, or off-peak energy used in pumped storage), it is not necessarily true for all types of energy storage in buildings. In such cases the energy for the store may have been provided wholly by localised renewable energy sources, or the energy in the store may not be reconverted to electricity e.g. in the case of thermal stores or phase change material applications.

Storage Technology Categories

CHEMICAL	ELECTROCHEMICAL	ELECTRICAL	MECHANICAL	THERMAL
Hydrogen • Magnesium	Batteries: • Lithium ion • Copper • Zinc • Lead acid • Flow batteries	Capacitors • Super capacitors • Super-conducting magnetic energy storage (SMES)	Compressed air • Kinetic (e.g. flywheels) • Hydroelectric • Gravitational	Heat storage • Latent heat storage (phase change) • Liquid air • Heat batteries

For the purposes of this report we define Active Energy Storage as: *the act of capturing low cost and/or low carbon energy and storing it to deliver controllable energy on demand.* The captured energy will typically be stored as chemical, electrochemical, electrical, mechanical or thermal energy.



THE RISE OF STORAGE SOLUTIONS AND KEY ENABLERS

As the efficiency and capacity of energy storage technologies have improved, costs have fallen and applications have multiplied. Increased consumer interest in storage devices and systems has enticed large manufacturers and providers into the market, and sales of building and network connected storage devices are expected to increase. This is happening alongside high-level policy backing, incentives and research funding for storage and its recognised role as a key element in the future energy system. These technologies offer clear benefits and flexibility to network operators and consumers, and, though there are initial challenges around connecting large volumes of storage, demand for connections is high from consumers and storage providers alike. As BEAMA stated in the *Electrification by Design* report, energy storage technologies look set to play a key role in the electricity networks transition.

Economic analysis commissioned by Eaton, the REA and Bloomberg New Energy Finance suggests that by 2040, the highest weekly output from wind and solar will almost meet total demand. At present, the highest-output month of wind and solar generation is equivalent to 70% of demand. The report goes on to highlight that '70GW of dispatchable resources (generation, storage, flexible demand, interconnectors) are needed in 2040 to meet peak demand during periods of low wind and solar generation.'[2] Solar and wind generation are intermittent, but there have been instances where the total energy produced across on windy and sunny days has been enough to meet total demand. Therefore the role for storage as an enabler to match supply and demand and provide energy system flexibility is key.

Recent policy decisions, funding streams and announcements backing research and development highlight that there is strong policy and financial backing from Government for these schemes as we continue to move to a more dynamic and smarter electricity system.

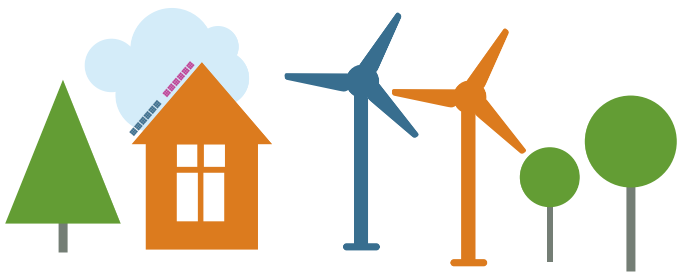
AT PRESENT, THE HIGHEST-OUTPUT MONTH OF WIND AND SOLAR GENERATION IS EQUIVALENT TO

70%

OF DEMAND

70GW

OF DISPATCHABLE RESOURCES ARE NEEDED IN 2040 TO MEET PEAK DEMAND DURING PERIODS OF LOW WIND AND SOLAR GENERATION[2]



[2] Eaton, Bloomberg & REA – *Beyond the Tipping Point* (2018)

ENERGY STORAGE APPLICATIONS AND VALUE OFFERING

Storage can be deployed at varying scales, from small domestic properties absorbing excess energy generated by a solar PV system during the day and then releasing it in the evening when the energy is needed in the home, right through to large scale battery storage systems connected directly to the grid and capable of serving thousands of consumers. As electricity becomes a larger part of the UK energy mix due to the increasing uptake of electric heating and electric vehicles, large scale storage systems will become increasingly important to network operators responsible for managing peak demand. These systems will also be able to offer value to consumers and businesses, who can buy storage services to make better use of their energy at building level which will be highlighted throughout this report.

Consumers could be incentivised to switch their demand from the grid to storage devices through network charging or dynamic pricing this could offer significant savings to Distribution Network Operators (DNO) as they transition to Distribution System Operators (DSO) by reducing the required levels of network reinforcement. These savings could be passed on to the consumer directly by being paid for providing a service, or indirectly through a reduction in the networks costs that form part of their energy bill. In opening the market to a range of storage types this would naturally encourage wider system applications and solutions and their associated value chain. The chosen technology may be the conversion of electricity to be stored as heat, for example, by heating a hot water tank, or by storing energy from low carbon generation sources and releasing it later for use at a time of the consumers' choosing. The challenge here is how do we appropriately reward consumers to change their behaviour?

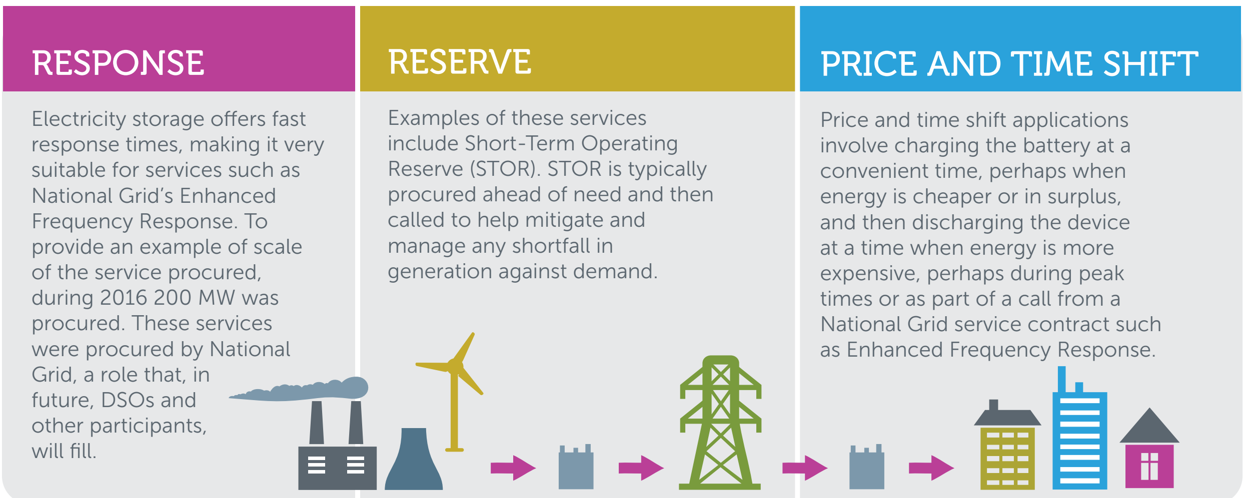
CASE STUDY

The Carbon Perspective

The case study involving Moixa's Solar Panel and Battery Storage Bundle shows that a customer integrating energy storage and PV generation in their home could reduce their carbon footprint by up to 1.2 tonnes of CO_2 per year and their energy bills by £600 per year. This scenario is based on an average 3.5kW system in Brighton with PV panels on a south facing, 40-degree pitched roof and no shade, using National Grid power plant carbon intensity statistics. The reduction in the energy bill is a combination of solar savings, feed in tariff payments and GridShare cashback payments.[3] The study also highlights how people can use energy storage to participate in new revenue streams, including how they can combine (stack) them to get a faster return on their asset investment.

Storage and Response Services Today

Network connected storage is varied in its applications and value offering. The Energy Networks Association (ENA) and Regen SW[4] suggest that there are three types of applications for electricity storage: response, reserve, and price & time shift.



3 Moixa – Use the Sun's Energy to Power Your Home Day and Night (2018) – [https://www.moixa.com/solar-battery/]

4 ENA and Regen SW – Electricity storage guide for communities and independent developers (2017) p. 9 http://www.energynetworks.org/assets/files/news/publications/ENA%20Electricity%20Storage%20Guide.PDF

The rapid reduction in the price of storage, allied to its ability to respond quickly and discharge over known and controllable durations, makes it the perfect solution for fast grid response services and a solid solution for many less rapid services. These include applications at building and network level via aggregated devices or larger single devices.

Bloomberg New Energy Finance (2018) highlight the increasing demand for fast-ramping resources such as energy storage, certain types of demand response and gas generators to support the forecast levels of ramping. Extreme ramp rates are likely to stress the system and cause conventional generators to operate less efficiently; flexible demand and storage may be able to help mitigate these impacts.[5]

National Grid held their Enhanced Frequency Response (EFR) auction via tender in summer 2016 and successful providers were given until 1 March 2018 to commence service delivery, on a four year contract. In the report Enhanced Frequency Response Market Information (2016), 1596 MW of options tendered for the wide service and 4034 MW for the narrow service. However, some of these options are mutually exclusive: the maximum site capability was 1684 MW, in total 201 MW were awarded to 8 providers at a value of £65.954 million. All of the accepted assets were storage – the report highlights that of the 64 sites, 61 are classed as Storage, 2 are Demand aggregation and 1 is Balancing Mechanism Unit (BMU) generation.[6]

The high number of tender submissions not only highlights the application suitability of Energy Storage in its ability to provide fast response networks services but shows the additional layer of revenue it can provide to those seeking to use storage for a network services (via aggregators or otherwise) in addition to other applications such as generation optimisation and demand management applications or use of system savings. In future markets could extend to capture those devices not only connected at network level but to storage devices in buildings as well, although further market development is required to realise this ambition.

Opportunities

Falling costs of lithium-ion batteries make battery use economic for a range of applications, from end-user storage to reducing peak system requirements.[7]

Heat storage can off-set peak energy costs via low cost time of use energy being utilised and the tariffs further developed

Understand and define the value of flexibility for the consumer and for market participants i.e. DSOs and Energy Service Providers

Smart home opportunities and interfaces well with other technologies and systems

Tariff innovation, network charging, Time of use and dynamic signals development

£££

Market structures – Clarify Regulatory uncertainty and further development to address the lack of storage markets and revenue at domestic level

Potential to stack value with other technologies and revenue streams solidifying the consumer value proposition

Reward rather than punish adoption of new low carbon tech that promotes cleaner energy and consider how to penalise carbon intense approaches i.e. VAT and Business Rates

CO_2

[5] Eaton, Bloomberg & REA – Beyond the Tipping Point (2018)
[6] National Grid – Enhanced Frequency Response Market Information (2016)
[7] Eaton, Bloomberg & REA – Beyond the Tipping Point (2018)

Storage and Generation Matching

When seeking to maximise the energy available from intermittent generation such as wind and solar, and from a carbon reduction perspective, electricity storage provides a fundamental piece of the energy systems puzzle. Electricity storage devices connected at key points on the networks or aggregated storage devices at building level could be used to soak up excess generation, for example a windy day in the mid-morning where wind generation is high but demand low. Alternately citing in a central location next to a motorway where demand for recharging electric vehicles is high and connection costs, demand and availability could be better managed by onsite storage. Rather than constraining a generator, the energy could be used to charge a battery for use later, perhaps during the tea time peak or for vehicle charging. This adds value for the generator, value for the storage operators, low carbon, offers a service to the system operator and ensures that assets are creating a solid investment for both consumers and investors. Careful legislation for such models is essential here to ensure that any offering is appropriately policed and that the qualifying criteria are established to ensure the in-practice delivery aligns with the policy concept and vision.

Back-up for Critical Circuits, Virtual Power Plants and Microgrids

Storage can be used as a back-up power supply to protect against power cuts for residential, commercial and industrial consumers. In conjunction with wind, solar and other sources of generation, it is a key component when building localised microgrids. This gives users greater certainty of supply and control of their energy and the ability to manage cost. Multiple smaller systems, even as small as a single home system, can be operated together by using signals from a remote operator to give charge or discharge commands depending upon system needs. This could be in response to pricing signals, to help manage grid stability by providing frequency response services, or to help manage constraint on the network. Such signals are likely to come from an Energy Service Provider, a System Operator, or an Aggregator. As an illustration of the potential of this opportunity, a single home fitted with a 6kW storage system will have little impact on its own, but if it is part of a network of 10,000 such homes then it can be aggregated to operate as part of a 60MW virtual power plant (VPP). Bearing in mind that 10,000 homes is only around 1% of homes in the UK fitted with solar PV systems, this is potentially a very powerful solution. Market frameworks, models and regulation should enable innovation to deliver diversity in the system.[6]

New Service Development Scenarios

As the market for storage products and services grows and new opportunities present themselves, consumers and service providers will find new ways to stack services. This is likely to further increase deployment of building energy storage devices and the return on investment for the consumer. Longer term offerings for storage at a building level could include aggregated storage assets (often referred to as a Virtual Power Plant) providing services to the grid at times of high network demand. Depending on the scale of the VPP and the market structure, this aggregation could provide services to the grid at a local, regional or national level.

The scenarios presented below are examples that may be achieved the short, medium and long term. The suggested time frames are dependant on policy and appropriate market development.

Short term [now] – Consumer buys an energy storage device and uses it to:

- Optimise self-consumption of building generation from PV and to supply loads at times of high demand

Medium term [less than three years] – Consumer buys an energy storage device and uses it to:

- Optimise self-consumption of building generation from PV
- Participate in paid-for services by discharging stored energy at times of peak network demand
- Access time of use pricing

Long term [five years] – Consumer buys an energy storage device and uses it to:

- Optimise self-consumption of building generation from PV
- Participation in multiple revenue streams (stacking) e.g. network services and access time of use pricing
- Provide grid services as an aggregated participant (either with the storage device of via vehicle to grid) as a VPP
- Participate in peer to peer trading, selling stored energy to a neighbour or local energy user either for immediate use or in exchange for energy at another time
- Charge an EV or have the home electricity provided by an EV with surplus stored energy if energy price increases

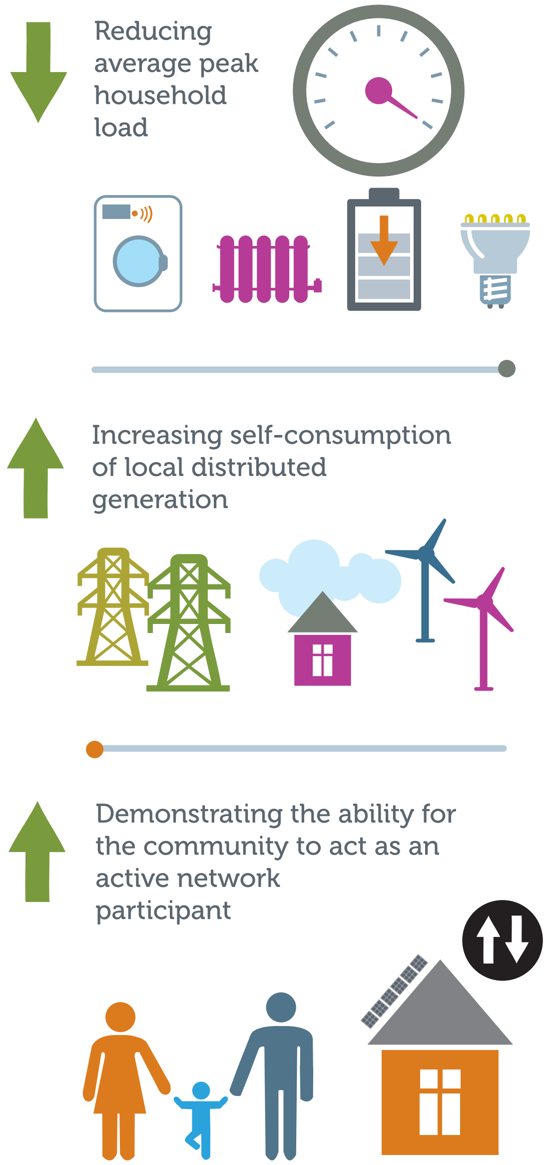
CASE STUDY

Moixa: Project ERIC and GridShare

Moixa aims to disrupt the way energy is generated, consumed and shared, making technology smarter so that it works for customers and helps others. Moixa's Smart Battery helps households save money by storing spare solar energy or cheap off-peak electricity from the grid. Their GridShare platform helps manage storage resources and deliver services and savings for the energy system.

Project ERIC (Energy Resources for Integrated Communities) is an initiative bringing smart energy storage and PV solar power to 82 homes, a school and a community centre in Rose Hill, Oxford. Moixa installed 90 units in Rose Hill and connected them using its GridShare aggregation platform. For the residents of this energy-poor community, Project ERIC had two objectives: lowering household bills, and increasing solar self-consumption. It has achieved these goals.

Project ERIC has also shown one way of time-shifting energy consumption at a community level. Using GridShare will have a beneficial impact on substation profiles. Additionally, Project ERIC demonstrates the value of community peer-to-peer energy models, as highlighted.[8]



The Smart Tariff Opportunity

Time of Use (ToU) tariffs incentivise consumers to use, store and export electricity at times that are most beneficial or least costly to the system. These tariffs are an intrinsic expression of smart energy network management. Achieving engagement with consumers and ensuring there is enough value to promote consumer response or behavioural change is fundamental to the success of the smart tariff.

In combination with home energy manager products and applications, these decisions could be automated. The consumer could predetermine and programme their preferences, and automated controls would be made and in line with those to deliver maximum value and carbon reductions at lowest cost. The consumer would be able to manually override these actions, subject to their agreement with the service provider and recognising that doing so may reduce the cost-reduction benefit of such systems. The more automated the system is, the more the consumer experience is likely to be focused on the service rather than on the technology or device that delivers it. This helps make demand response management available to consumers with little resources, inclination to engage or generally low interest in their energy bills.

Energy arbitrage links closely with smart tariffs, peer to peer models and provision of grid services. Using a smart tariff to buy energy at a low cost and sell back to the grid or other consumers at a time of higher cost would add incremental value to the stack and compliment other offerings and market developments outlined in this paper. This would allow consumers to be more dynamic with their energy use and shift their demand (or export in some instances) in response to price signals or other market factors. The added value to this approach would be a more balanced demand curve across the day which would serve to better balance demand on the electricity networks.

[8] Moixa – Project ERIC and GridShare (2017)

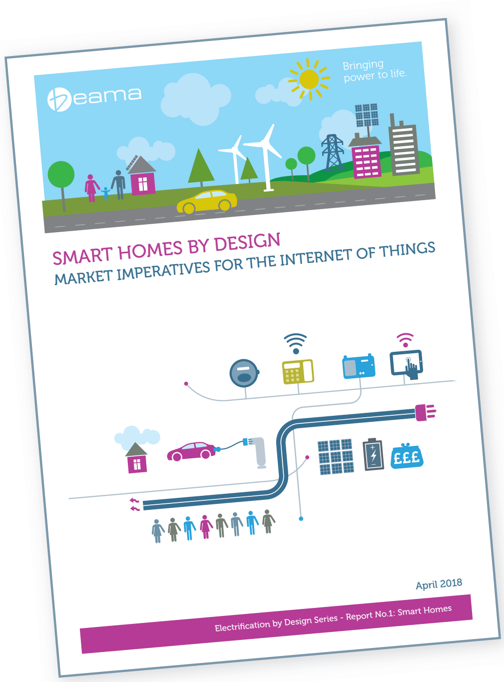
In response to half hourly data under half hourly settlement, consumers can respond to use more or less energy, for example avoiding times of day when energy is more expensive, when demand is higher or energy more carbon intense.[9] In this instance the consumer may choose to discharge their battery to cater for their current demand over a fixed period of time, charge their electric vehicle or, if demand in their building is low, sell to a neighbour or a network operator. Smart tariffs are available to business energy consumers now, encouraging them to shift demand away from more expensive periods. However, further innovation is required in tariff development, system offerings, consumer offering and controllability at domestic level. A consumer may not always wish to respond directly to a price signal and in this instance, home energy management products will add value, as well as improve uptake and increase accessibility to cheaper energy.

Smart Homes

From a smart homes viewpoint, when wind and solar generation is high, an intelligent, integrated home management system can turn up demand in the home, powering equipment from the grid. For example, under the terms of today's market the network would respond to high wind speeds and increased windfarm generation by curtailing the wind farm. Under the scenario for a flexible hybrid home, this increase in wind generation can be identified as a rise in frequency on the system. The integrated home management system can then increase its demand, drawing more electricity from the grid and using it to heat the water tank or recharge the battery store and electric vehicle. All other equipment keeps running, as does the wind farm even if generation output is curtailed slightly to match actual demand. Managing and controlling a response to changes in grid frequency can be the role of an aggregator, energy services provider or DSO.

Similarly, an aggregator can monitor wind energy production and on identifying a decrease in wind speeds through a decrease in frequency, can pass a signal to the integrated energy management system informing the home to reduce demand. The home then draws more electricity from local batteries and stored energy resources. This avoids using carbon intensive forms of energy. Under today's market operational constraints, fossil fuel power plants would be asked to increase production and the house would continue to draw from the network.[10]

Some stakeholders have suggested that one option would be to require DSOs to move towards a system of competitive auctioning for different solutions including storage, demand-side response and energy efficiency, to deal with network constraint issues.[11] Storage may be an easier sell to the consumer than direct control of appliances in the home, as well as providing more certainty to the network operator.



Given that there is a growing UK capability and supply chain in this sector it has rightly been a target for government support.

These themes are explored in more detail in BEAMA's Electrification by Design series – *Smart Homes by Design: Market Imperatives for the Internet of Things* (2018).[12]

The Role for Peer to Peer Models

Peer to peer in this instance is the generation or storage of energy and the sharing or selling of it locally to other system users. These models allow consumers to serve their own energy needs and are increasingly seen as future models for consumer engagement with microgeneration, electricity use and using domestic energy storage. Smart homes and installed technologies will give consumers greater control of how much energy they use and what they use it for. This use can include storage or peer-to-peer local trading. Storage, smart appliances and ToU energy pricing all have a role to play here. This would not only help network operators to better balance the load on the grid but would also generate some extra revenue for the consumer.[13]

Peer to peer trading can be open to neighbour to neighbour or household to network operator, but also business to business, matching demand with local renewable generation. For businesses, platforms already exist to match renewable generation with local demand. In 2016 Open Utility commercially trialled this and have since received funding from BEIS and other sources to trial in other European countries.[14]

9 Ofgem – How half-hourly settlement will help cut energy bills (2018) – [https://www.ofgem.gov.uk/news-blog/our-blog/how-half-hourly-settlement-will-help-cut-energy-bills]
10 BEAMA – Demonstrating Flexible Hybrid Homes (2016)
11 BEIS/Ofgem – Call For Evidence: Building a Market for Energy Efficiency (2017) p. 46
12 BEAMA Electrification by Design Series – Smart Homes by Design: Market Imperatives for the Internet of Things (2018) – http://www.beama.org.uk/news/beama-publishes-its-firsts-report-in-the-electrification-by-design-series.html
13 Huffington Post – Peer-To-Peer Energy Trading Holds Huge Potential (2017) – [http://www.huffingtonpost.co.uk/lynne-mcdonald-/peertopeer-energy-trading_b_18068158.html]
14 Open Utility – Open Utility secures £412k of BEIS funding to develop a ground- breaking online marketplace for flexibility trading (2017) – [https://www.openutility.com/press/]

The potential to manage large numbers of low-carbon technologies and distributed energy such as storage, PV or electric vehicles to provide services to the network or to peers and businesses is a challenging one, and appropriate platforms, simplicity and accessibility are essential from the consumer perspective. DSOs will at times seek to manage large sections of demand and, at a domestic level, this will require market innovation and a critical mass of consumers signed up to demand aggregation services. In this instance, when the network supply to an area is constrained, or the price is high then there is a high value for transfers between consumers within that area.

Energy Storage in Buildings and Electric Vehicle Charging

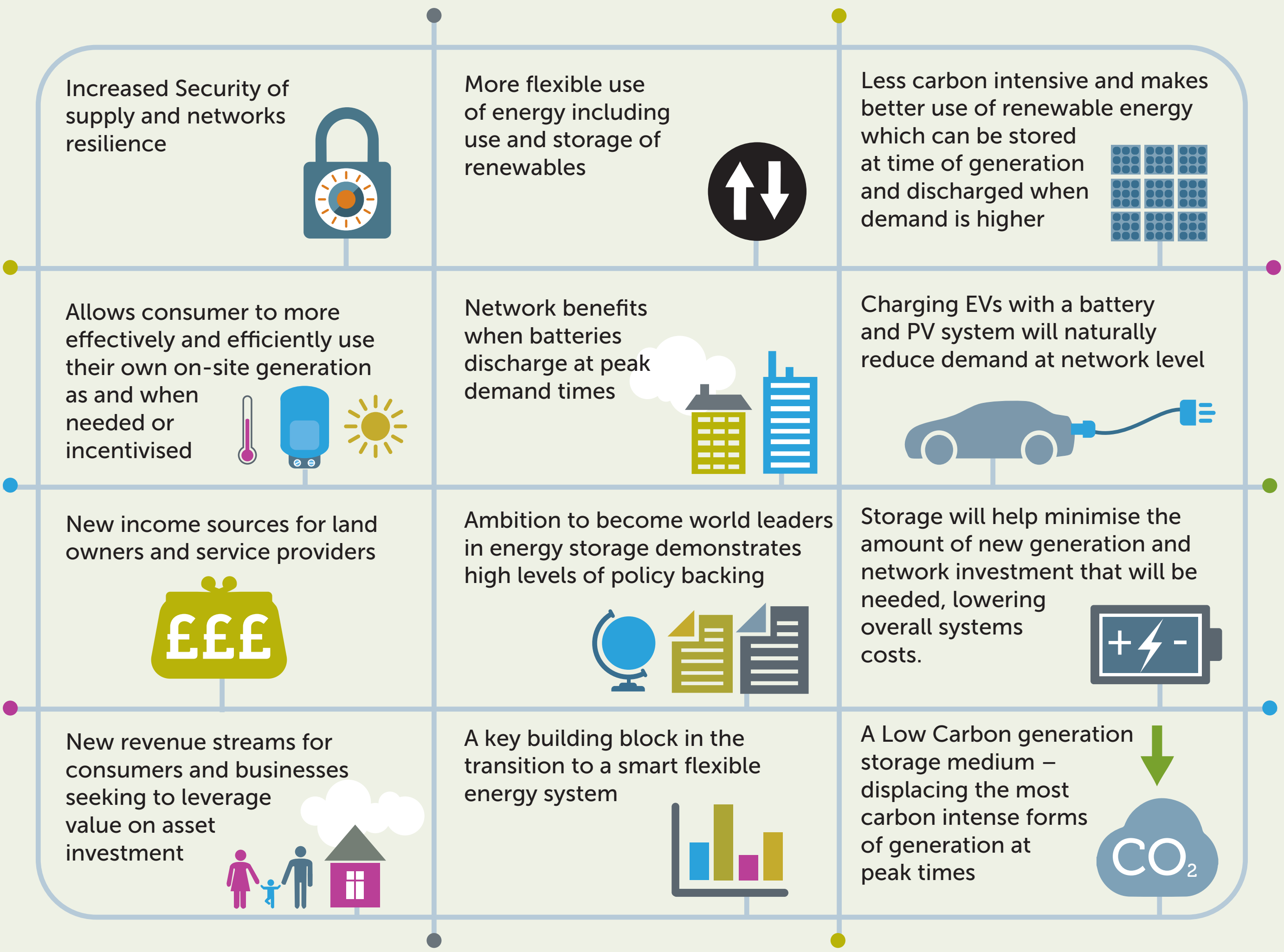
There are strong links between energy storage and transport. EVs can act as storage devices or virtual power plants in their own right, and storage systems can buffer the increase in intermittent demand arising from the take-up of electric vehicles.

From a building perspective, the interface between storage, EVs and generation is key. Optimisation of vehicle charging patterns could go a long way to managing demand peaks on local low voltage networks. Vehicles could interface directly with a storage device that has been charged via PV during the day. With appropriate price signals such as smart tariffs and dynamic pricing, the market could discourage consumers from charging at peak times, and those with a storage and PV system would be able to access cheap low-carbon energy and provide a demand reduction service to the network operator.

Rapid charging networks and high proliferation of standard charging points, such as workplaces, forecourts, and car parks in retail centres, could add significant additional loads to existing networks at peak times and could be managed by buffering with storage during these times, or by incentivising charging to take place at times of lower demand.

In an ideal world, low carbon energy would fuel low carbon vehicles. Energy storage connected to renewable generation provides greater traceability of source fuel and can be sold to the consumer as such based on environmentally sound principles and low carbon fuel for low carbon transport. It is something of a paradox to fuel low carbon vehicles with energy generated via gas (or even coal) fired power plant.

Benefits



CASE STUDY

Eaton: Energy Storage for Stadiums and Arenas

Sporting and other events hosted at stadiums and arenas can consume several megawatts of electricity to power lighting, broadcasting, essential services and other equipment. The power management infrastructure serving these venues must address critical and operational power needs, as interruptions caused by unplanned outages can lead to significant financial losses and reputational damage.

Eaton's xStorage Buildings energy storage system meets the back-up power requirements of stadiums that would otherwise usually be provided for by Uninterruptible Power Supply (UPS) systems and diesel generators. Sports events and concerts often coincide with peak electricity demand on the local distribution grid, so xStorage Buildings reduces the overall peak demand by allowing recharging of the batteries with low cost off-peak electricity from the grid, or with on-site renewable energy sources such as solar or wind. In addition, xStorage Buildings can generate additional revenues by participating in grid stabilization services, selling excess energy back to the network operator.[15]

Heat Storage

Heat storage solutions offer flexibility to the consumer and the network. There are a range of commercially viable products that suit differing consumer needs, buildings and system applications. Depending on the specific technology and application, heat stores in buildings work by capturing thermal energy from hot water heating, on-site renewable energy generation, or waste heat. This stored energy can then be used later at a time of the consumer's choosing.

Heat stores can help balance demand across the day by converting surplus, cheaper or lower carbon energy to heat and storing it. Storing heat in buildings in this way can help consumers to avoid drawing on the grid at peak heating times.

This complements other forms of energy storage (such as batteries) to make best use of available generation and capacity in the smart and flexible home energy system.

Thermal Stores and Heat Batteries

The majority of home energy is used for heat. Heat batteries provide consumers with compact, cost effective, low carbon solutions to space heating and hot water. Heat batteries can be charged using a variety of energy sources. They can offset peak energy costs by charging the store using cheaper off-peak electricity (such as the current Economy 7 tariff) or diverting energy from PV, heat pumps or other low carbon sources. Once charged, the heat can be released instantly when needed, delivering hot water and space heating during peak times.[16]

Heat batteries in just hundreds of buildings can deliver meaningful capacity (MWh) and power (MW) to balance the electricity network while supplying the required heat and hot water. Phase Change Material (PCM) applications can also be very efficient; by using the latent heat of melting and freezing, a PCM application can store three or four times as much energy as hot water. These batteries are modular and can be stacked to create the heat storage and output required to suit most buildings.

15 Eaton – Energy storage for Stadiums and Arenas (2018)
16 Sunamp – Heating your Home and Water (2018) – https://www.sunamp.com/residential/

CASE STUDY

Sunamp – EastHeat Retrofit Social Housing Project

The EastHeat Retrofit Social Housing Project consisted of two key project components.

Component 1: Funded PV on the Roof:

- 850 rooftop PV systems installed
- Two major housing associations (ELHA & CRE)
- £5.6m from a Chinese investor + FIT
- Delivered by Edison Energy
- Rural, semirural and urban settings
- Average system size 2.9 kWp
- Tenant electricity savings of more than £160 a year

Component 2: Thermal Energy Storage in the Home

- 700 homes with Sunamp heat battery thermal storage with more than 500 linked to PV
- £3.2m from Local Energy Challenge Fund as a large R&D Trial + £800k from partners
- Delivered by Sunamp with Edison Energy, Castle Rock Edinvar, ELHA and R3
- Additional tenant advantage in reduced hot water and heating cost – up to £550 a year total saving

Electric Hot Water Storage

A hot water storage heater is a heating appliance that uses hot water storage to provide instant hot water and building heat via hot water heating systems. A simple water cylinder combined with a traditional gas boiler can be linked to renewable generation via a smart tariff. Ideally, however, the output from the renewable generation will be directly channelled to the heating system, for example by adding an immersion heating element to the cylinder. It should be noted that the move towards installing combination boilers means that this option is disappearing.

The storage water heater market has seen a steady, gradual decline (currently 2%-3% per year). This decline is predominantly driven by Government policy and is reducing the potential for domestic energy storage using hot water. Targeted legislation and policy should be put in place to halt this decline and ensure better use of existing storage capacities within buildings.

Heat storage is a readily available, affordable and widely used technology that could be easily adapted for smart grid control. Control systems already exist to provide this function and have been demonstrated in small-scale field trials. However, hot water storage products are not routinely supplied "smart grid enabled" at present, mainly because the market for this capability is small and not supported by appropriate tariffs. The infrastructure and incentives for consumers do not exist, so consumers are unwilling to pay the additional cost of such controls. The technology will only become mainstream and affordable in the mass market if there is a mechanism that makes it worthwhile for consumers.

Smart Electric Thermal Storage

Smart Electric Thermal Storage (SETS) is the new generation of electric storage heating. A SETS system offers decentralised heating, hot water and energy storage. It is a heating and hot water solution that can be cheaper than traditional heat storage solutions. SETS systems also bring sizeable storage functionality to networks, enabling the storage of heat generated from renewable electricity at times of high supply and low demand and providing load control for the system operator at distribution level. SETS systems consist of electric space heating radiators, an insulated thermal mass, and a hot water cylinder.[17]

Assuming a 20-year replacement cycle, between 90,000 and 120,000 homes per year will need to replace their electric storage heating systems. Often they will install direct electric heating systems, but if these systems were to be replaced with SETS then they can be linked to the grid and used for demand side management.

SETS can provide decentralised space heating and hot water and can store energy to provide distributed flexibility to the electricity grid. It can drive down energy bills, with up to 20% efficiency gains compared to current night storage heaters. SETS is fully controllable and designed for integration into smart grid control systems. It can contribute to accommodating the increasing penetration of renewable generation.[18]

A SIMPLE WATER CYLINDER COMBINED WITH A TRADITIONAL GAS BOILER CAN BE LINKED TO RENEWABLE GENERATION VIA A SMART TARIFF.

17 Glen Dimplex – Potential for Smart Electric Thermal Storage Contributing to a low carbon energy system (2013)
18 BEAMA – Smart Systems Call for Evidence Response (2017)

CASE STUDY

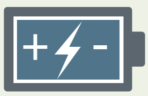
Glen Dimplex – Quantum and Northern Isles New Energy Solutions (NINES)

The Glen Dimplex Quantum SETS space and water heating system has been designed to prioritise the consumer over the network so that there is no impact on the end user when the appliances are used for demand side management or grid-balancing purposes. As part of the NINES project Quantum systems were installed in 223 Hjatland Housing Association properties on the Shetland Islands. Using these appliances to move from tele-switching to demand side management has reduced the maximum possible load from these houses during the periods of historical maximum peaks from 0.6-0.7MW to just over 0.1 MW, if the devices are following the prescribed schedule. Changing the fixed and default schedule timing, as well as the capability for flexible scheduling, contribute to this.[19]

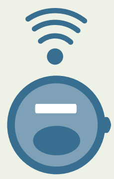
The NINES project has also demonstrated that using flexible demand appliances such as Quantum can increase the total system demand when this is wanted, such as during periods of surplus wind generation. When heating elements were fully charging in all 223 homes, the total maximum connectable wind generation could be increased by 212 kW. Frequency responsive demand (with the current settings) could also be used to maintain the frequency stability of the system within set limits. When heating elements were fully charging in these 223 homes, the total maximum connectable wind generation could be increased by 1.36MW, which is about six times greater than what can be achieved with demand side management only.[20]

Recommendations for Heat Storage

Behind the meter energy storage solutions should continue to share focus, from a policy perspective, with grid and electrical building connected storage. In particular, it is important to highlight the area of power to heat and small to large scale thermal storage solutions.

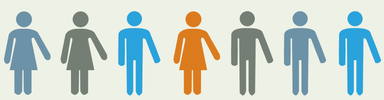


The impact of smart tariffs for the valuable flexibility presented by all forms of heat storage will require an innovative targeted approach that promotes growth of the technologies and encourages the specification of suitable 'flexible and dynamic' storage technology.



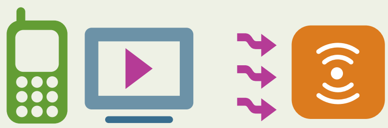
Targeted legislation and policy should be put in place to halt the decline of hot water storage systems and ensure better use of existing storage capacities within buildings.

Consideration should be given to consumer choice and comfort. Acceptance will be low if energy input is always determined by the network as this may lead to consumers not having the heat they need at the time they need it.



Develop a way of assessing how products are selected on the basis on differing customer needs so that they receive the best value and fit for purpose solution for their heat requirements. Consider reform under ECO and Building Regulations and BEAMA suggest the development of a building level indicator to inform and justify technology choices.

Target support for upgrading electric storage heaters to modern 'dynamic' and efficient technologies.



19 NINES DSM Network Benefits Report, p. 4 http://www.ninessmartgrid.co.uk/wp-content/uploads/2017/12/1C-NINES-DSM-Network-Benefits-Report.pdf

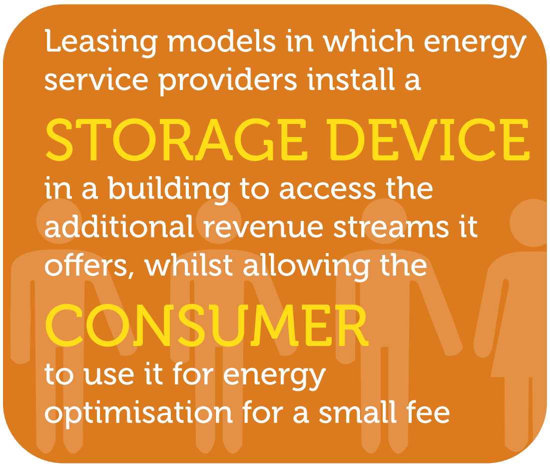
20 NINES Knowledge and Learning Report (2017), p. 9 http://www.ninessmartgrid.co.uk/wp-content/uploads/2017/12/7A-NINES-Knowledge-and-Learning-Report.pdf

FINANCING STORAGE

Installing energy storage in buildings is initially a considerable investment, but in light of the affordable low carbon energy that it can help to optimise and promote access to, the savings on offer are considerable and the asset can pay for itself over relatively short periods of time. Therefore initial access to a storage device is still the primary challenge for most consumers, and product finance and longer-term service provision offerings may be required to facilitate a large scale transition to building energy storage.

As the distinction between devices, systems and services becomes less clear to the consumer and these 'products' are bundled together into market relationships, there will be increasing pressure on market participants to collaborate with the supply chain to deliver products that reduce demand for energy and allow it to be used more flexibly. We are already seeing consumers having a different relationship with the larger, more expensive products in the smart home and that new lend/lease arrangements could become more popular. One example of this in recent years is the electric vehicle, a product that is very suited to this approach as its running costs are so much less than the petrol or diesel alternative, but some consumers are put off by its high upfront capital cost. Now however, prices continue to decline and the increasing second hand EV market could further stimulate consumer interest.

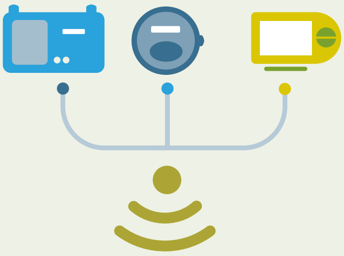
There is not one correct answer to these uncertainties, or to the challenge of supporting and financing a supply chain that will provide consumer choice in a market of increasing complexity. As discussed above, business models involving white label box shifting for re-badging by other suppliers may coexist alongside much more complex offers built around technology supply, data management, maintenance and servicing contracts.[21]

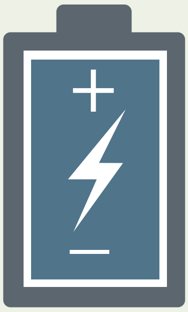


WE ARE ALREADY SEEING CONSUMERS HAVING A DIFFERENT RELATIONSHIP WITH THE LARGER, MORE EXPENSIVE PRODUCTS IN THE SMART HOME AND THAT NEW LEND/LEASE ARRANGEMENTS COULD BECOME MORE POPULAR.

21 BEAMA Electrification by Design Series – Smart Homes by Design: Market Imperatives for the Internet of Things (2018) – http://www.beama.org.uk/news/beama-publishes-its-firsts-report-in-the-electrification-by-design-series.html

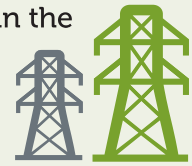
Ease of connection for storage devices



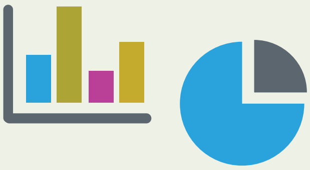


Ability to stack revenues at a building level due to the absence of widespread DSR and Flexibility markets

Uncertainty in short term and more so in long term (National Grid Power Responsive SNAPS consultation will lead to changes in the ancillary services markets



Long-term view and market uncertainty

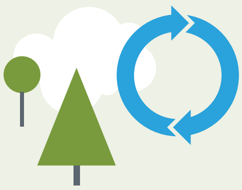


VAT at 5% at install stage (if fitted at the same time as a new PV system) but 20% at retrofit to properties with existing PV – Viewed as a penalty for low carbon technology investement

Business rates – Consulting on handling of storage from business rate perspective and how this will impact take up of low carbon technology

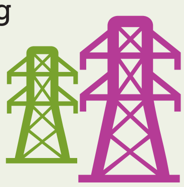
Regulatory clarity and review of final consumption levies for storage

Rewarding or incentivising those investing in low carbon technology to ensure more efficient system operation



Consider review of SAP which can currently be seen hinder new low carbon technology – particularly CO_2 factors

A need to overcome the upfront cost of low carbon technology by creating added value in the market, value stacking and services development



Clearly demonstrating the value offering of building energy storage now and in the future

Routes to Market and Market Imperatives

As the market expands, the cost of smart home products will fall and interactive services and demand-side price signals will bring new value to consumers. It is essential that consumers retain confidence in the value for money of smart controls, and that the upstream beneficiaries of smart data management pass on savings in an equitable and transparent fashion. This will naturally lead to new and more complex ways of buying or leasing devices and energy services, and the increasing complexity of the market will have far-reaching consequences for how we think about competition and consumer protection.[22]

Market Imperatives

Integrated finance packages to enable market transformation at scale

Sufficient capacity in the supply chain

Confidence in Interoperability, data security and the consumer proposition

Regulation, technology and markets working together to enable demand management

New ways of purchasing, participating in and providing energy services as well as new consumer opportunities

AS THE MARKET EXPANDS, THE COST OF SMART HOME PRODUCTS WILL FALL AND INTERACTIVE SERVICES AND DEMAND-SIDE PRICE SIGNALS WILL BRING NEW VALUE TO CONSUMERS.

22 BEAMA Electrification by Design Series – Smart Homes by Design: Market Imperatives for the Internet of Things (2018) – http://www.beama.org.uk/news/beama-publishes-its-firsts-report-in-the-electrification-by-design-series.html

THE POLICY CONTEXT

There have been calls from industry to modernise the regulatory treatment and environment for electricity storage. Storage is suitable for many applications, helping to integrate low carbon generation, reduce the costs of operating the system, and avoid or defer costly reinforcements to the network.[23] Whilst upfront costs can be high, they are decreasing, and the flexibility that storage can offer the energy system is extremely valuable. So, positive steps to improve the market for storage are to be welcomed. Other technologies and solutions will play a large role in modernising the energy system and storage is open to some of these, including demand side response.

Flexible technologies, including demand side response and storage facilitated through smart meters, could save the system £17bn-£40bn by 2050.[24] The National Infrastructure Commission's central finding is that smart power – principally built around three innovations: interconnection, storage, and demand flexibility – could save consumers up to £8bn a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for generations.[25] The role for storage is recognised as a key function of the transition underway, although work is still required to deliver a fit for purpose market environment for storage.

The Government has announced an investment of £246m in the Faraday Challenge, a commitment over the next four years on battery development for the automotive electrification market opportunity. BEIS and Innovate UK have made available up to £30m for collaborative research and development projects for new battery technologies, and up to a further £10m for feasibility studies.[26] To further develop the battery technologies and applications, the Government has launched a competition to identify the best proposition for a new state-of-the-art open access National Battery Manufacturing Development Facility.[27]

The regulatory treatment of storage has been a key challenge for storage projects. In Autumn 2017 Ofgem announced its plan to develop and clarify the way storage is treated from a regulatory perspective. Ofgem committed in the plan to promote and develop a competitive market for storage and associated flexibility services by clarifying the regulatory position on ownership and operation of storage by network operators. Ofgem also committed to consulting on modifications to the generation licence to clarify the status of storage in the regulatory regime. The proposal for storage operation by network operators is to introduce a new condition in the electricity distribution licence to ensure that network operators cannot operate storage. Ofgem suggested that there are a small number of scenarios where network operator operation of a storage asset would be acceptable, but this would require Ofgem's permission on a case by case basis.[28] This is intended to add transparency and make the market more competitive, in particular clarifying the ownership of smaller scale storage under 100MW.

Under the EU Clean Energy Package, a market design proposal also includes a recast of the regulation on the internal market for electricity.[29] It proposes a new definition for storage that, in alignment with Ofgem, seems to allow for a range of storage products. Its guidance on the ownership and operation rules for storage assets also aligns with Ofgem in its opinion that unless a DSO can prove the market procurement of storage is not feasible, its ownership and operation should then be procured from a competitive storage market.

A new, more accurate definition of energy storage in legislation and with its own asset class, as opposed to being classified as a subset of generation is required to ensure appropriate treatment for storage. In delivering a flexible energy system for the consumer, codes, regulation or primary legalisation that will prohibit future business cases, technology applications and the full range of scaled storage applications should be avoided.

Ultimately, if industry collectively resolves connection and charging methodologies it will alleviate barriers to market for storage. This needs to allow for multiple options for ownership and allow storage operators to bid into the full range of services at building and network level. Doing so will make the market more viable and allow value to be passed to the consumer. Having a stable, reliable market for demand side response is a key enabler for the storage market and the rollout of low carbon technologies.

Energy Performance in Buildings and the Smartness Indicator

The final agreement for the European Energy Performance of Buildings Directive includes a voluntary measure for member states to implement a Smart Readiness Indicator (SRI) under existing building regulations.[30] This could form part of the existing Energy Performance Certificates provided with properties when sold or rented. The methodology for the SRI is currently being developed by consultants, led by the European Commission. This in its simplest form is a measure

23 BEIS – Upgrading our Energy System: Smart Systems and Flexibility Plan (2017) p. 4
24 BEIS – Cost of Energy Review (2017)
25 National Infrastructure Commission – Smart Power: A National Infrastructure Commission Report (2016)
26 BEIS – Millions of pounds is available to UK businesses to work on projects in battery design and development (2017) – [https://www.gov.uk/government/news/leading-the-world-in-battery-technology-apply-for-funding]
27 BEIS – Business Secretary to establish UK as world leader in battery technology as part of modern Industrial Strategy (2017) – [https://www.gov.uk/government/news/business-secretary-to-establish-uk-as-world-leader-in-battery-technology-as-part-of-modern-industrial-strategy]
28 Ofgem – Enabling the competitive deployment of storage in a flexible energy system: changes to the electricity distribution licence (2017)
29 https://ec.europa.eu/energy/en/news/commission-publishes-new-market-design-rules-proposal
30 Commission welcomes final vote on energy performance of buildings press release (2018) – [http://europa.eu/rapid/press-release_IP-18-3374_en.htm]

of a building's ability to interact with occupants and the grid. Industry are working closely with the consultants developing this methodology. The principle of the SRI could significantly aid the development of the storage market and demand side services for domestic consumers. There are four key principles in enabling and ensuring the ongoing success of a smartness indicator:

1. **Simplicity: it needs to be simple to implement and to understand**
2. **Output measurement: it needs to demonstrate results such as available storage capacity**
3. **Technology neutrality: it should indicate the building's ability to provide smart services to the grid, and therefore should not focus on individual technologies**
4. **Complementarity with Energy Performance Certificates (EPCs)**

Work is still required to ensure that the SRI adequately addresses the above principles which are key market requirements. BEAMA's concern is that if the methodology is over complicated then few member states will implement it and a fantastic opportunity will be lost to advance building energy management. BEAMA has made some clear proposals for the final methodology for the SRI.

BEAMA recommends that the SRI could provide firm basis for energy service providers such as DSOs and aggregators to determine a building's capability to deliver demand side services to the market. The assessment process would therefore include simple measures for:

- **Stored capacity – electric / heat / hot water**
- **Capacity to shift load in the short term, capacity to shift/ supply electricity over a period in kWh**
- **Availability of a central home energy manager**
- **Availability of smart meter and associated data to the consumer**
- **External communication link into the property (via the smart meter or cloud-based services)**
- **Availability and capacity of onsite generation**
- **Control**
- **Automation**

The ability for service operators to adequately assess a building's capability to provide different market services is not well established, and the SRI could provide a basis to make comparable assessments between buildings to aid the development of demand side market services. This would especially be especially useful where aggregators are contracting with multiple dwellings. It would also enable an aggregator to provide assurance to the network operator that the provision is there for whatever service they are contracted to deliver (for example frequency response).

CONCLUSIONS

This paper has considered the state of play for energy storage applications in buildings and their upstream value potential as well as new models and key recommendations for energy storage products and services development. We have set out the challenges and the key opportunities, highlighted where the market has developed and suggested where it could go in the future.

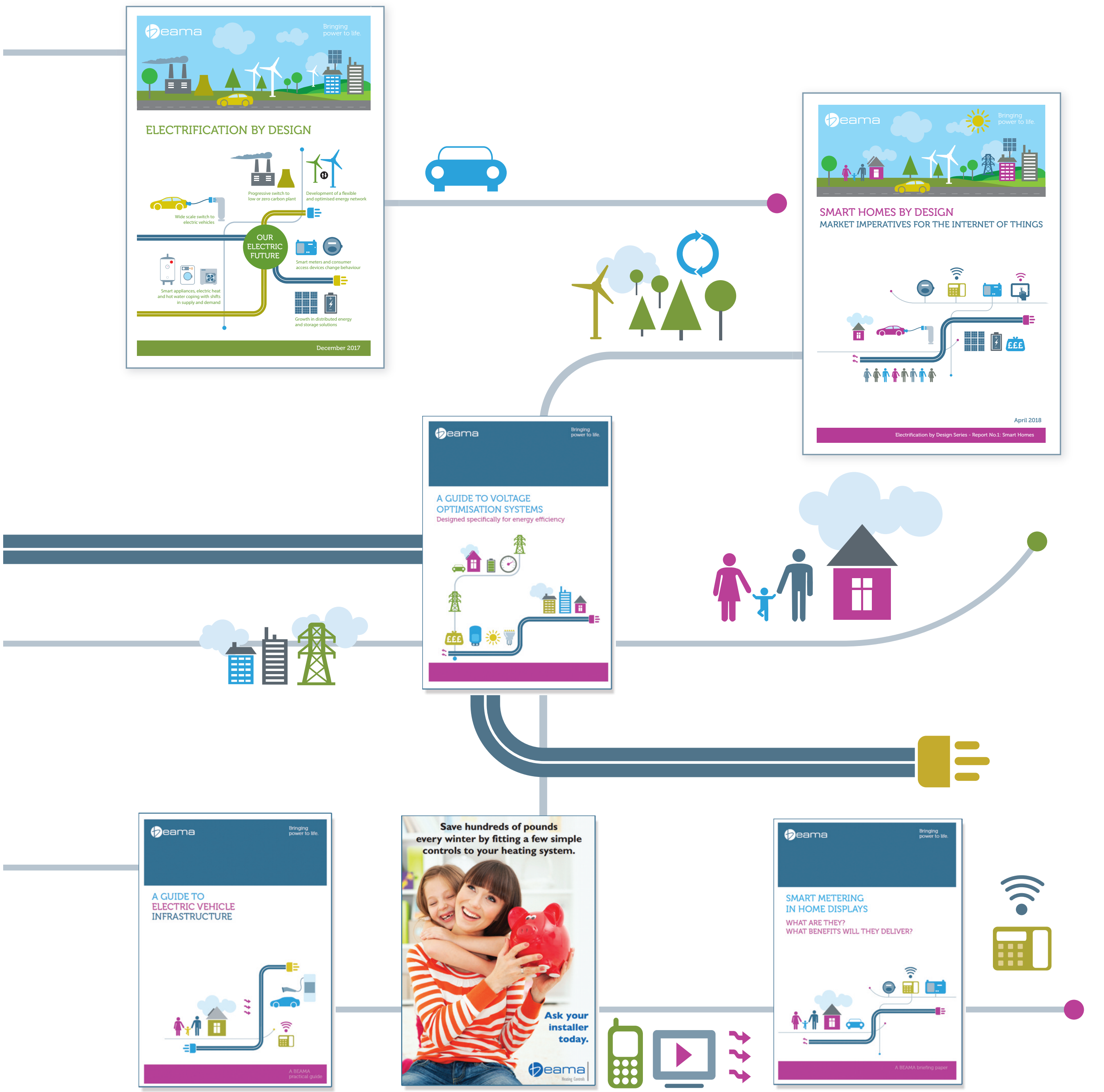
Great progress has been made in delivering storage products over recent years, and the market continues to adapt to facilitate uptake and add further value for the consumer and market participants. In delivering a smart and flexible energy system there is little doubt that storage will play a fundamental role allied to its already significant progress over recent years. This transition affects a much wider array of new technologies than just storage products. They will all play a role in a smart energy system that caters for interoperable, innovative, systems-based approaches to delivering the future consumer energy experience.

BEAMA is working towards delivering smart systems in homes and buildings by promoting national and international approaches to standards and specifications. We envision a market that will provide consumers with interoperable devices, systems and services that are easy to access and participate in, and that engage consumers to manage energy more effectively. In this market, consumers would not become locked in to a particular brand, communication protocol or system approach, but would be free to build a diverse and bespoke system of devices and services that suits their individual needs. We trust that this paper has been a useful addition to the debate of how best to engage the Regulator, Government, service providers, the supply chain and consumers themselves to realise the vast and still largely untapped potential of Energy Storage by Design.

Summary Recommendations

Market Development and New Value Streams	Enable the formation of markets for storage at domestic level	Agree a market framework for domestic Demand Side Response by 2020	Develop regional market mechanisms so energy prices reflect the network constraints that DSR is best suited to solving	Encourage new markets, models and applications to fully realise the benefits and value that storage offers to consumers and the energy system	Keep the market open to new entrants offering diverse service propositions to consumers
Smart Tariffs and Intelligent Control	Smart tariffs will require an innovative targeted approach that promotes growth of domestic storage and other low carbon technologies	Smart Tariffs should be simple and accessible and structured in a way that does not require frequent consumer intervention	Maximise the value of intelligent automation by enabling platforms capable of controlling multiple manufacturers' systems, and multiple storage vectors		
A Consumer Focus	Make consumers aware of the financial, social and environmental benefits of domestic storage	Develop innovative financing models for storage and other low carbon technologies			
A Role for Market Participants	Industry needs to be in a position to influence consumer choice and ensure that markets and propositions are available to consumer for storage and other low carbon technologies	Make the approach to installing storage in buildings consistent across regions and network operators			
Policy and Regulation	Focus on markets that can create a critical mass where the majority will follow, such as DSR and additional services	Define energy storage more accurately, with its own asset class, instead of as a subset of generation	Define energy storage more accurately, with its own asset class, instead of as a subset of generation		

For further reading on the subject of electrification, visit **www.beama.org.uk** and download one of our associated publications



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