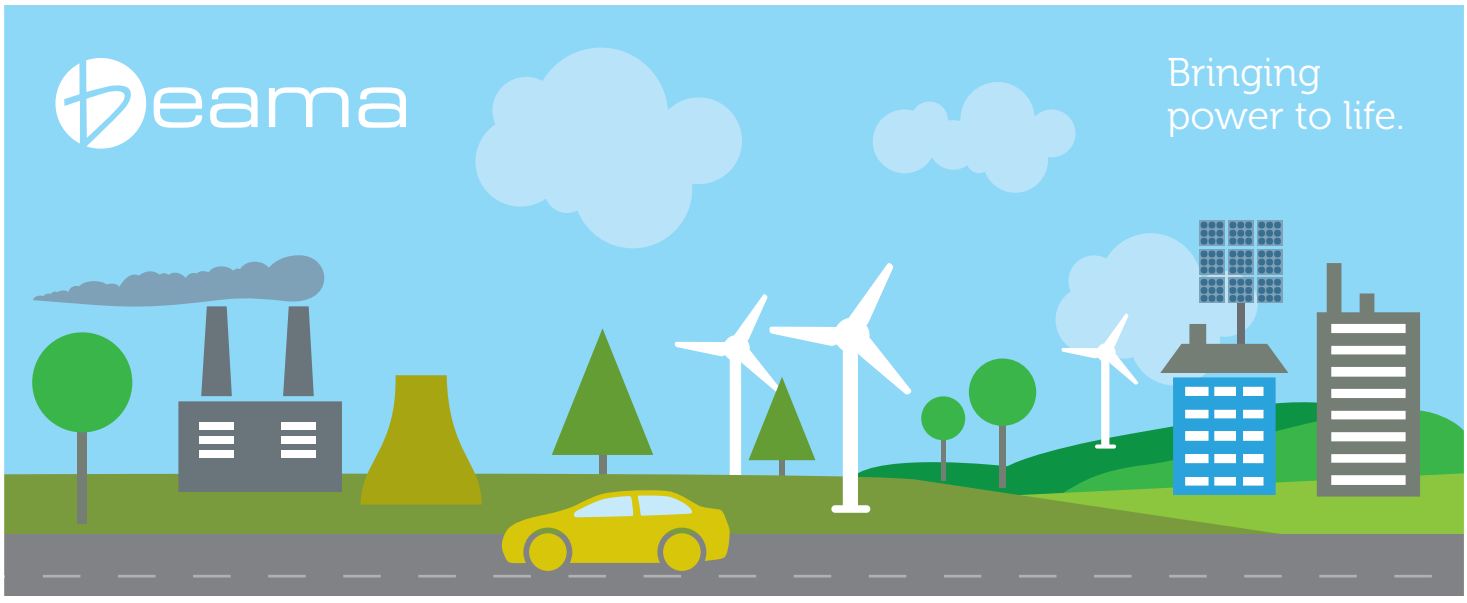
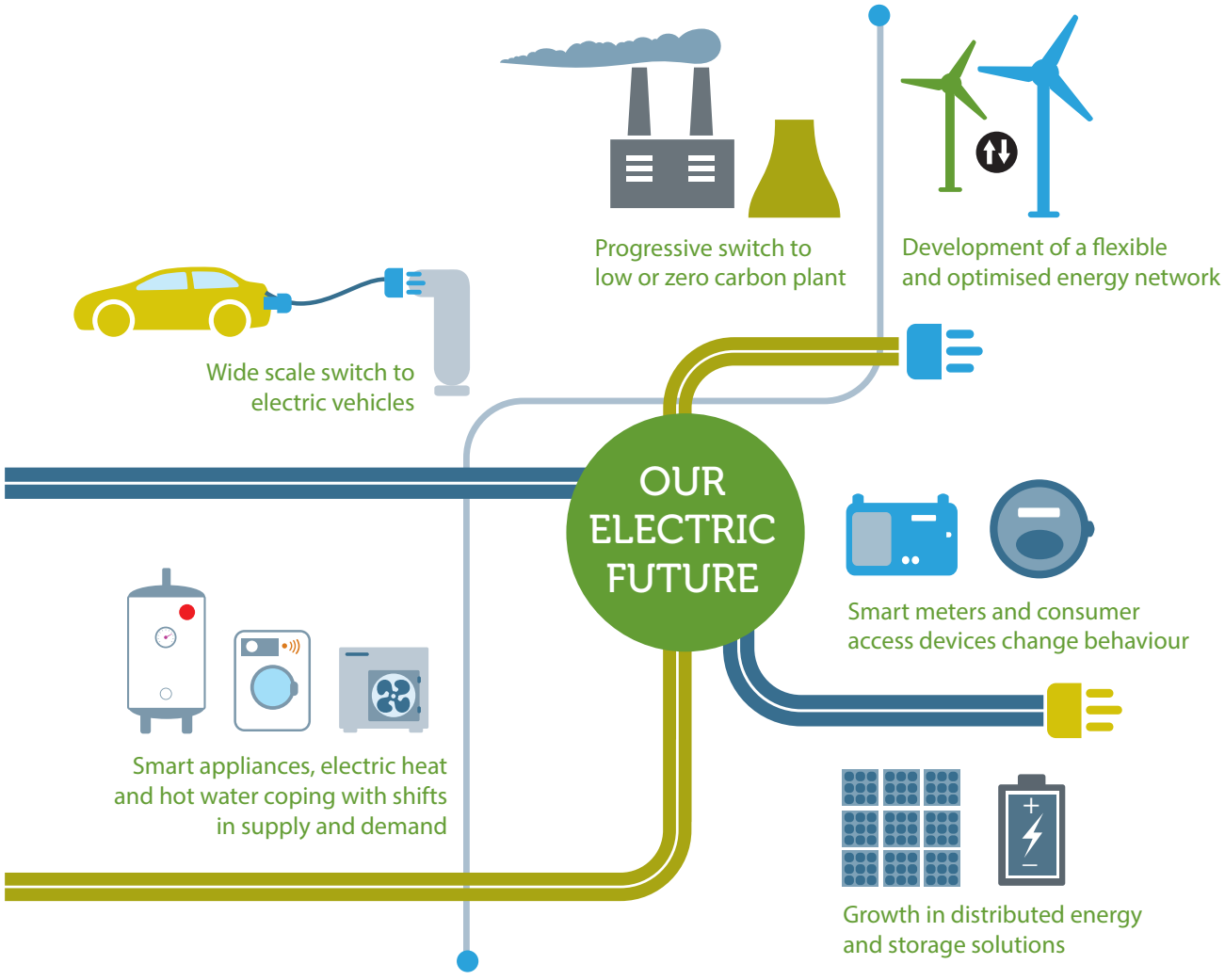


ELECTRIFICATION BY DESIGN



Supported by

Lucy Electric

December 2017

This report has benefited from our relationship with the Energy Systems Catapult and the valuable insights we received from co-hosted workshops attended by senior energy industry stakeholders. A steering committee of BEAMA members has informed the content and conclusions, and we appreciate the open dialogue we have had with a number of peer associations along the way.

Finally, we are grateful to the various referenced individuals and organisations who continue to publish the research that makes reports such as this possible.

FOREWORD

Successive Governments have maintained a strong commitment to ensure the UK navigates a path towards significant electrification of the energy system, and we are continually adapting to a fast changing marketplace in which low carbon decentralised generation, storage and electric vehicle technologies are becoming increasingly mainstream. Incentives and price control levers have been used to boost the electrification of heat and transport and transform our electricity distribution system, and the smart meter rollout gathers pace as a key gateway to a flexible energy market.

In the past year, the Government has provided further direction for industry right across the energy value chain. The summer publication of the Smart Systems and Flexibility Plan and more recently the Clean Growth Strategy and the Industrial Strategy have laid out the challenges ahead and presented a number of critical actions to stimulate the transformation of our energy system.

Some stakeholders are sceptical of our capacity to electrify, suggesting that 'there is no silver bullet' to the challenge of providing secure, affordable and low-carbon energy. The reality is that we have a wealth of technical capability and demonstration learning here in the UK which will help us achieve our electrification and carbon abatement goals simultaneously. Within BEAMA's own membership there are many companies involved in high profile and successful programmes that utilise energy-efficient connected systems to provide flexible demand right through the energy supply chain. The challenge at the domestic building level remains the same: How do we structure our supply chain and regulate it effectively to develop suitable domestic consumer propositions that harness and share the intrinsic value of demand flexibility?

The Government's Industrial Strategy acknowledges that if we can set the right course we will 'deliver cheaper and cleaner energy across power, heating and transport, while creating high value jobs and export capabilities'. In the context of this report, which seeks a better co-ordinated, zonal approach to market transformation, we were particularly pleased to see the Industrial Strategy build on earlier Clean Growth Strategy commitments to support a local energy programme. There is express support for local areas in England to play a greater role in decarbonisation through local system change in a way that keeps costs down and maximises economic benefit. Coming a full four years after BEAMA first produced its Renewable Heat Zones discussion paper, this summary report swings fully behind the Government's contemporary vision of our energy future.

There is no more exciting time to be the President of a forward-thinking trade association that is able to utilise its strong platform and informed membership to help formulate how the current market structure should be adapted to accelerate the electrification of our energy system. I would like to offer my congratulations to the BEAMA team for pulling together this insightful report. It will be followed by a series of more detailed reports in 2018 covering flexibility, heat, transport, storage, smart connected homes, network charging and consumer finance options. The BEAMA team has the full support of my Board colleagues as we work with Government, the Regulator and other industry stakeholders to deliver 'Electrification by Design'.

Patrick Caiger-Smith
CEO, Green Energy Options
BEAMA President

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ELECTRIFICATION BY DESIGN: CONTEXT AND DESIGN IMPERATIVES

Since the 2011 publication of the Coalition Government's vision for our energy future, *Planning our electric future: A White Paper for secure, affordable and low carbon electricity*, policy makers, regulators and the supply chain have been developing trial solutions to turn that vision into reality.

Our 'electric future' will mean replacing fossil fuels with electricity on a wide scale, including for transport (private and public, passenger and freight, road and rail and, eventually, aviation) and heat in buildings. We also need to rapidly decarbonise electricity generation, replacing old carbon-intense plant with distributed energy and centralised plant that allow our energy-related carbon emissions to approach zero. This means much greater reliance on renewable electricity generation, so we need to develop a flexible and optimised energy network to cope with shifts in supply and demand.

There has been no shortage of policy initiatives along the way, from the all-important smart meter rollout through to regulated investment via the Low Carbon Network Fund, other Government initiatives to promote localised electricity generation, renewable heat and energy efficiency, and sustained grant support for electric vehicles. As well as decarbonisation, the Government has identified other reasons to increase the proportion of electricity in our energy mix. For example, there is now a commitment to address air quality by switching high emission vehicles to electric equivalents and phasing out new petrol and diesel vehicles.

Much progress has been made: in June 2017 we generated a record 19.3GW from connected wind and photovoltaic sources, and the installed base for electric heat pumps has grown from the low tens of thousands in 2010 to an estimated 200,000 units by 2020. We install more than 50,000 Smart Electric Thermal Storage (SETS) units each year, and in the year to March 2017, 43,819 new ultra-low emission vehicles (ULEVs) were registered, an increase of 34% on one year before and 91% on two years previously.[1] More than £600m has been invested by Distribution Network Operators (DNOs) to demonstrate and trial the potential of flexibility and grid management solutions to support the transition to a low-carbon economy. Finally, arguably despite the absence of policy or widespread natural market levers, we are seeing strong penetration of electricity storage technology in networks and buildings.

However, as a body representing the lifeblood of electrical technology innovation, BEAMA understands that the next phase of market transformation for wide scale electrification by 2050 will only occur if we apply innovation to the design of our markets and the way we engage with consumers as well as to new devices. We currently have plenty of pilot studies and knowledge across the UK, but regulatory and policy constraints are slowing down our progress towards the mass rollout of these solutions. This is compounded by poorly co-ordinated market design which fails to bring 'the actors' and 'the enablers' together within a functional structure to optimise our energy system through financed measures, energy services, data management and investment planning.

Four years after BEAMA first published its *Renewable Heat Zones* discussion paper, the appetite for a zone solution (by regional authority, county or municipality) to the broader energy challenge has grown. This is due not least to significant market developments outside of the single dimension of heat and centred on the intrinsic value of energy system flexibility. This paper identifies the key technology sectors and their status today, looking ahead to consider how we can grow markets sustainably. The paper also looks at the wider value chain: the rise of Energy Service Providers and Distribution System Operators, clustering deployment, finance and how consumers can benefit, the role of regulation in encouraging distributed energy and storage, and the impacts all these may have on the supply chain.

We identify six key market design imperatives. All are crucial to success, and each needs to be considered in the context of a critical path to electrification:

1. Electrification is a national need, but optimised, flexible energy systems will be delivered by regions and zones empowered to identify the most appropriate paths.

2. Integrated and innovative finance packages are essential for market transformation.

3. The supply chain must have sufficient capacity to promote sustainable growth.

4. Consumers need confidence that services, systems and devices form part of a structured consumer journey. We need to navigate a critical path to electrification and decarbonisation.

5. DSR needs concurrent and planned development of regulation, technology and markets.

6. New and innovative ways of purchasing and providing energy services will emerge.

[1] Department for Transport – Vehicle Licensing Statistics: Quarter 1 (Jan - Mar) 2017 – [https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/620223/vehicle-licensing-january-to-march-2017.pdf]

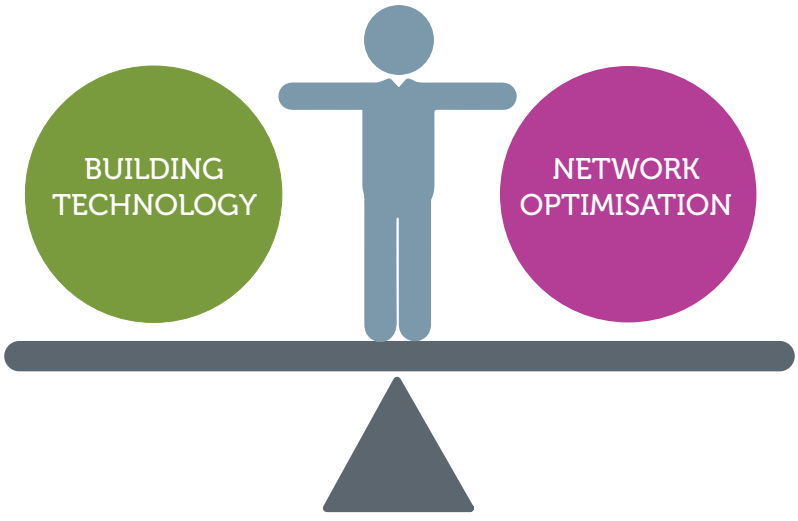
BALANCING A FLEXIBLE AND OPTIMISED ENERGY SYSTEM

A lot of reports approach the pathway to energy system flexibility by examining each sector in isolation but taking a holistic view of its supply chain. This leads to one-dimensional mythologies, for example the idea that a nationwide switch to electric vehicles would require 10 new nuclear power stations. More recently there has been better reporting, recognising that in fact the impact will be closer to an 8% increase in peak demand – 5GW – and that the development of smart solutions and new market designs will flatten the load demand[2].

A flexible and optimised energy system will balance the introduction of new technologies into buildings with the challenges these new loads can place on the network. This is particularly relevant to the sharp increase in electric vehicle charging infrastructure.

Technology that can perform load management or response functions can be connected to the network or deployed in the home, electric vehicles can be sold to the consumer and charging points installed, but without markets that allow providers to stack revenues and build their consumer propositions the potential value of this technology will never be realised. As the rollout of new technology and services continues without the right market conditions, their value is eroded or delayed. This is even without considering the lost upstream value and savings that these services could be providing to other market participants such as focused and planned infrastructure spending and energy management supported by DSR.

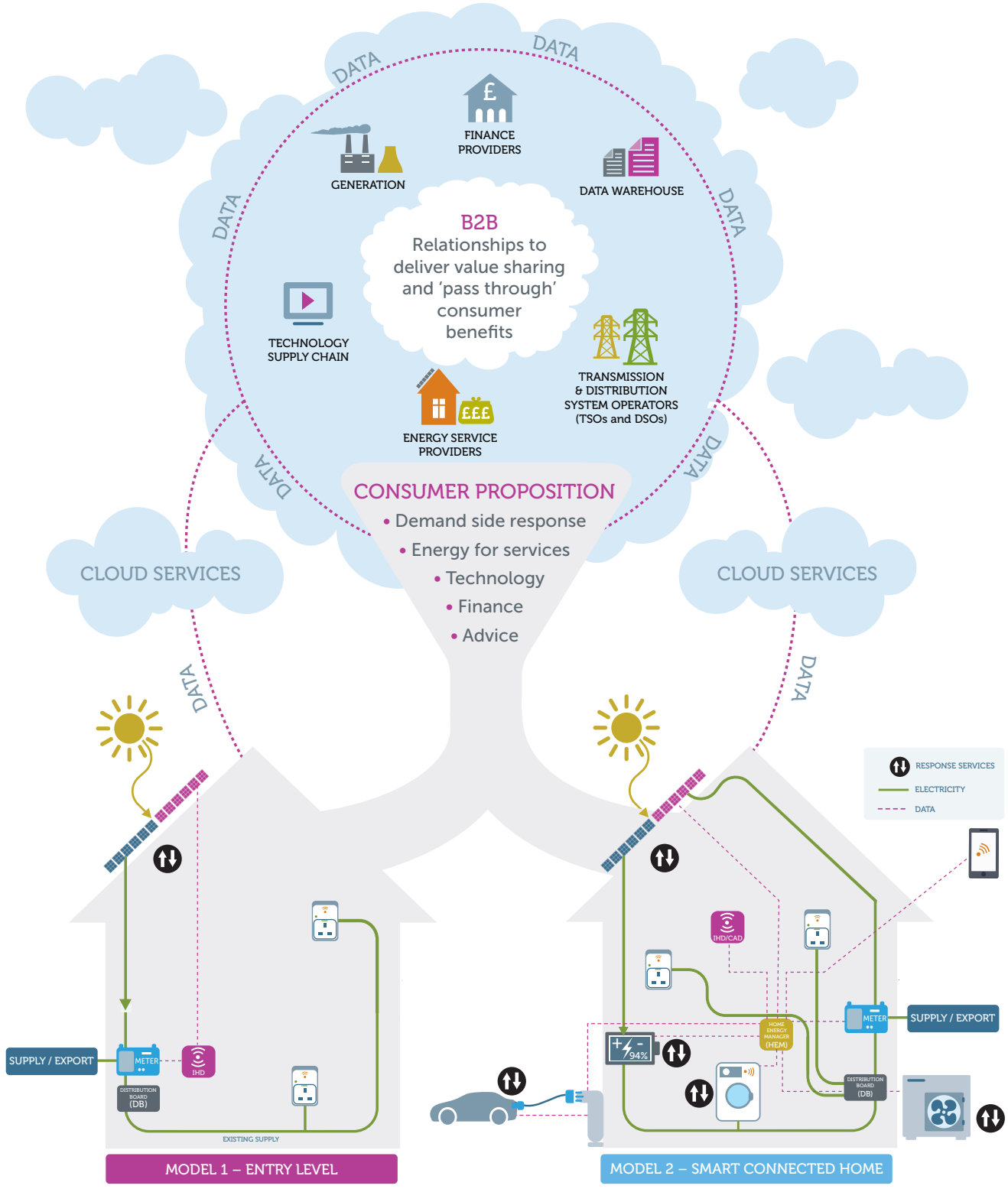
In practice, the swiftest method of co-ordinating this critical path is to bring the actors together, each with its own perspective and set of activities. Each actor may have a different target market but, crucially, this approach would build the business-level relationships needed to identify the critical path before consumers receive their propositions. This would require well defined relationships and a willingness to collaborate to deliver packages of technologies and services. Some companies will prefer to provide their consumer offerings in isolation, but others will collaborate to package together new and interdependent devices, systems and services that engage with and respond to the different needs of an appropriately segmented customer base. This is a policy challenge. The emerging market will need leadership at every stage from design to delivery so that each stakeholder realises the potential benefits in what is effectively a flexible and value-shared market.



THE EMERGING MARKET WILL NEED LEADERSHIP AT EVERY STAGE FROM DESIGN TO DELIVERY

2 National Grid – Our Energy Insights: Electric vehicle announcement and what the papers say (2017) – http://fes.nationalgrid.com/media/1264/ev-myth-buster-v032.pdf © National Grid plc, all rights reserved

THE FLEXIBLE AND VALUE SHARED MARKET



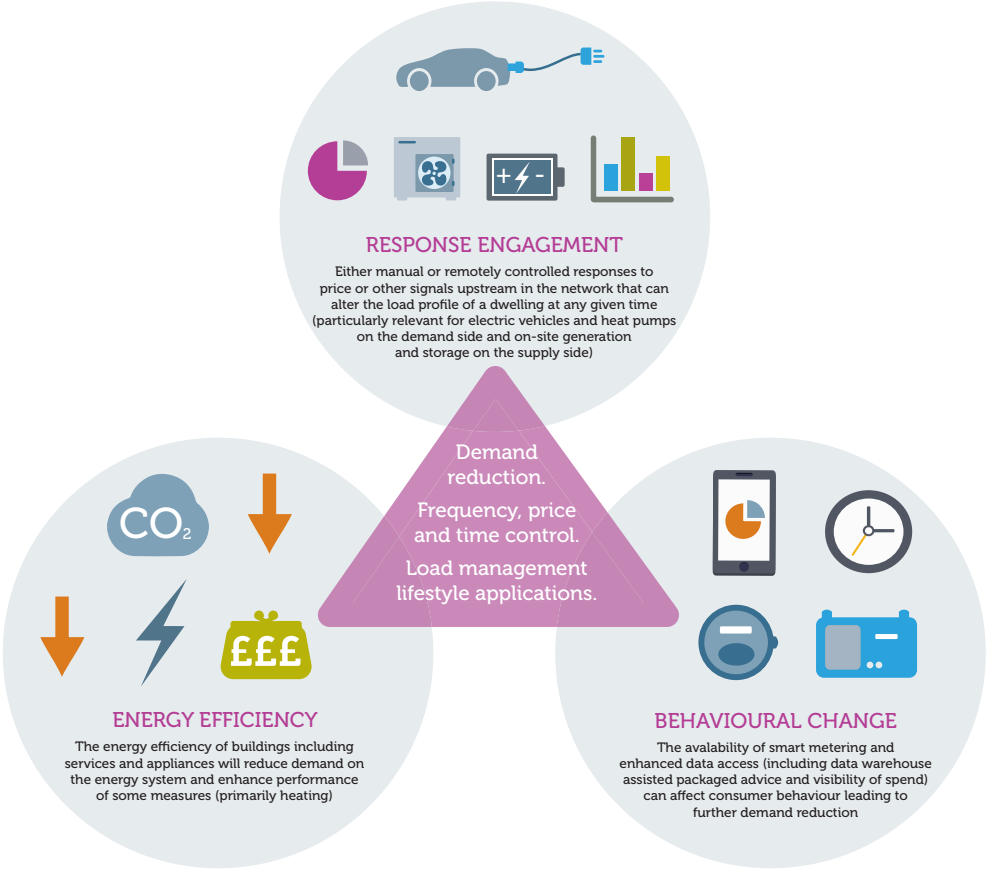
THE BUILDING-BASED FLEXIBLE ENERGY SYSTEM MIX

A fully flexible energy system requires a mix of energy efficiency, response mechanisms and behaviour change. The building itself is integral to the flexibility.

Optimised flexibility will depend on whether the mix is fully or partially achieved, and some automation will be required. The highest priority is the energy efficiency of the building. This is the first step; demand reduction measures, whether based on behaviour change or on automated responses to price signals, are unlikely to be as effective in an inefficient building as they do not tackle the root challenge of reducing peak generation.

Reducing energy demand is particularly critical to our electrically heated future. It is accepted that consumers may invest in on-site generation (possibly with some form of building based energy storage) independently of energy efficiency or response engagement considerations.

In this environment, the consumer is a participant in the flexible energy system but does not have to be fully and actively involved in the research and decision-making process for technology investment or tariff engagement. In addition, the consumer does not need to make complex behavioural changes; these can be co-ordinated remotely by a service provider based on agreed permissions or service packages. The business-to-business leadership and collaboration model defines the pre-packaged offer, and the service provider delivers it.



In a full mix scenario the consumer:

- Installs cost effective energy efficiency measures in the building fabric to manage peak heat demand
- Adopts the most efficient appliances to further reduce energy demand (including upgrading less efficient storage heating to modern Smart Electric Thermal Storage units)
- Adopts electric appliances or systems in favour of carbon-intensive building services technology, for example switching from an inefficient oil boiler to an electric heat pump
- Generates electricity to export, store or use on-site
- Engages with response offers such as static or dynamic time of use (ToU) tariffs
- Adjusts energy use behaviour to adapt to generation, storage and optimum use profiles (which are usually dynamic in nature).

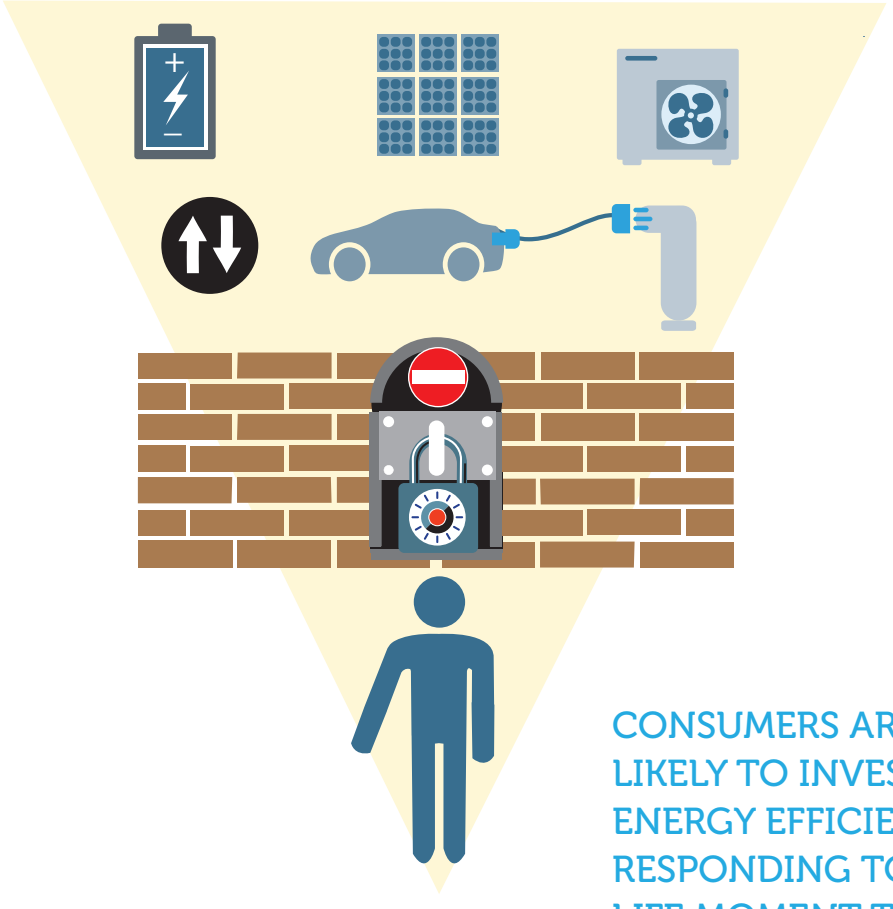
PLANNING A SYSTEM AROUND THE 'PASSIVE' CONSUMER

The consumer plays a critical role in the development of our new flexible energy system but outcomes will depend on many factors, including their willingness to engage.

Consumers have a tendency towards apathy, and BEIS research into consumer interest in response mechanisms[3] shines a light on the scale of the challenge relating to energy supply choice and response behaviour. With only 37% of those surveyed having changed the way they buy energy in the past two years and 72% of the sample preferring simple static time of use tariffs, there is clearly some passivity in the relationship between consumers and energy suppliers. Fewer than 50% of surveyed consumers would probably or definitely take up a smart tariff offer from an energy supplier. In even a partially electric future we would need to accept that in many cases the consumer will require a simple and pre-determined solution to a complex problem. The challenge is to create regulations and markets that work for the good of consumers without depending on unrealistic levels of consumer engagement.

We know from research[4] that consumers are more likely to invest in energy efficiency when responding to specific life moment triggers (for example a growing family or a sudden increase in disposable income) or within 12 months of moving to a new home. Households with low incomes present a particular challenge. Supplying units of energy may not be the most effective way of providing such households with what they need for cooking, comfort and warmth. But a focus on providing the desired outcomes rather than a simple kWh may allow a more effective collaboration between consumer and energy provider so that the services are provided at an agreed price, and each partner works together to ensure an efficient home and an affordable level of service that maintains business profitability upstream.

An additional consumer challenge is the level of trust in advice. Consumers tend to trust advice from local authorities rather than advice from retailers or tradespeople. This is compounded by the fact that no normal sales route exists for some technologies and positive energy efficiency decisions rely either on researched consumer information or the advice of an installer who may have a bias to a single solution or, in the case of heating, be advising in a 'critical event' situation.



CONSUMERS ARE MORE LIKELY TO INVEST IN ENERGY EFFICIENCY WHEN RESPONDING TO SPECIFIC LIFE MOMENT TRIGGERS

3 BEIS Smart Energy Research Consumer Panel: 2016

4 Energy Saving Trust UK: Pulse 2016

Away from buildings and the associated flexible energy systems mix, we see an alternative story for consumer interest in electric vehicles. This market is driven more by a framework of grants, tax incentives and cost effectiveness versus the counterfactual fuel alternatives, as well as a stated intention to phase out all new high-emission vehicles in the interests of improved air quality by 2040. Electric vehicle sales are rising rapidly and a well-functioning flexible energy system will reduce the impact of the 'all electric' switch to as little as a 5GW peak rise in electricity demand (8%)[5], but only if we have the required level of engagement from consumers; in turn, this means getting the consumer proposition right.

THE CONSUMER PROPOSITION SHOULD BE BASED ON A SET OF WELL-DEFINED BENEFITS THAT PROVIDE COMFORT, CONVENIENCE, LIFESTYLE CHOICES AND AFFORDABILITY BASED ON A BUSINESS-TO-BUSINESS FRAMEWORK THAT AGGREGATES VALUE AND FINANCE

So, when engaging consumers, are we asking the wrong questions? Are we presenting consumers with questions that cement the status quo? Most research relates to customers having to pay high upfront costs for building measures or efficient appliances and having a simple pence per kWh tariff relationship with an energy supplier. Under these conditions it is unlikely we will be able to effect the market transformation we need.

Perhaps this is not how we should be packaging the offer. Instead, perhaps we should be asking questions based on models where consumers do not own the devices or systems. Leased technology solutions, including heat pumps, could be bundled with tariff propositions that reflect the services available. A market where we pay for a service to match our needs rather than a silo energy contract separate from the measures we use and the energy demand profile they require may create significant value further upstream in the market for DSR.

Such an approach has consumers at its heart and approaches energy management and delivery of the smart, flexible energy system in an holistic way, built around a packaged combination of smart metering, low carbon technology, energy efficiency and innovative finance and energy retail propositions.

Under this vision, it is not only the energy supplier's relationship with the consumer that changes but also its relationship with the technology provider, as measures are channelled through a single energy service provider route. This approach can unlock the finance needed and support leasing or longer term paybacks.

5 National Grid – Our Energy Insights: Electric vehicle announcement and what the papers say (2017) – http://fes.nationalgrid.com/media/1264/ev-myth-buster-v032.pdf © National Grid plc, all rights reserved

THE CRITICAL 'ACTORS'

Generation

The way that energy is generated has changed significantly over the last 10 years. The generation mix has evolved from large baseload power stations and, in a bid to decarbonise, the installed park of large and small scale distributed renewable generation has grown to around 7.2% of supply versus 4.8% in 2009. The combination of incentives and obligations on large energy suppliers has helped to facilitate this transition towards low and zero carbon generation. The transition to renewable energy is not without its challenges: integrating them into the energy system, maximising capacity and making optimum use of largely intermittent and unpredictable renewables are just a few.

The Energy Efficiency Directive proposes a Primary Energy Factor reduction from 2.5 to 2.0 due to the decarbonising nature of electricity production.

UK Share of Generation Mix 2016[6]

	COAL	GAS	RENEWABLES	NUCLEAR	OTHER
2016	9%	42%	24.5%	21%	3.1%
2011	30%	40%	9.4%	19%	2.4%

Wind and solar generation are intermittent by their nature, so the way the energy system operates is changing. To maximise the value and usage of an increasingly dynamic generation mix, we need greater flexibility and significant changes to our energy infrastructure. While network operators are working to maximise capacity through Active Network Management, response services and other innovative solutions, the transition to a smarter more flexible system is by no means over and needs improved planning and investment timing.

The use of batteries and other technologies to store electricity from renewable generation at times of high output to then be used later at times of higher demand is changing the way energy is distributed, from a direct and passive approach to an approach where the timing of delivery or use of energy is more actively dictated by when it is needed. Smart tariffs and price signals can influence consumer behaviour and shift demand to times when generation output is high. Electric vehicles could strain the network if clustered vehicles recharge at the same time, but shifting charging to times when renewable generation is abundant and energy cheap helps to manage demand.

The proposed CO_2 emission factor for electricity within the Standard Assessment Procedure (v.10) has fallen from 0.519kg CO_2/kWh in 2012 to 0.399kg CO_2/kWh in 2016. This is a 23% reduction.

6 Digest of United Kingdom Energy Statistics (DUKES) 2017: main chapters and annexes (2017) p. 116.
Digest of United Kingdom Energy Statistics (DUKES) 2013 main chapters and annexes (2013) p. 117

The Distribution System Operator transition

The Government's Smart Systems and Flexibility Plan outlined policies for delivering a smarter energy system. The plan included strategies to help DNOs manage their networks more actively. Key to this was exploring innovative techniques and market based solutions as alternatives to reinforcement. This marks a shift from traditional DNO operation to assuming the role of Distribution System Operator. New techniques could include demand management and demand response, energy storage and energy efficiency measures, with the recommendation to adopt these solutions if they offer better consumer value than reinforcement.[7]

As the network operators move to more dynamic ways of operation as Distribution System Operators (DSOs), more tools will become available to them to operate the networks more efficiently and effectively. This will give rise to new solutions and new market opportunities for a multitude of industry parties and will help to ensure best use is made of flexibility, DSR, storage and renewable generation at all network levels, helping to support decarbonisation ambitions and delivering an efficient, resilient and future proofed energy system.

The Energy Networks Association's Open Networks Project, led by network operators, offers the following definition of a Distribution System Operator (DSO):

"A DSO securely operates and develops an active distribution system comprising networks, demand, generation and other flexible distributed energy resources. As a neutral facilitator of an open and accessible market it will enable the optimal use of resources on networks to deliver security, sustainability and affordability in the support of whole system optimisation. A DSO enables the prosumer, facilitates customer accessibility and choice, delivers great customer service and promotes competition."[8]

DSO Roles and Responsibilities:

- Maintain distribution network resilience and security
- Support whole system stability
- Provide fair and cost-effective distribution network access
- Provide capacity in an efficient, economic, coordinated and timely manner
- Enable competition in energy markets
- Provide and maintain systems, processes and data to facilitate markets and services

CASE STUDY:

The Open Networks Project is a major energy industry initiative that will transform the way our energy networks work, underpinning the delivery of the smart grid. This project brings together academics, NGOs, Government departments, Ofgem and nine of the UK and Ireland's electricity grid operators.

The role of the DSO in facilitating an open and accessible market does not address market formation and delivery. As such, ownership and leadership are provided by the responsible authority. This emerging role is essential if markets are to work for customers, market participants, new entrants and the system, and to provide certainty to all parties. Local energy zone models would provide the results required, Energy Service Providers could provide the scale and aggregation needed direct to the DSO through market platforms (when they exist), and new market entrants could disrupt the way we think about, engage with and use energy. With scenario planning and more certain market requirements, participants can start to make sense of what the system should look like and what is needed to deliver it.

Role for Independent Distribution Network Operators (IDNOs) and Independent Connection Providers (ICPs)

IDNOs and ICPs build new connections for new properties, in some cases up to 10,000 in one zone. If new properties and new connections could be appropriately designed, incentivised and enabled in tandem with new approaches to energy with low-carbon generation, heat, and transport supply then large sections of demand could be catered for at design stage. As well as enabling and providing flexibility services across the connection boundary to DSOs, this regional approach to network building and energy distribution could ensure fit-for-purpose networks for changing consumer needs and an upgraded energy system. The most cost-effective option for new build dwellings is a more robust network that can cope with the increased loads that electrification will bring. Here system resilience is even more important than system flexibility; smart solutions and technologies for EV load management for example will be better suited to retrospective applications or as an interim solution to defer reinforcement. Whilst this approach alone will not address the energy system's challenge in its entirety, it could address new sections of additional demand in a joined-up way.

7 Call for Evidence: Building a market for energy efficiency (2017) p. 45

8 ENA Open Networks Project – Workstream Products (2017) – [http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-workstream-products.html]

CHALLENGES FOR OUR ENERGY & TECHNOLOGY MARKETS TODAY

Electric Heating

Heating accounted for 44% of the UK's energy demand in 2011. Reported figures vary but we estimate around 81% of residential buildings rely on natural gas for heating; heat pumps, district heating and electric resistance heating (including storage) account for 11%, with the remaining 8% split between oil and LPG.

Despite the dominance of gas infrastructure, the future of heating points to widespread electrification as 2050 scenarios which meet the 80% carbon reduction target universally include an electrified heat supply. Most commonly, heat pumps are seen as the key proven technology, capable of delivering 80%-90% of low carbon and affordable heating. However, substantial research and field trials have taken place under the LCNI, and EU-funded RealValue Project to also prove the value of deploying modern Smart Electric Thermal storage (SETS) as a viable replacement to old and inefficient storage heaters.

Beyond electrification, the Climate Change Committee advises more efficient use of gas for heating in higher density areas. There are 17,000 heat networks in the UK (91% in England and 6% in Scotland), serving 446,500 dwellings. The Climate Change Committee estimates 18% of UK heat will need to come from heat networks by 2050. In 2013 it was only at 2%[9].

In the path to decarbonisation, the most likely 'hot spots' for electrification will be the 8% of homes using high carbon oil or high cost LPG systems. Even with a relatively low heating oil price, a typical well-insulated three-bedroom home can save £1089 when installing a high-efficiency air source heat pump compared to a non-condensing oil boiler equivalent[10]. Existing storage heating technology can be replaced by SETS units. Both heat pumps and SETS offer energy efficiency benefits but, crucially, both also provide the flexibility value required to support an energy system with a higher proportion of renewable energy generation. If we are to reach the Climate Change Committee's recommended target of 1.2m heat pumps installed by 2030, we will need changes to building regulations and a co-ordinated set of collaborative partnerships to deliver financed technology purchase and lease propositions. These will overlap beyond the current renewable heat incentive (RHI) for heat pumps. Using pure electric heat pumps in gas heated homes beyond 2030 will be dependent on investigations into the claimed, but as yet unproven, decarbonising nature of gas distribution. In the meantime, we are already witnessing substantial growth in hybrid heat pump specifications whereby the heat pump works alongside an existing boiler or as an integrated unit to provide a low carbon heat supplement. The flexibility capability of this solution will depend on the storage potential of the heat pump's output compared to the boiler.

A controlled and sustained switch to electric heating powered by regional or local grids will have the following benefits: decarbonisation of heat, response benefits to upstream actors, improved efficiency, and optimised approaches to heat and transport planning (ensuring that the network is appropriately reinforced). Sensitivity to local conditions will also have the benefit of supporting regional development objectives.

Challenges

A lack of cohesive technology finance	Consumer choice too driven by critical events	Lack of additional stacked value propositions such as DSR
High initial upfront costs for some solutions	Constrained investment planning impacting on reinforcement costs	Carbon tax and incentive regimes are insufficient for market transformation
Network capacity constraints	Poor routes to market leading to lack of trust in advice	Low numbers of designers and installers in heat pump supply chain

Recommendations

A collaborative and localised framework model must be adopted across the UK to promote a target based approach to electrification	Appropriate incentives and tax regimes are required to accelerate growth in heat pumps, storage heating and hot water systems and heat networks
The long awaited Assignment of Rights mechanism linked to the Renewable Heat Incentive needs to be urgently agreed along with accompanying enabling legislation	Policy initiatives need to work together to promote electrification e.g. Energy Company Obligation working with the Renewable Heat Incentive
Building regulation provisions are required to target off gas areas with suitable electric or heat network alternative systems	Fast track the publication and roll out of SAP 10 software to ensure new build developments can utilise the latest reduced CO2 emission figure for electric heating solutions
Undertake a fundamental review and update of Government advice for heating systems to ensure the present and future value of electric heating solutions	Provide greater regulatory scrutiny over DNO activity relating to the speed and cost implications of network connections

9 The Future of Heating: Meeting the Challenge DECC March 2013
10 BEAMA Energy Modelling Tool

Transport

According to the International Energy Agency, between 2011 and 2016, the number of electric vehicles (EVs) on the road globally increased thirtyfold. The UK Government's target is that almost all vehicles on Britain's roads will be ultra low emission vehicles (ULEVs) by 2050. The Clean Growth Strategy (2017) highlights that UK carbon emissions from transport in 2015 were down 2% compared to 1990 while new cars in the UK are up to 16% more efficient than they were in 2000. Currently, road based transport accounts for approximately 24% of UK CO_2 emissions. There is a push to reduce the transport sector's reliance on fossil fuels in favour of cleaner and less carbon intensive sources.

EVs offer a low or zero carbon alternative to purely fossil fuelled vehicles if the electricity that powers them is also from low-carbon sources. EVs and other low emission vehicles also help avoid other forms of air pollution, and electricity is usually a cheaper fuel source than petrol or diesel. All this attracts consumers looking to save ongoing costs but willing to spend more upfront on a vehicle, as well as those who want to use cleaner fuels. EV prices are gradually falling and are expected to be close to or at parity with their petrol- and diesel-fuelled equivalents by 2018/19.[11] With improvements in battery technology and cost effectiveness, increasing range, innovative finance models, energy storage and increasing levels of renewable generation, the consumer proposition for EVs becomes even more appealing.

One impediment to the growth of the EV market is slow charging rates. Faster charging could transform the market and pose new challenges for the electricity networks. Technology is likely to enable faster and faster charging rates, and reducing charging times to 5-10 minutes (similar to the time it takes to refuel a petrol or diesel car) could mark a tipping point for consumer interest. Another may be when ongoing innovation in battery technologies allows for a range similar to what is currently available from a tank of petrol or diesel.

Such technological development and deployment could also change the way consumers charge their vehicles, moving to centralised and co-located fast charging alongside or instead of slow charging. This could allow infrastructure investment to be better targeted. Centralising or co-locating the charging infrastructure with generation and storage can alleviate the pressure on local domestic low voltage networks.

Much has been said in the media about reinforcement requirements for the electrification of the infrastructure to cope with electric vehicle demand, with some going so far to suggest that in excess of 10 new nuclear power stations would be required to meet EV charging demand alone. But in August 2017, National Grid suggested in an Energy Insights paper that if the Government's ambition for all new cars and vans to be electric by 2040 is realised, this move would represent around an 8% increase in peak demand growth (around 5 GW).[12] This scenario acknowledges that smart solutions and deployments can help to minimise the effects of increases in demand, but it does need joined up and intelligent solutions and systems rather than more traditional demand-led reinforcement approaches.

Challenges

Connection and grid capacity challenges	Concerns around battery life and replacement	Loss of duty on fuel may need to be recouped elsewhere
Delayed connections for public fast chargers	Higher upfront costs, though these are falling	Making wider applications and services a reality
Facilitating the stacking of revenue for EV buyers	Range concerns	Effective combination with energy efficiency and demand reduction strategies

Recommendations

Communicate consistent messages on the benefits of EVs.	Ensure smart charging maximises the customer value offering for buying an EV
Implement a mix of smart solutions e.g. managed charging, reinforcement and infrastructure upgrades to facilitate consumer uptake of EVs with tailored approaches for new build and existing networks	Incentivise consumers through smart tariffs, applications exist for diary like solutions that place time of charging in consumer control and outside of network peaks, or alternately manage energy usage on behalf of the customer
Enable schemes such as DSR, stacking solutions and services to allow consumers to further leverage investment	Subsidies and incentives promote increased uptake of low emission or electric vehicles and this should continue to grow the market for EVs
Smart charging should incentivise the customer, or third party acting on the customer's behalf, to shift their electricity use to a time outside of peak demand	Co-locate storage, generation and charging at key large charging locations to promote flexible charging and manage network constraints at peak times and to move demand away from the LV network
Future proof the housebuilding programme, for example making smart charging installations standard in new properties	

11 The Telegraph and UBS – Electric vehicles to cost the same as conventional cars by 2018 (2017) – [http://www.telegraph.co.uk/business/2017/05/19/electric-vehicles-cost-conventional-cars-2018/]

12 National Grid – Our Energy Insights: Electric vehicle announcement and what the papers say (2017) – http://fes.nationalgrid.com/media/1264/ev-myth-buster-v032.pdf

Energy Storage

Energy storage captures generation for use at a later time as decided by the operator. Typical uses vary from grid scale connected batteries that provide services such as flexibility, security of supply and network resilience to domestic energy storage that allows consumers to make better, more flexible use of the energy generated by their solar panels. As a result of technological improvements and the falling cost of systems, storage is a commercially and technically viable solution both at grid scale and at domestic and building scale.

Over recent years energy storage technologies have become more efficient and cheaper, and the applications have multiplied. This has led to a huge increase in consumers storing their energy and exporting to the grid. These technologies offer clear benefits and flexibility to network operators and consumers. Although connecting large volumes of systems to the network remains a challenge and demand for connections is high, energy storage technologies will play a key role in the transition to a flexible, optimised system.

Storage can be deployed at a small scale, for example to store PV generation in a domestic battery for use at peak times, or in large scale battery storage systems deployed on the grid that are capable of serving thousands of consumers and helping network operators manage fluctuations in demand. Storage isn't just valuable for networks management, but will also be able to offer value to the consumer and to businesses to participate in paid-for services to make better use of their energy.

CASE STUDY – MOIXA

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, East Oxford. Moixa installed 90 units in Rose Hill and connected them using its GridShare aggregation platform. Project ERIC achieved two goals for this energy-poor community: lowering household bills and increasing solar self-consumption.

Challenges

Network Operator consistency for storage connections and the continued rollout of fast track connections at domestic level	Service development and tariffs will add further value	Recognising the load reduction value of storage at networks level, particular when installed with export limitation
Network usage charging	Consistency of expedience and process from network operators	Lack of standards for technology and systems
Planning	Regulatory clarity	No consistent advice for consumers

Recommendations

Identify new market and financing models and applications to fully realise the benefits	Focus on the value of intelligent control and enable platforms that support interoperable services, systems and devices
Achieve a known market framework for domestic Demand Side Response by 2020	Keep the market open to new entrants to expand the range of service propositions to consumers
Influence consumer choice and ensure that markets and propositions are available to domestic consumers	Focus on sectors that can create a critical mass where the majority will follow: storage can play into DSR markets and service markets
As the combined use of local generation and storage allows customers to reduce their interaction with the grid, re-allocate network costs so that consumers are treated fairly	Improve consumer and installer understanding by developing of guides and checklists and marketing material that facilitates access to funding
Make network operator installations consistent, prioritising fast-track connections	Use AI energy management services to extract the value of stacked revenues from installed technology.

Smart and Connected Homes

The introduction of smart meters, Consumer Access Devices (CADs) and in-home displays (IHDs) into nearly every British home and small business is expected to facilitate a rapid increase in the technology and services available to consumers wishing to manage their energy better. It is vital that Government and industry together take best advantage of this sudden increase in consumer engagement to maximise the realised benefits of smart metering and visible data and to encourage the uptake of smart appliances and smart energy management systems. Data will be available for both electricity and gas consumption, and new services and products will appear on the market to help consumers interrogate and analyse the data to identify cost saving opportunities.

Many consumers are likely to respond to the increase in access to near real-time energy consumption data by becoming more engaged with the way they buy and consume energy. However, this renewed interest will not be seen everywhere and may not last long if there are limited consumer-centric offerings. The challenge for Government and industry will be to maximise the public's engagement with their energy bills and their new options for energy management, control and services. management, control and services.

There is a challenge for all parties to develop ways of facilitating simple, flexible and responsive energy use without relying on continued high levels of consumer engagement. This will be achieved by developments in energy storage and intelligent automation. For example, more visibility of the load and cost of running specific appliances may encourage consumers to schedule their use according to static Time of Use (ToU) tariffs, but load shifting in response to dynamic ToU tariffs is most likely to be at least partially automated.

We need to be bolder in our approach to connectivity and smart capability and establish a UK position on how to shape building regulations to introduce the Smart Readiness Indicator proposed within the Energy Performance of Buildings Directive. The indicator should assess a building's ability to actively connect and co-operate with the flexible energy system by managing its internal load, self-generation and any potential storage. Minimum levels of smart readiness can be applied through new build regulations of course, and to aid consumer choice in the advice process the indicator can also be added to the Energy Performance Certificate.

Much of the technology needed to support a fully connected home already exists. Intelligently automated responses to consumer needs and behaviour, including the ability to learn ways of responding better, as well as responses to static and dynamic ToU tariffs and the integration of smart appliances into one single Home Energy Management System, are all examples of how an integrated and flexible energy system can be realised at domestic level.

Challenges

Facilitating enhanced value propositions for customers and the market	Lack of consistent advice for consumers	Data protection
Delivering new services and value stacking opportunities	Active customer participation and negative media reporting	Security
Using the smart meter rollout as a basis to build in further value over time	Interoperability	Early state of the market with no obvious commercial champions

Recommendations

Provide consumers with attractive and appropriate ways to use the real-time gas and electricity data that CADs provide	Make devices and systems interoperable
Facilitate real-time data to inform big decisions that consumers make about energy efficiency, such as building design, microgeneration and electrification of heat, as well as the small, everyday behavioural decisions assumed in the smart metering business case	Ensure consumers do not feel locked in to a particular brand, communication protocol or system approach, but are free to build a diverse and bespoke system of devices and services that suits their individual needs
Define standards for cybersecurity and build capability to manage and respond to threats	Increase security organisations' engagement with technology providers and other participants to ensure resilience is designed and built in at the earliest opportunity in product lifecycles
Make devices, systems and services affordable and easy to access and participate in	Work towards making connected systems standard in new homes by agreeing a UK approach to defining minimum specifications using the proposed Smart Readiness Indicator

Technology Supply Chain

The technology supply chain includes upstream network transmission and distribution system equipment and downstream building based or linked equipment, encompassing manufacturers, distributors, designers and installers.

The distinction between upstream and downstream technology is less important than the need to acknowledge that the markets for each are becoming inextricably linked. In a disaggregated and poorly co-ordinated market we would continue to have an increasing amount of load impacting technology in and around the building but completely blind to the requirements to reinforce the network; similarly, we would have the TSOs and DSOs proposing business plans for reinforcement with no real understanding of what is being connected.

The solution to this is covered later in this report, but what technology providers need to be aware of is the changing nature of the supply chain and how this might impact on their role and business outlook.

- **Ensure the integrity of the electricity network is upheld as we shift to electrification**

  Both the *ReShaping Regulation* by Laura Sandys, Jeff Hardy and Richard Green and Dieter Helm's *Cost of Energy Review* point towards a different future for network technology providers as they respond to well-planned and timely specifications of system optimisation and reinforcement solutions within the business collaboration model discussed earlier. The better co-ordinated and leadership-driven value chain will utilise macro data analysis and locally-driven energy service provision to invest more appropriately in the resilience, reinforcement and smart control technology required to balance the network and drive down infrastructure development and maintenance costs. This will smooth technology investment cycles and empower the supply chain to manage manufacturing output better and develop more appropriate design and installation skills.

- **Stimulate home improvement, technology ownership and leasing at the consumer level**

  The traditional one and two step distribution model for heating and other home appliance related sectors will be challenged by a market designed to build a service based system around the consumer. The extent of the challenge is evolving, but traditional manufacturers may either see themselves as commodity unit sellers or perhaps evolve into data service providers, linking their technology to cloud based data aggregation that in turn is linked to other Internet of Things data sources. The choices are varied and we will see multiple approaches, but the flexible energy system mix suggests technology will be offered within a bundled service. Whether units are re-branded by service providers or supplied under large volume call-off contracts with specific finance solutions, this will be a major step into a new market model for many companies as they wrestle with trade-offs between volume, value and associated market diversification.

Energy Service Providers

The Energy Service Provider model is hardly a new one for the delivery of a consumer proposition, but the shift to a new decarbonised flexible energy system combined with electrification should re-establish and re-define its role. The key opportunity for a new breed of energy service providers is the additional focus of supplying aggregated flexibility services to consumers, potentially under a paid service contract to a DNO wishing to fulfil its DSO obligations with contracted services.

As the energy sector becomes smart-enabled, we see a number of factors converging to support the Energy Service Provider proposition:

- **DSR availability and return on investment in flexibility**
- **Private finance bundling**
- **Data management and advice**
- **Possible links to third-party schemes (such as the Energy Company Obligation (ECO) via the DNO)**
- **Management of the connection process**

This model needs a different supply paradigm that is no longer driven by the old quantitative kWh metric but instead focused on delivering lifestyle, comfort and qualitative services. The model will still enable the service provider to maintain a profitable business. It is the same marketplace but with different value streams, different offerings, and different business-to-business relationships; it is a market in which success is driven by longer term planning and collaborative working.

Local Authorities

Local authorities are already making moves into the energy market through supply contracts and purchase agreements. Bristol Energy and Nottingham's Robin Hood Energy are flagship exemplars, and others may follow suit. They have options for entering the market; a local authority can 'white label' an existing supply service but manage the marketing and consumer engagement along with the business-to-business relationships required with companies. The risk associated with this option is the lack of control over pricing and potential access to full or partial flexibility value. An alternative is to obtain a supply licence, although this has inherent risks associated with the obvious changes to core business models.

The less explored route is the collaborative 'lead authority' partnership approach which utilises third party expertise and helps that partnership leverage funding using its high credit rating via its asset base. A business may also choose to operate within a broader regional framework with its own governance structure.

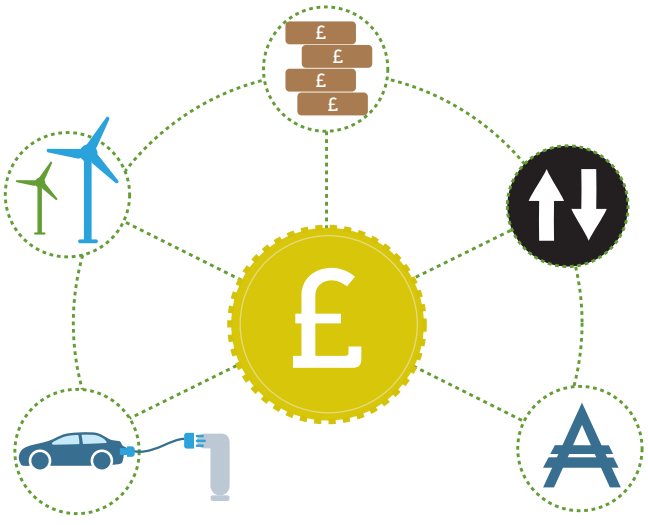
THE CRITICAL 'ENABLERS'

Collaboration and Ownership

Implementing new solutions, creating new markets and facilitating market transformation will require new levels of collaboration. A single organisation may retain ownership of the responsibility for delivery but will still need to collaborate with other participants to ensure common ambitions are realised.

It is crucial that ownership and responsibility reside with those most able to deliver the change required. There will be synergies that need to be monitored and managed to ensure that one action does not have a detrimental effect on other work items. All stakeholders need to contribute to the development of a critical path for energy system transformation. This may be driven by regulation and Government policy, but it is up to industry with appropriate leadership to devise, develop and agree approaches to delivery and the critical path to achieving energy system ambitions.

Finance



The routes for finance include:

- Publically funded or regulated subsidy schemes for home improvement and technology ownership (e.g. Energy Company Obligation, Feed in Tariff, Renewable Heat Incentive)
- Regulated price control mechanisms to stimulate asset investment for infrastructure integrity (e.g. RIIO ED1 and ED2)
- Private finance provision (e.g. low interest loans, home equity loans and green mortgages)
- Demand Side Response value (the realised financial value that is released into the system through reducing or shifting electricity use at peak times)

The role of Publically Funded Schemes

ECO as a stand-alone subsidy does not offer the level of stakeholder interaction appropriate for a co-ordinated market. Ideally, all subsidies and financial instruments would be channelled towards critical mass 'clustered' deployment and links to other energy related value drivers. Some commentators have suggested that ECO and energy suppliers generally are the wrong vehicle to address fuel poverty, and the recent BEIS *Call for Evidence: Building a Market for Energy Efficiency* has rightly identified that consumers do not recognise the wider value presented by energy efficiency measures, whether it is increased property value or impacts on fiscal measures such as council tax or stamp duty. An extension of this value in the case of heat pump technology is a reduction in energy demand when installing insulation that not only reduces the capital cost of the heat pump (because a smaller unit can be specified) but also begins to unlock the value of DSR . The benefits of using ECO to support the installation of multiple mutually beneficial measures has been explored, but with limited success. An ideal ECO framework would offer measures as part of a wider energy solution package.

The solution to improving ECO penetration – particularly in homes that are harder and more expensive to treat – is to find a design mechanism that channels funding towards available additional finance, links it to additional measures and helps to deliver flexibility. Such a move would also enable policy makers to extract more value from the Renewable Heat Incentive.

The BEIS view is that bringing DNOs into the ECO arena will be justified by the savings they can accrue from reduced loads and associated network costs, but we see this as a narrow ambition. If the future for electrification lies in the creation of Energy Service Providers that are likely to have a customer base below ECO's 250,000 customer threshold, there may be a void in ECO funding as consumers switch away from traditional energy supply channels. BEIS will need to identify the appropriate regulated mechanism to link a proportion of ECO obligations to DNOs which they can administer on a tradeable basis in support of contracted Energy Service Provider propositions.

The solution rests in the allocation of tradeable ECO obligations to DNOs, who could then leverage finance due to their substantial asset base to offer packages of measures that may be passed through the Energy Service Provider route. This links particularly well to the concept of dynamic network charging as proposed by the *Cost of Energy Review*, but we are mindful of the potential impacts on billing systems. DNOs may be better served by a hybrid network charging model negotiated at a business-to-business level and linked to the value assumptions made about DSR and reductions in load and demand. This brings ECO into the DNO business model but recognises the link to flexibility propositions and potentially makes it more acceptable to DNOs as it may help them to fulfil their DSO obligations.

Government will remain chained to the provision of Renewable Heat Incentives and Feed in Tariffs until the market restructures

itself to offer bundled and finance-backed services. Generation and renewable heat value is constrained by a one-dimensional approach to the flexibility mix. Generating and using energy more efficiently has its own intrinsic value for consumers, but incentives are calibrated to only focus on savings rather than the additional value of their flexibility characteristics. Before the next decade, the Government will need to encourage initiatives and a regulatory environment that will realise the potential of collaborative leadership-driven models to transform the market.

Housing-Related Fiscal Measures

The subject of fiscal measures for driving consumer demand has been well documented, with some private sector stimulus coming in the shape of green mortgages or Pay As You Save products. Government remains cool on the topic of using council tax and stamp duty charges as levers for consumer change, and even the latest Energy Efficiency Call for Evidence seeks to explore private sector initiatives attaching lower mortgage rates to the perceived link between cheaper energy bills and disposable income for mortgage payments. Perhaps this reflects a silo view of council tax and stamp duty, and the fact that one is a local tax whilst the other is a Treasury income stream. In 2013, the UK Green Building Council published its Retrofit Incentives report, making a strong case for reducing stamp duty and council tax for homes with lower EPCs, offsetting the income loss with higher rates of taxation for higher EPCs. The proposals were not adopted at the time as the Government still held high hopes for the Green Deal. These proposals should be revisited in a creative way that enables authorities to offset their reduced council tax income in high performing areas with an allowance of a 'top up' from the marginal higher stamp duty income from lower EPC scoring homes. This trade-off builds a bridge between national and local taxation, but successful budgeting and implementation will require a regional approach to defining council tax breaks based on average dwelling data and the levels of targeted aspiration for dwelling improvements, which will in turn impact on the Treasury spend from the stamp duty marginal.

Channelling Private Finance

The Each Home Counts finance stakeholders have identified that there are significant levels of private finance available to underpin the Repair, Maintenance and Improvement sector. Within the EHC framework, energy efficiency measures (for example heating, fabric and ventilation), renewables, storage technologies and connected homes solutions are all caught in scope and will be brought into relevant activities under pressure from finance providers who wish to de-risk their lending portfolios. The de-risking exercise will also need to align with a simplification of the channel to lending.

The answer to providing finance to consumers does not lie in the one-off loan or equivalent product route. Currently, finance provider representatives see the Each Home Counts Quality Mark as a safety net for de-risking investments and BEAMA agrees with the broad principle. Notwithstanding this protection, the prize is to be able to reach multiple consumers through a single channel which in itself can act as the risk holder and provider of suitable credit profiles to secure best rates of interest and offset payments against other sources of income. There are several options for this, but the most likely channel to market for finance and technology uptake will be either through an Energy Service Provider (with a shift away from pure energy retailer propositions) or with technology providers offering solutions directly to consumers or indirectly via an energy supply or services contract. The latter clearly has a closer link to other value drivers such as DSR.

DSR and the consumer

Higher levels of flexibility will provide major benefits by increasing the amount of renewable output that can be captured while also reducing the amount of firm generation needed to provide security of supply. Of the various forms of flexibility, DSR has a lot of potential but also high uncertainty over how much can be delivered; Imperial College's analysis of the CCC scenarios indicates a possible range of between 4 GW and 16 GW that could be delivered by DSR. More than other forms of flexibility, DSR depends on positive consumer engagement. BEIS research shows that the provision of static or dynamic tariffs do not in themselves stimulate much engagement from consumers, indicating that an indirect route needs to be considered in market design. Such an indirect route may be the bundling of DSR value within an energy service proposition that could involve provision of finance under-written technology (owned or leased), through which the Energy Service Provider extracts the value for itself but the consumer benefits from the DSR enabling technologies: the warmth and comfort of heat pumps and thermal storage, or the low running costs and low emissions associated with electric vehicles.

Appliances have increasingly smart capability and can be integrated into automated DSR responses in a variety of ways. They may be remotely managed by the networks operator or aggregator or driven locally by variable tariffs. Technology allows many options and various control infrastructures are being developed. What is needed is a clear market design that all participants can converge on and that also allows for a market evolution as improved technology emerges. Early versions of appliance management might involve smart sockets with a shift to smart appliances as confidence in the market develops. The Clean Growth Strategy seeks the delivery of 4.9 GW of DSR by 2032 to power electric vehicles, currently achievable with industrial DSR.

At a transmission level, there are likely to be more than enough balancing services available; this is demonstrated by the capacity market prices. Residential DSR is about mitigating the effects of local generation and increased electrification on the distribution network, but there is currently no mechanism for the value of this to be fed into the market. DSR requires a market framework with some agreed principles. A key challenge is measuring the change in customer demand. It may be economic and feasible to forecast a demand profile for an industrial site and compare this with the actual demand, but this is less feasible for domestic consumers, who clearly will not all wish to respond at times inconvenient to them. The responsibility for measuring the response can be passed to an aggregator, though it will face the same challenge when it passes on the income to individual customers.
One approach to this problem would make use of smart

metering and dynamic and nodal charging for customer energy and network access. Consumers could be offered a dynamic tariff and could choose how they respond. With this approach there is no need to measure the change in response as users would respond to price signals, most likely using smart home technology to automate the home management. Networks would have to accept a statistical, market response to their signals rather than a contracted, firm response.

Securing the right asset investment profile over time

The RIIO framework (Revenue = Incentives + Innovation + Outputs) is a regulated requirement under the price control mechanisms laid down by Ofgem to DNOs. It is split into two periods. The RIIO second period – ED2 (Electricity Distribution 2) – will leave network operators with a choice and the opportunity to chart a new course: to maintain the ED1 (Electricity Distribution 1) trajectory and approaches or to ramp up and combine with smart solutions to ensure a network fit for the changing consumer and a flexible energy system.

The *Cost of Energy Review* indicates that the RIIO E1 network allowances are forecast to be underspent by 10% and 9% for transmission and distribution respectively at the end of their eight-year durations. After three years the transmission underspend is 24%, with promises that the programmes are being back ended. For transmission and distribution much of the underspend is said to be because anticipated load growth did not materialise, but the distribution companies are also forecasting an underspend of £400m (7%) for maintenance and asset replacement, which is equal to the underspend on load growth.

To facilitate a more structured approach to spending, network operators will need a better understanding of where spend is required and of where new low-carbon technologies are being deployed or are organically proliferating, for example in new-build development or focused zones and roles for IDNOs and ICPs combined with technology deployment and incentives. Standardised offerings for smart vehicle charging management would allow interoperable technology to be deployed as standard and ensure that technology can be managed by exception, and to minimise disruption to the network. Reinforcement or other interventions should be rolled out at or ideally before the point at which the network is within a set percentage of its operational limits. Technology and new flexibility services such as DSR can go a long way to facilitating a smart system, but the way the reinforcement is installed and prioritised should be smart too.

Network Charging

Consumers pay for energy from generators and for the use of the networks to supply them that energy. Network charging covers the cost of the networks and funds the transmission and distribution activities. Distribution Network charges are determined for customer categories according to the Common Distribution Charging Model, which allocates charges to each customer group. In practice there are few signals from network charging that support flexibility, but, if well designed, network charging can provide powerful signals to customers and Energy Service Providers to reduce demand on the network at peak times or when the capacity of the system is constrained.

As we move to an electricity system with high levels of embedded generation and increasing loads, the charging regime must adapt to ensure that network costs are shared fairly between customers and that users of the networks are incentivised to behave efficiently and reduce the cost of their use of the network. To address this challenge, smart meters will provide much richer data, and network automation products will give DNOs much greater visibility of their network status.

The main options are:

Option	Advantages	Disadvantages
Capacity charging, or a hybrid combination of capacity and volume charging, for the residential sector	More cost reflective and able to drive efficient behaviour	Would incur significant cost to set up
Locational (nodal) network charging	More cost reflective and able to target efficient behaviour	Would be prone to a perception of unfairness with variation in energy costs within a single neighbourhood
Dynamic network charging	Responds to variable renewable generation output	Would incur significant cost to set up and require greater understanding of actual network costs
Flexibility Contracts	Cheaper to set up	Less cost reflective Potential for multiple fixed costs for each contract

Peer to Peer Energy

In this market, any energy consumer can choose to purchase their power from any generator who has power available at that moment. Recovery of network costs could be achieved by the generator factoring some additional (or reduced) cost or the network company providing a market for network capacity that the users can access. These peer to peer models could offer consumers increased choice, new opportunities and markets to participate in. They could allow users to realise the maximum value and benefit from installed technologies by selling to peers, to network operators or to both if capacity allows.

Building and Network Data

As the next generation of gas and electricity meters, smart meters are a vital upgrade to Great Britain's energy network. They will bring significant benefits; very few of the innovations discussed in this paper would be possible without them. Meters will provide consumers with near real-time energy data, expressed as kWh and as pounds and pence. Electricity will be measured every 10 seconds; gas readings will be half-hourly. Consumers will read this data via a Consumer Access Device (CAD), which may be a logical application on a computer, tablet or phone, or a physical in-home display (IHD) or both. The CAD will store this data for 13 months, allowing for seasonal comparisons and analysis.

Consumer access to near real-time energy data will drive significant behavioural change, giving consumers more control over how they use energy and empowering them to make better choices.

Outside of the building, the data will not be readily available at the same granularity. Network operators will have access to half-hourly data only if they meet the requirements of the Data Communications Company (DCC) and only if the consumer actively elects to allow her or his data to be shared. Otherwise the network operator will have access only to a daily meter reading. Thus, most data will be historic and will be useful primarily for comparative purposes, for example to influence capacity planning. Nevertheless, this daily reading will drive important new initiatives in energy efficiency, including enabling comparisons within and between property types and facilitating complex energy advice services that will help consumers and networks to use energy more efficiently and make decisions better suited to each property.

BEAMA is collaborating across the industry to support a data warehouse of information about buildings in Great Britain that will inform the decisions of property owners and, possibly, network operators and Energy Service Providers to maximise the benefits of smart data in the interests of energy efficiency and energy management. The current intention is for the design, implementation and operation to be provided by the Each Home Counts framework.

Half-hourly data will support efforts to optimise the energy in the network, but it is not yet clear how much of this will be available. The benefits of half-hourly data and, hypothetically, 10-second readings will be significantly greater than those likely to flow from daily data readings, so an ideal future energy system would involve a mechanism to maximise the number of consumers who allow their half-hourly data to be shared and then look to ways of allowing networks to access even more granular data.

This could be done with a consumer-based model that incentivises consumers to share their half-hourly or real-time data with network operators in a way that facilitates better system management. This extra resolution of smart data would depend on new aggregation services that package the data in a way that can inform price signals.

One challenge in such a scenario would be to aggregate data in a way that protects consumers' privacy but does not unduly constrain the value of the data. In any case, the optimal resolution of this data may not be house by house; some aggregation will be required not only to anonymise the data but also to aggregate it to a level that the network operator will find manageable. The mechanisms for incentivising consumers to share this data, at whatever resolution, have not yet been fully explored. Energy Service Providers and network operators will need to work together to ensure that consumers understand how the data will be managed and how they would benefit from sharing it.

One solution may be found in the move away from a straight utility models of energy supply to a market in which energy retailers diversify their consumer offerings with bundled additional services that rely on the sharing of such data.

AS THESE NEW MORE COMPLEX BUSINESS MODELS EMERGE, CONSUMERS MAY BEGIN TO REALISE FIRST-HAND THE BENEFITS OF REAL-TIME SMART DATA AT NETWORK LEVEL AND ENGAGE MORE WITH THE SMART AND FLEXIBLE SYSTEM.

POLICY AND REGULATORY ENVIRONMENT

Building Regulations

Building Regulations are a powerful enabling tool for effecting change in UK housing stock. Our market transformation to electrification is highly dependent on some early and ambitious regulations to either require that certain technologies be installed or at least make homes 'ready' for the switch to electrification. There are many options that can facilitate the shift to a flexible energy system in both the short and medium term. These could be national regulations that are tailored and managed regionally to suit local conditions and strategic energy plans. Our minimum recommendations for regulation requirements are set out below.

Recommendations – New Buildings

All new single unit dwellings (not multi-residential) off the gas distribution network to utilise heat pump technology with minimum volume thermal hot water storage for DSR unless they have access to an existing low-carbon heat network

All new dwellings to include a minimum IHD, CAD or Home Energy Management specification regardless of fuel availability.

All new dwellings on the gas distribution network to have a minimum hot water volume thermal storage for DSR capability in the longer term and regardless of the boiler specified (for example, combi boilers can have integrated or separate minimum volume storage capability)

All new multi-residential dwellings off the gas distribution network to utilise either a low-carbon heat network or unitary electric heating with minimum volume thermal storage (either heat or hot water) for DSR

All new dwellings on the gas distribution network to use a common flow temperature specification for low temperature heat distribution

The incorporation of a Domestic Electrical Centre (specification to be developed by BEAMA and relevant stakeholders) built around the consumer unit to cope with the shift to electrification technologies in both new and existing buildings.

Recommendations – Existing Buildings

The electrification of existing dwellings presents even more complex challenges. These relate to the suitability of existing heat distribution infrastructure and insulation levels for heat pumps or electric heating. However, there are at least three ways of reducing the carbon footprint and increasing the energy flexibility capability of existing housing stock.

Require a minimum volume thermal hot water store for dwellings with two sanitary bathing outlets to enable DSR

Require fuel-determined minimum energy label rating levels to be achieved when replacing heating appliances (except for electric heating, which is not covered by an energy label)

Require SETS capability in all replacement electric storage heaters.

Energy Market Regulation

Both the *Cost of Energy Review* and the *ReShaping Regulation* report set out radical proposals for future energy regulation and reflect a widespread view that the existing regulatory model is poorly suited to delivering the industry changes needed by 2030. Innovation needs strong regulatory drivers or, as proposed by the *Cost of Energy Review*, a switch to market mechanisms. The capacity market, Offshore Transmission Owner (OFTO) and the latest Contracts for Difference prices show that allowing industry to compete for business is a powerful driver for innovation and lower costs. As pressure grows on energy bills we can expect an increasing use of auctions. And as the role of DSOs evolves, there will be a tension between establishing the DSO as an independent body (the publicly owned Regional System Operator (RSO), as proposed in the *Cost of Energy Review*) that facilitates a market for network services and a model that seeks to use the DNOs' financial power and access to consumers to deliver policy goals such as residential energy efficiency. It is unlikely that either extreme – a pure market or a monopoly DSO – will be acceptable, and a solution somewhere between them is likely. In the interests of opening the market to new players, a key enabler for the introduction of new Energy Service Providers and products will be a requirement for the DNOs to reveal their costs so that other parties can use areas of high costs as the basis for new businesses and services. Smart grid technologies and the smart metering rollout will be providing much richer data sets to allow the DNOs to understand the condition and costs of their networks. Ensuring that regulation can keep pace with innovation and adapt to the rate of change that energy system transformation will entail is a key consideration.

ELECTRIFICATION BY DESIGN: SUCCESS LIES IN REGIONAL STRUCTURES

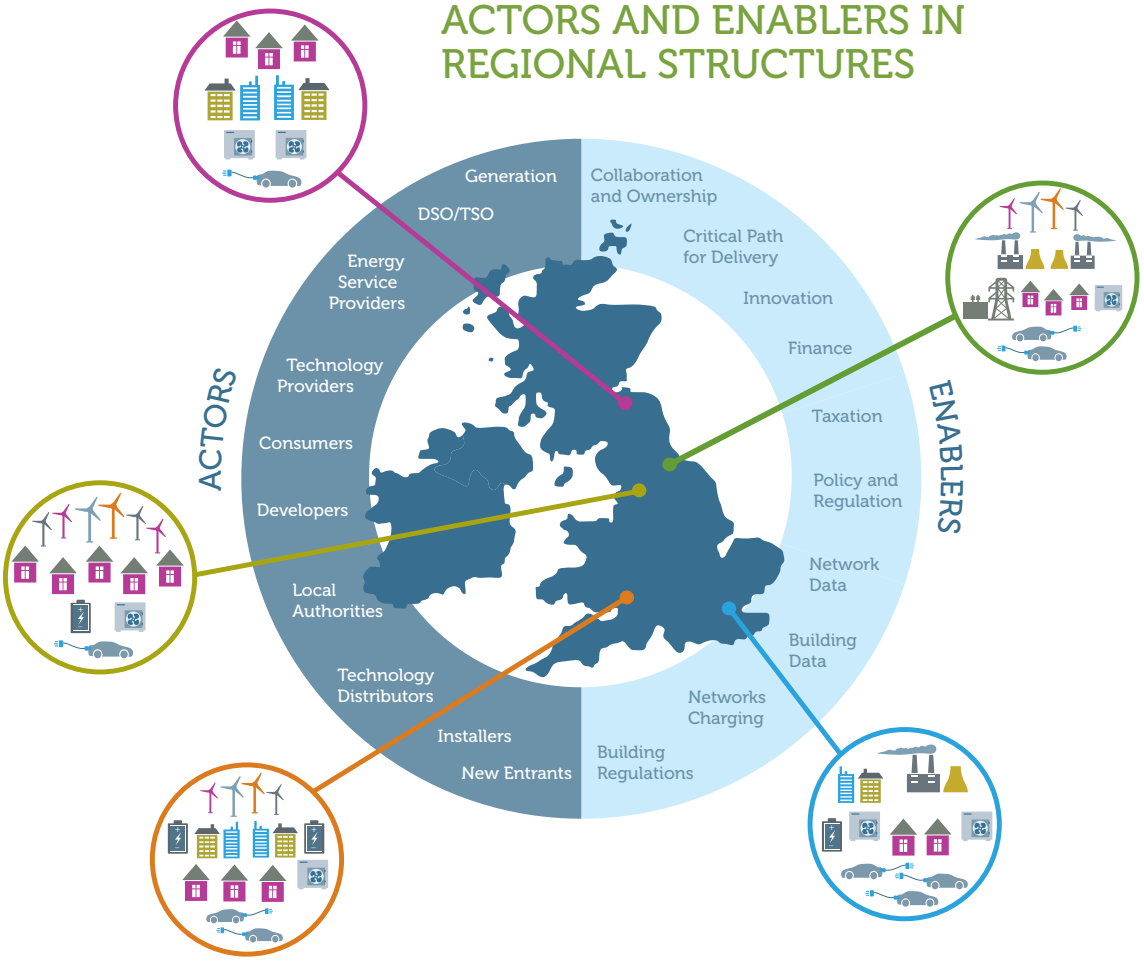
Many of the essential ingredients for encouraging the electrification of heat and transport for consumers already exist. There are price control structures for asset investment, incentives and subsidy schemes, a building regulations framework, wholly or partially mature technologies that carry one or all of energy efficiency, carbon abatement, demand response, improved air quality benefits, and an enabling smart metering programme. What is missing is the catalyst for making them all work together, along with an acknowledgment of the barriers to serious progress towards a decarbonised future. That catalyst must achieve:

- a level of targeted ambition that is not dependent on a 'scatter-gun' approach
- appropriate bundling of finance and investment instruments that can accelerate technology rollout and capitalise on the fact that there are firm links between the value of energy efficiency, flexibility drivers such as DSR, and asset planning and investment
- associated co-ordination of market enablers through collaboration between the technology supply chain, energy service providers, network operators, finance providers and local authorities
- capacity building for the supply chain linked to zonal planning and deployment targets and an associated skills development programme
- advice about energy measures and services that best reflect the needs of a designated zone based on building stock, available fuels, energy system infrastructure planning and finance availability to help equip dwellings with the necessary technology
- a planning and regulatory enforcement regime that satisfies a methodology for designing an appropriate energy zone (for new and existing buildings)

This is not a small challenge, and it strays beyond the national policy, regulatory and institutional structures we have today. The challenge requires a level of market design through collaborative working that is regional in nature. In 2013, BEAMA first published a brief paper promoting the benefits of pursuing a zone approach to promote heat pumps. Now, in 2017, we further endorse this approach but this time acknowledge the role that can be played by energy storage in networks and buildings, connected homes solutions and EVs.

A well-considered and sustainable approach to electrification could be found by considering a zone as analogous to a micro grid, with the ability to determine its own supply and demand constraints and ensure that the correct balance of flexibility enabling technology is specified.

ACTORS AND ENABLERS IN REGIONAL STRUCTURES



BEAMA has identified three options for achieving the zonal methodology:

Regulated Regional Energy Authorities

Providing oversight and strategic leadership for collaboration between the range of actors within the clustered zone, the Authority would be a new addition to what is already a crowded yet fragmented energy market. Operating with a slim governance structure ('slim' because of its reliance on the commercial power and active engagement of others), the Authority would promote a strong focus across a range of aligned regional issues including infrastructure planning, energy, transport and housing. Designated Authorities would take their powers from a sub-regulated environment and map across either the regional authority or the DNO regions, though the latter may be too large. Overall success would be dependent on strong local authority links and their direct influence on regional issues.

Positive	Negative
The Authority drives action by its regulatory status	Resource sensitive and reliant on external funding
Can pick up competition remit within a sub-regulated structure	Energy market already crowded
Allows a better managed approach to fiscal measure trade-offs. e.g. stamp duty and council tax	Could be some confusion over remit compared to 'Combined Authorities'
Trusted status to manage essential data for long-term strategic planning built on shorter-term consumer service propositions	Public negativity towards growth in public sector structures
Regulatory status provides a channel for public finance resource	

Government Funded Regional Partnerships Driven by Lead Local Authorities

Operating with a similar strategic leadership remit to the regulated regional energy authorities, Government-funded regional partnerships could provide the same focus by working with existing bodies under a 'lead authority' board. Funding could be sourced from existing infrastructure and construction initiatives but used to leverage additional private sector investment within a collaborative model.

The 'Combined Authority' model already exists, enabled by the Local Democracy, Economic Development & Construction Act 2009, and could be the basis for a structured approach if CA status is dependent on delivering energy zone targets and delivery plans. The Government's Home Energy Conservation Act 1995 has inspired a number of successful lead authority energy efficiency initiatives, showcasing local authority capability to deliver activity, but constrained funding and limited human resource can be an issue.

Positive	Negative
Local authority models have proven successful	Resources are constrained
Local authorities offer 'trusted status' for consumer advice, data handling	Not all local authorities have the required vision and capability
Initiatives managed by lead authorities can factor in regionally devolved stamp duty and council tax	Only England and Wales are covered by Combined Authorities

Independently Funded Regional Partnerships

BEAMA's original 2013 zone methodology discussion paper set out a less formal, self-funded model that relied on initial funding from re-patriated energy market fines. Potential regional partnerships would bid for this funding based on the framework of planned activity defined with collaborative partners for delivery within a pre-defined timescale. The ongoing sustainable funding would come from levies applied to commercial transactions within the business-to-business environment. Whilst such a model can work in practice, it lacks the formal regulated or authority-linked status required for success, and the allocation of such initial funding would in itself require a body to be created unless it were a function of central Government or the Regulator. Success would also depend on the involvement of a lead party that could pull together a broad range of partners, including the all-important lead authority.

Positive	Negative
Initiatives driven purely by the private sector can result in partnership-driven propositions for consumers	Could not rely on the ability to employ innovative approaches to fiscal measures (e.g. stamp duty and council tax)
Less reliance a Government funding and industry driven	Funding by no means certain and levy approach may be unpopular with technology supply chain
	Trusted advice and data sourcing success is dependent on strength and influence of external partnerships

These structural changes required to deliver a functional and focused market place for electrification absolutely meet the requirements of the Government's Industrial Strategy. The Strategy is very clear that a whole systems approach is required, and to achieve this you need all the actors and enablers working together under a common framework. Businesses that will innovate and work collaboratively to deliver our low carbon vision require a direction of travel and a reliable and stable environment within which to operate.

> Many of our stakeholders have called on us to take a 'whole systems approach' to the decarbonisation of energy infrastructure systems. We agree with this principle, and will position the UK as a leader in clean and efficient power, transport and heat through an integrated approach to decarbonising these increasingly connected systems. We aim to implement our Smart Systems and Flexibility Plan in full by 2022, enabling the electricity system to work more flexibly and efficiently. The zero emission road transport strategy, to be published in the coming months, and work on the options for the long-term decarbonisation of heating will build on this. They will support the growth of markets for technologies that create synergies between systems, such as energy storage, smart meters, vehicle-to-grid charging and heat networks.
>
> Industrial Strategy: Building a Britain for the future

Our regional vision laid out here goes beyond the current Local Enterprise Partnerships network scope, although we believe the LEPs network can seamlessly work with a regional structure that is focused entirely on energy systems. The associated benefits of enterprise growth and skills development work hand in hand with a strategic vision matched by ambitious plans that bring private sector organisations together with some leverage to public sector support in the shape of regulatory enforcement, planning, relevant incentives and a trusted platform for data sharing and consumer engagement.

CONCLUSION

Our electric future is full of challenges and opportunities. To maintain pace with technological developments and changing consumer behaviour, the energy system will need to change at a rate not seen for many decades. In this paper we identified six market design imperatives in addition to a number of other market, industry and sectoral recommendations.

1. Electrification is a national need, but optimised, flexible energy systems will be delivered by regions and zones empowered to identify the most appropriate paths.

2. Integrated and innovative finance packages are essential for market transformation.

3. The supply chain must have sufficient capacity to promote sustainable growth.

4. Consumers need confidence that services, systems and devices form part of a structured consumer journey. We need to navigate a critical path to electrification and decarbonisation.

5. DSR needs concurrent and planned development of regulation, technology and markets.

6. New and innovative ways of purchasing and providing energy services will emerge.

The new market functions and principles that are discussed in the paper are not wholly owned by one sector or organisation, and value and opportunity are embedded for a cross section of market participants. Industry needs to work together with critical actors and establish delivery routes and ownership to identify and extract the value of system flexibility.

We propose new roles and functions for energy retailers, device manufacturers, network operators, service providers and consumers. With appropriate regulation, incentives, engagement and market design the critical actors can creatively package the enablers to deliver the optimised flexible energy system.

BEAMA is committed to help deliver our new energy system and welcomes the opportunity to work with policymakers and other stakeholders on the journey to an electrified, low-carbon economy. We will continue to work with the Energy Systems Catapult to organise and host relevant seminars and workshops aimed at informing policy and facilitating relationship building across the industry.

RECOMMENDATIONS

The building-based flexible energy system mix

Engage consumers in energy efficiency, demand response and behavioural change; but the first priority is the energy efficiency of buildings

Simplify behavioural change by empowering providers to deliver packages of services based on agreed permissions and intelligent automation

Planning a system around the 'passive' consumer

Empower consumers to participate in the flexible energy system mix but ensure that benefits flow to all

Provide appropriate and full mix advice through local authorities and trusted channels

Bundle financed technology solutions with tariff propositions that help consumers to be energy efficient whilst accessing flexibility

Plan for a future where we pay for a service to match our needs rather than a silo energy contract

Electric heating

Make coherent policies that work together to promote electrification (e.g. RHI and ECO)

Target off gas areas with appropriate building regulations and SAP 10

Provide scrutiny over DNOs to ensure network connections are encouraged

Transport

Implement a mix of smart solutions such as managed charging, reinforcement and infrastructure upgrades to facilitate consumer uptake of EVs

Future proof the house building programme

Energy Storage

Focus on the value of intelligent control and enable platforms that support interoperable services, systems and devices

Keep the market open to new entrants to expand the range of service propositions to consumers

Smart and Connected Homes

Give consumers reasons to use and share their energy data to inform big decisions about energy efficiency and network management

Make smart devices, systems and services interoper able so consumers are free to follow a diverse and bespoke 'smart journey' that suits their individual needs

Agree a UK approach to the Smart Readiness Indicator for building regulations

The Critical 'Actors' and 'Enablers'

Responsible authorities should support DSOs to facilitate open and accessible markets

Collaborate across the industry to facilitate market transformation; ownership and responsibility should reside with those most able to deliver the change required

Link subsidies and financial instruments to other value drivers so funds are channelled towards critical mass 'clustered' deployment

De-risk and simplify finance and make engagement more straightforward

Design markets so that all participants can engage with price signals and allow for market evolution as improved technology emerges

Design network charging to provide signals to customers and Energy Service Providers to reduce demand on the network at peak times or when the capacity of the system is constrained

Deliver frameworks to enable networks to access even more granular data while protecting consumers' privacy

Using building regulations to accelerate change and future proof buildings

Require DNOs to understand and reveal their costs and constraints so that other parties can use areas of high costs as the basis for new businesses and services

Electrification by Design: success lies in regional structures

Select a suitable governance option for regional zones based on deployment targets as a key criteria for success

Bundle financial and investment instruments that can accelerate technology rollout and capitalise on the links between the value of energy efficiency and flexibility drivers

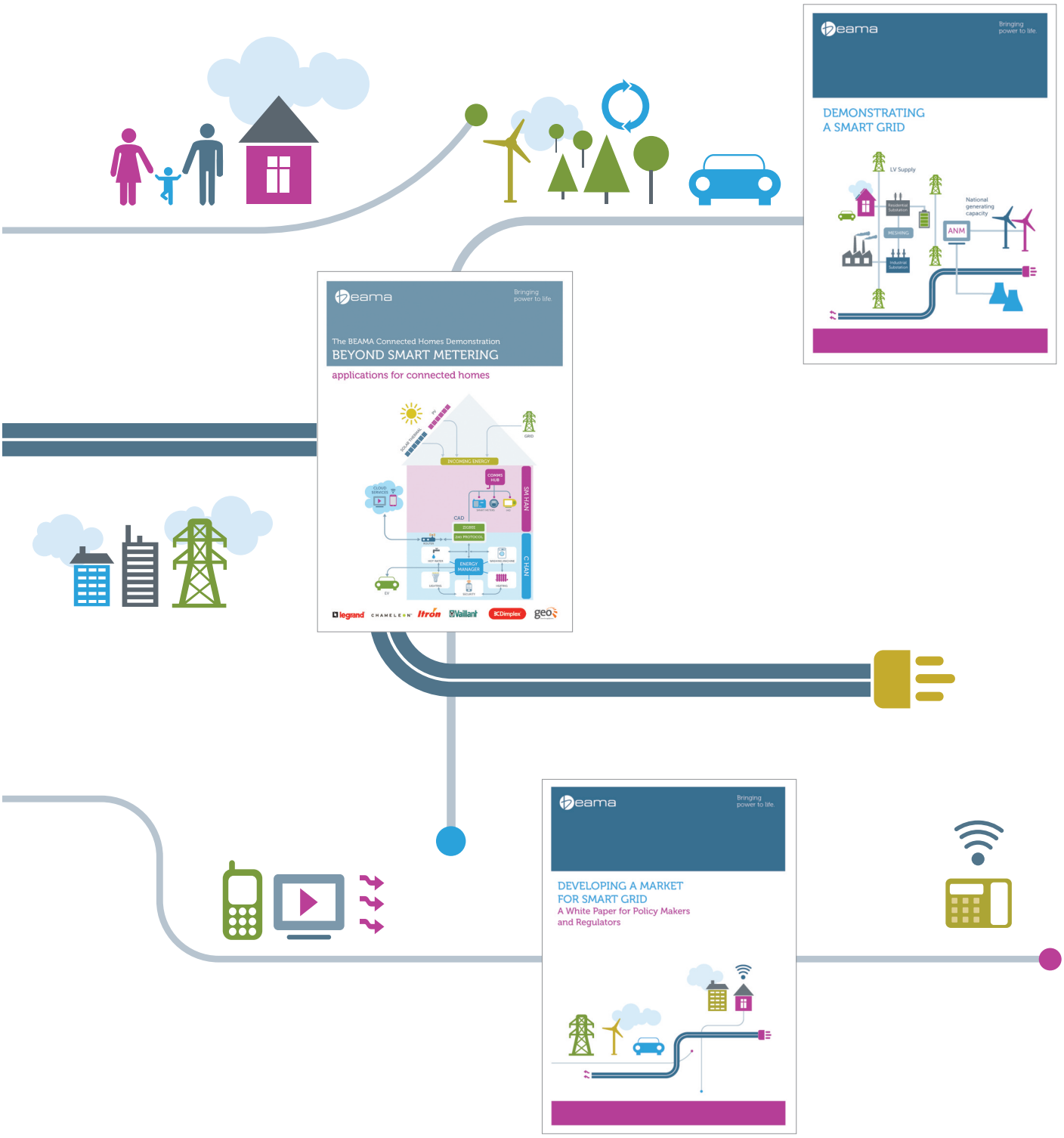
Build the capacity of the supply chain by supporting regional structures and deployment targets

Regulate and plan in the way most appropriate to each energy zone (e.g. local sub-regulatory approach)

Co-locate storage, generation and charging at key large charging locations

These are recommendation highlights. Further recommendations are featured throughout the report.

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



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