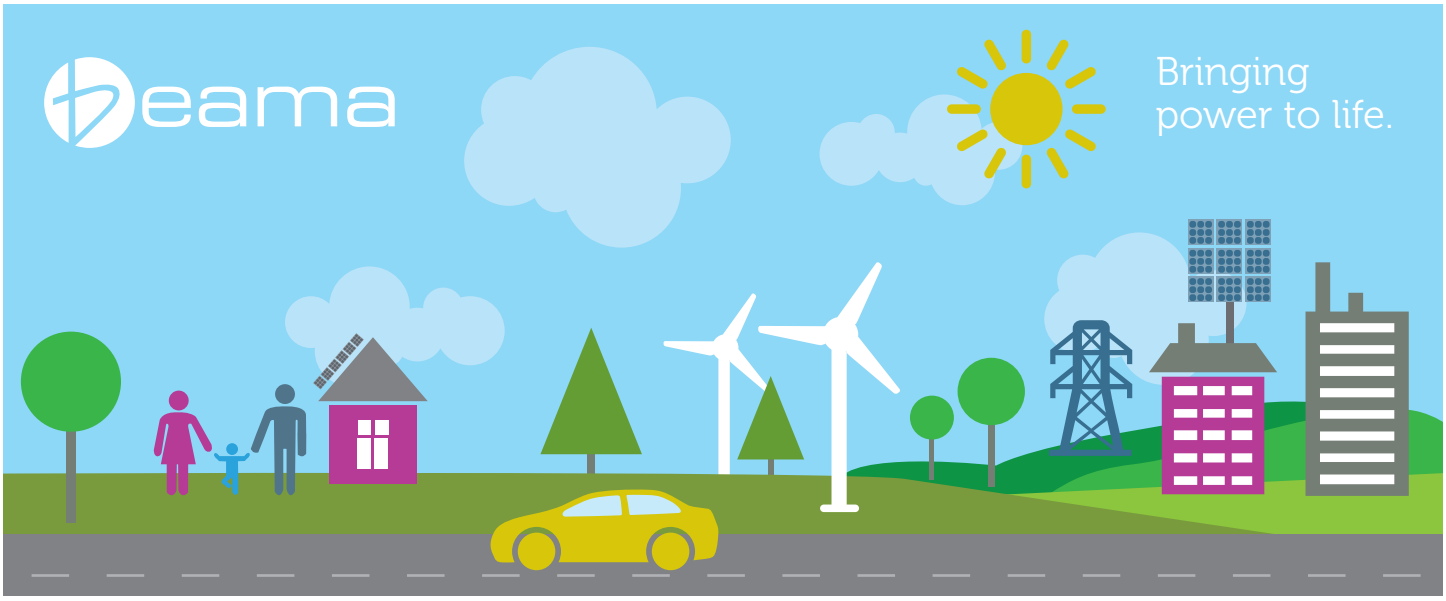
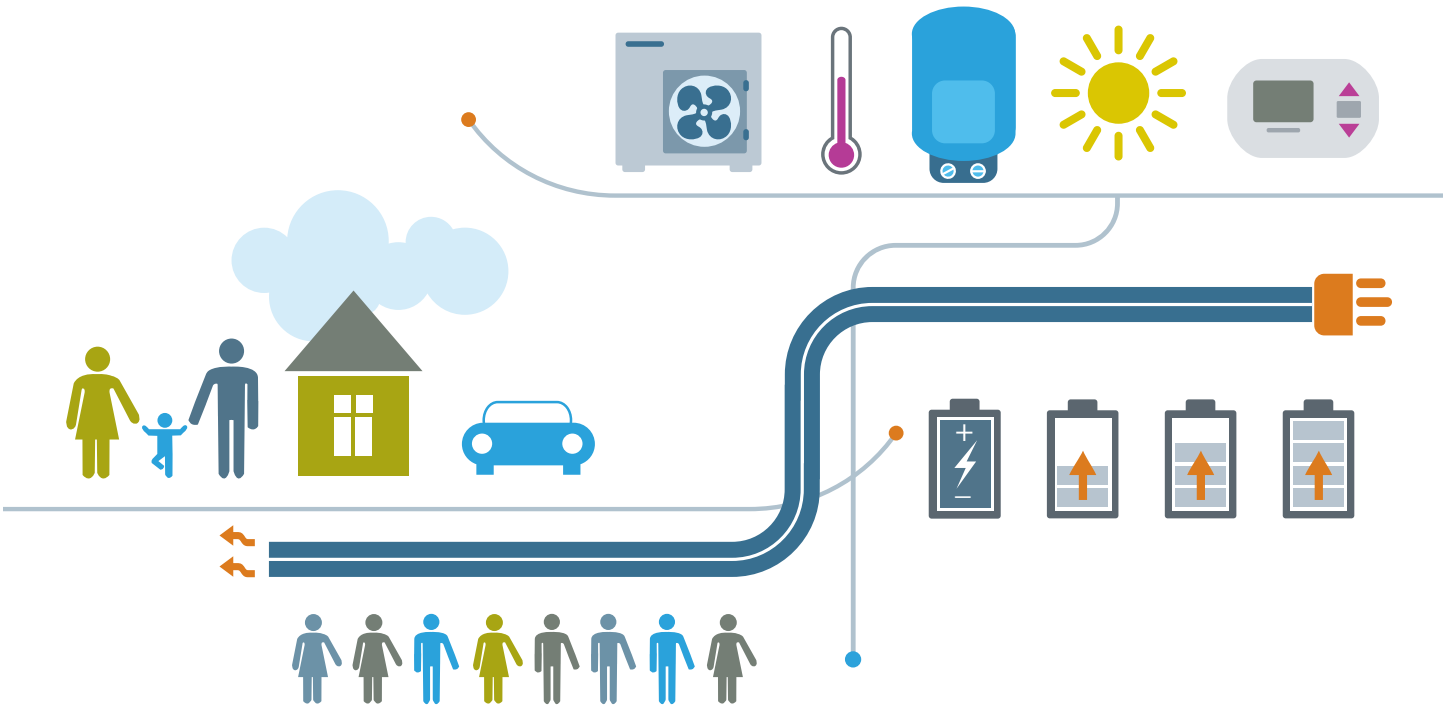


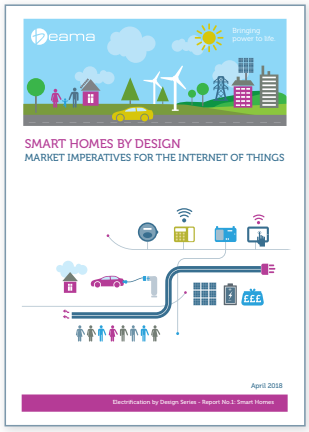
HEAT ELECTRIFICATION BY DESIGN

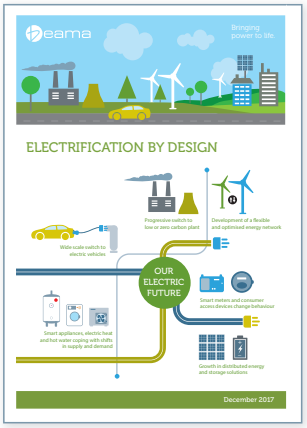


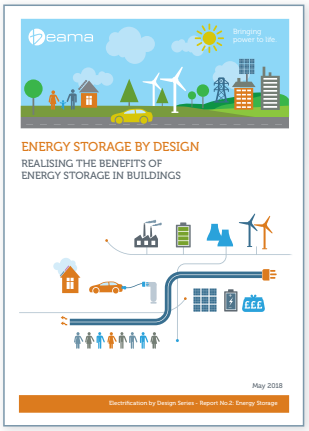
June 2018

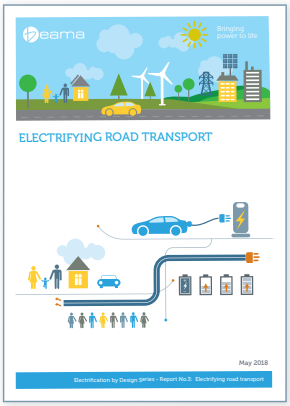
BEAMA Electrification by Design Series

In December 2017 BEAMA published Electrification by Design, exploring simple policy and market mechanisms to promote deployment of low-carbon electric systems. In it we identify critical enablers of a flexible and efficient low-carbon energy system. These include consumer engagement with energy use, energy storage, transport and automated demand-side energy management in buildings. We also made recommendations for how government, industry, consumers and other stakeholders can work together to enable and maintain the market for smart products and maximise benefits to the consumer and to the electricity transmission and distribution networks. This report provides more context to BEAMA's view of Heat Electrification, what these shared benefits could be and how to realise them.









CONTENTS

INTRODUCTION

Having a balanced offering of low to zero carbon fuel sources and methods of heat generation is possibly the most significant challenge we face in the drive to decarbonisation and clean growth. Heating our homes and business premises contributes around a third of UK carbon emissions, and if we focus on residential heat alone, over 80% of energy consumption is spent on space heating and hot water services[1].

Since the publication of the energy white paper, *Meeting the Energy Challenge (2007)*, there have been numerable policies and initiatives to promote the growth of renewable heat technologies and heat networks. Support for heat electrification and growth in heat networks remains strong as we approach 2020, but successful market transformation across the EU has been built on decades of consistent Government strategy, resulting in private sector investment and targeted promotion to deliver growth[2].

The challenge for Government and the supply chain is complex. The rapidly decarbonising nature of electricity generation paves the way for electrification of heat and transport, and in turn we are using levers to encourage network infrastructure investment to accommodate the necessary large-scale switch to electrification of the system. The smart meter roll-out is bringing a new generation of connectivity for buildings including grid interaction to optimise the production and use of energy and the network. And finally, there is a swinging tide towards regional and localised strategies for energy that can incorporate the essential consistency and public/private sector collaboration that has delivered well in other EU member states.

The only proven route for heat decarbonisation in the lead up to 2030 is electrification and investment in heat networks in suitable areas. Heat pumps and intelligent storage products have been successfully installed in the UK and around the EU, with market growth built on consistent policy, a push for quality and sustainable supply chain development built on private sector confidence and growing consumer demand. Investment into the potential for biofuels and hydrogen gas may change the picture beyond 2030 but we need to act now to promote growth in heat pumps and heat storage technologies to seriously address heat decarbonisation, along with keeping pace with the roll out of electric vehicles and connected homes solutions which are shaping the residential energy services market.

Heat is about people and places, but we must ensure policies and market frameworks are structured to co-exist and complement each other to support well targeted solutions that consider the relevant housing stock and incumbent fuels. Government needs to take industry with it on the journey in a way it has not mastered so far: Private sector market development activity in areas such as skills and capacity building in the supply chain along with active promotion of electrification solutions depends on private sector confidence and a functioning value chain from generation to end user. With the right level of long term commitment and the creation of a workable framework for targeted Heat Electrification, the private sector will deliver the required results.

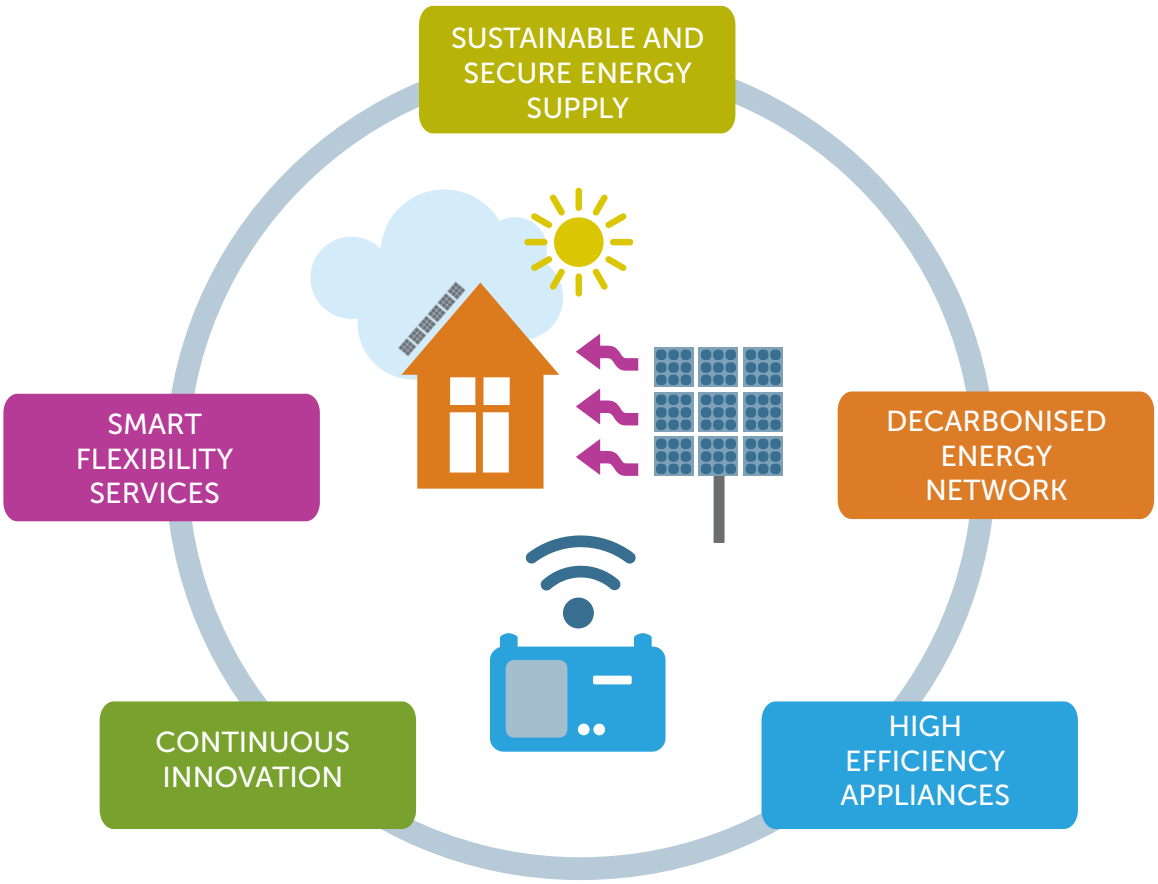
This paper looks at the heat electrification challenge; avoiding the presentation of a panacea but rather focusing on current technologies and the barriers and opportunities to deliver the 2030 target for heat decarbonisation.

[1] Energy Consumption in the UK – data tables (2017)
[2] European Heat Pump Association – Outlook (2017)

THE KEY TECHNOLOGIES FOR HEAT ELECTRIFICATION

The take up of heat electrification technologies brings together a range of energy system benefits which mirror technology characteristics that define the basis of an end to end smart grid.

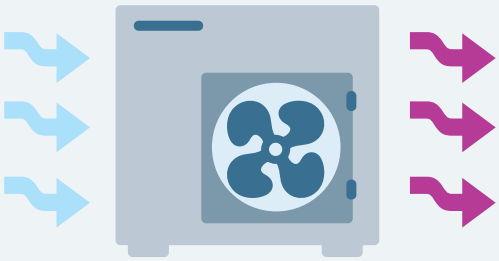
The compliment of technologies for heat electrification provide a mix of heating and hot water services. Each brings its own discrete emphasis to any one or more of the benefits above but all share a common core principle... they all enable a store of heat that can mitigate imports of energy at times of high demand, and therefore high prices.



A word on heat storage

Heat storage solutions offer flexibility to the consumer and the network. There are a range of commercially viable products that suit differing consumer needs, buildings and system applications. Depending on the specific technology and application, heat stores in buildings work by capturing thermal energy from hot water heating, on-site renewable energy generation, or waste heat. This stored energy can then be used later at a time of the consumer's choosing. Heat stores can help balance demand across the day by converting surplus, cheaper or lower carbon energy to heat and storing it. Storing heat in buildings in this way can help consumers to avoid drawing on the grid at peak heating times. This complements other forms of energy storage (such as batteries) to make best use of available generation and capacity in the smart and flexible home energy system.

HEAT PUMPS



Heat pumps use a reverse refrigeration cycle to generate heat, drawing in low temperature ambient heat from the ground, air or water and turning it into high temperature heat. A heat pump's efficiency is expressed as a seasonal performance factor (SPF). If an SPF of 3 is claimed, this means a single unit of electricity used by the heat pump can generate 3 units of heat. This high efficiency is important when considering the reduced peak power demand required to deliver peak heat demand.

Likely installation scenario: Alternative low carbon heat solution for off gas dwellings up to 2030. New build specification. District heating scale applications.

Benefits: More efficient than boilers leading to reduced energy bills. Increasingly low carbon. Flexibility potential through hot water storage lead demand side management. Can work alongside other technologies e.g. existing boilers, heat interface units.

Key market barriers: Lack of customer awareness. Higher up-front technology cost than 'one off' boiler equivalents. Better performance in well insulated homes. Low installer capacity. Lack of clear marketing and supply route to the end user. Requires careful heat system design. Limited smart tariffs or innovative service packages. Network upgrade costs in some instances can push a project outside of feasibility.

CASE STUDY

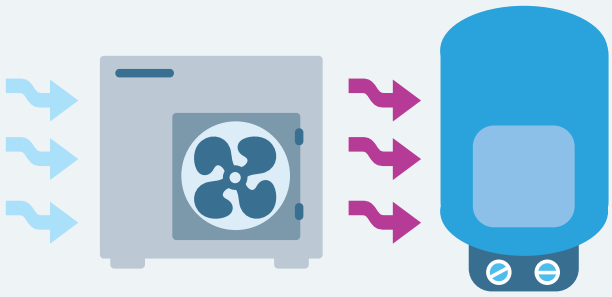
NIBE: Hallam House, Dumfries

A communal Ground Source Heat Pump project, Hallam House demonstrates the value of partnership and collaboration. The project was joint funded by Scottish Government's Affordable Housing Supply Programme and Dumfries & Galloway Council along with private finance from housing association, Loreburn Housing. Additional energy efficiency measures were funded through a £25,000 injection from the local authority and advice support was provided by The Energy Agency.

The new build housing development with 5 purpose built supported-housing properties was the first communal ground source project undertaken by Loreburn, although the association had used NIBE heat pumps previously.

The project involved installing a 24kW NIBE F1345 Ground Source Heat Pump, linked to an individual room controlled underfloor heating system for consistent space heating. Heat is harnessed from boreholes on site and the heat pump meets 100% of Hallam Houses's annual space heating demand of 54,283kWh. The system has a 7 year warranty and is eligible for ongoing payments under the Government's Renewable Heat Incentive (RHI).

HYBRID SYSTEMS



Using heat pump technology as mentioned above, a hybrid solution is either an integrated heat pump with boiler in a single box, or a separate heat pump and boiler operating bivalently i.e. simultaneously. Typically, the heat pump will supply the heat whilst supplementing the production of higher temperature hot water with the boiler.

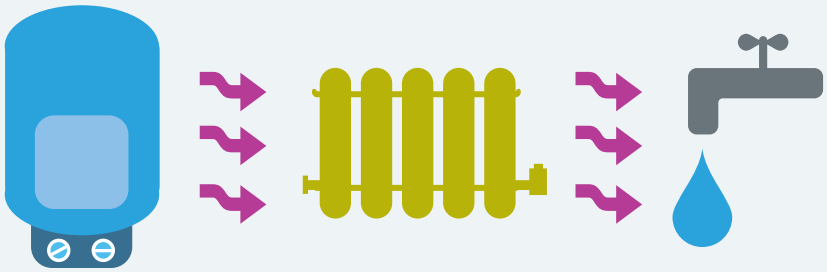
Likely installation scenario: Low carbon heat supplement for existing gas or off gas homes. Larger buildings with high heat demand where reduced heat pump capacity is required to avoid network reinforcement or upgrade to a three phase connection.

Benefits: Energy efficient heat system. Increasingly low carbon supplement to a boiler. Flexibility potential through hot water storage if system set correctly. Reduced costs compared to full heat pump system.

Key market barriers: Lack of customer awareness. Low installer capacity. Lack of clear supply route to the end user. Requires careful system design and optimisation for flexibility.

SMART ELECTRIC THERMAL STORAGE

Smart Electric Thermal Storage (SETS) is the new generation of electric storage heating. A SETS system offers decentralised heating, hot water and energy storage, often cheaper than through traditional heat storage options and with up to 20% efficiency gains. SETS systems also bring sizeable storage functionality to networks, enabling the storage of heat generated from renewable electricity at times of high supply and low demand and providing load control for the system operator at distribution level. SETS systems consist of electric space heating radiators, an insulated thermal mass, and a hot water cylinder.



Likely installation scenario: Existing electric storage heater system upgrade with a potential for 90,000-120,000 homes per year. New build specification.

Benefits: Flexibility potential through demand side management. Lower energy bills compared to older storage systems.

Key market barriers: Without awareness and subsidy, customers may choose to switch to alternative solutions which are more expensive to run and do not offer flexibility. Availability of smart tariffs or innovative service packages.

CASE STUDY

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

The Glen Dimplex Quantum SETS space and water heating system has been designed to prioritise the consumer over the network so that there is no impact on the end user when the appliances are used for demand side management or grid-balancing purposes. As part of the NINES project Quantum systems were installed in 223 Hjatland Housing Association properties on the Shetland Islands. Using these appliances to move from tele-switching to demand side management has reduced the maximum possible load from these houses during the periods of historical maximum peaks from 0.6-0.7MW to just over 0.1 MW, if the devices are following the prescribed schedule. Changing the fixed and default schedule timing, as well as the capability for flexible scheduling, contribute to this.[3]

The NINES project has also demonstrated that using flexible demand appliances such as Quantum can increase the total system demand when this is wanted, such as during periods of surplus wind generation. When heating elements were fully charging in all 223 homes, the total maximum connectable wind generation could be increased by 212 kW. Frequency responsive demand (with the current settings) could also be used to maintain the frequency stability of the system within set limits. When heating elements were fully charging in these 223 homes, the total maximum connectable wind generation could be increased by 1.36MW, which is about six times greater than what can be achieved with demand side management only.[4]

3 NINES DSM Network Benefits Report, p. 4 http://www.ninessmartgrid.co.uk/wp-content/uploads/2017/12/1C-NINES-DSM-Network-Benefits-Report.pdf
4 NINES Knowledge and Learning Report (2017), p. 9 http://www.ninessmartgrid.co.uk/wp-content/uploads/2017/12/7A-NINES-Knowledge-and-Learning-Report.pdf

THERMAL STORES AND HEAT BATTERIES

The majority of energy used in the home is for heat and hot water. Heat batteries provide consumers with compact, scalable, cost effective, low carbon solutions to space heating and hot water. Heat batteries can be charged using a variety of energy sources. They can offset peak energy costs by charging the store using cheaper off- peak electricity (such as the current Economy 7 tariff) or diverting energy from PV, heat pumps or other low carbon sources. Once charged, the heat can be released instantly when needed, delivering hot water and space heating during peak times[5].

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

Likely installation scenario: Existing heating system upgrade. New build specification. Part of an integrated on-board renewable energy solution.

Benefits: Lower energy bills. Decarbonisation. Flexibility potential through demand side management.

Key market barriers: Lack of customer awareness. Low installer capacity. Lack of clear marketing and supply route to the end user.

CASE STUDY

Sunamp – EastHeat Retrofit Social Housing Project

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

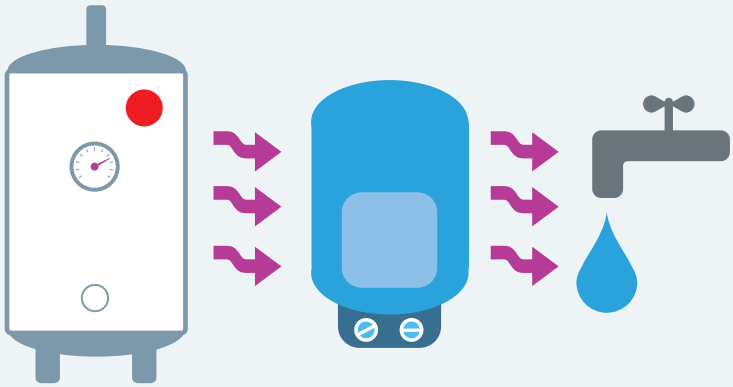
Component 1: Funded PV on the Roof:

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

Component 2: Thermal Energy Storage in the Home

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

[5] Sunamp – Heating your Home and Hot Water (2018)



ELECTRIC HOT WATER STORAGE

A hot water storage heater consists of a cylinder, an immersion for boost and a heat generation coil fed by a primary heat appliance such as a heat pump or a boiler. The immersion could supply more than a boost function if there is available low cost and/or low carbon supply, either from the grid or a local PV system. Electric hot water storage systems can respond to available grid supply renewable energy via a smart tariff and meter.

Likely installation scenario: Existing heating system upgrade. New build specification. As part of an integrated on-board renewable solution.

Benefits: Flexibility potential through demand side management.

Key market barriers: The growth in combination boiler sales has dramatically reduced cylinder use and necessary space for retrofit options. Associated installer apathy to hot water storage in favour of combination boilers. Limited smart tariffs or innovative service packages.

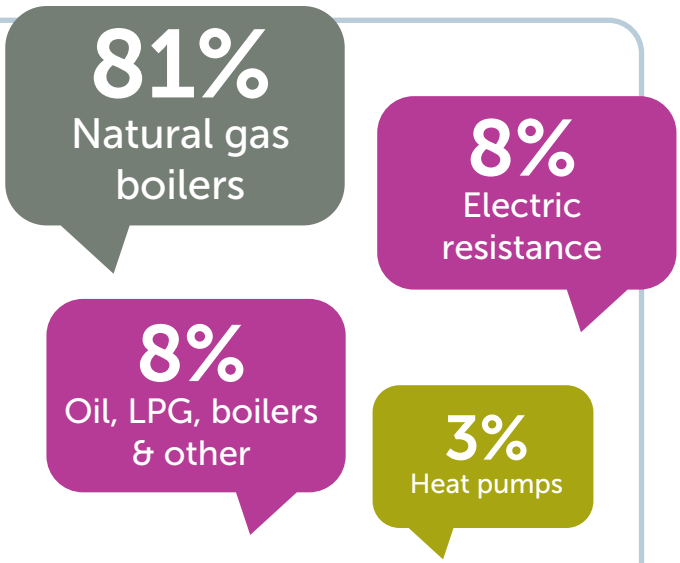
THE UK HEAT MARKET IN 2018 (BUILDINGS, TECHNOLOGIES)

Heating Fuel Mix

Heating accounted for 44% of UK national energy demand in 2011 with more recent statistics showing it represents around 80% of final energy consumption in domestic buildings[6]. The dominant fuel is natural gas supplying boiler lead central heating services with the remainder split across electricity (resistance and heat pump), oil, LPG, solid fuel/biomass and heat network systems.

Heat Electrification Market Relevance

- Customer conditioning towards boiler driven heat systems (89% of installed heating park)
- Individual heat systems dominate the market
- Still a significant segment of off gas heating to target c. 4-5m homes



Housing Overview

The quality, type and tenure of the UK housing stock has a major impact on heating strategy. It determines the level of decision making related to heating and can affect heat energy demand dependent on the heat loss of the home.

The residential housing market falls into 4 key categories[7], each representing its own relevance for heating market transformation.

Heat Electrification Market Relevance

1. Housing Association and Local Authority

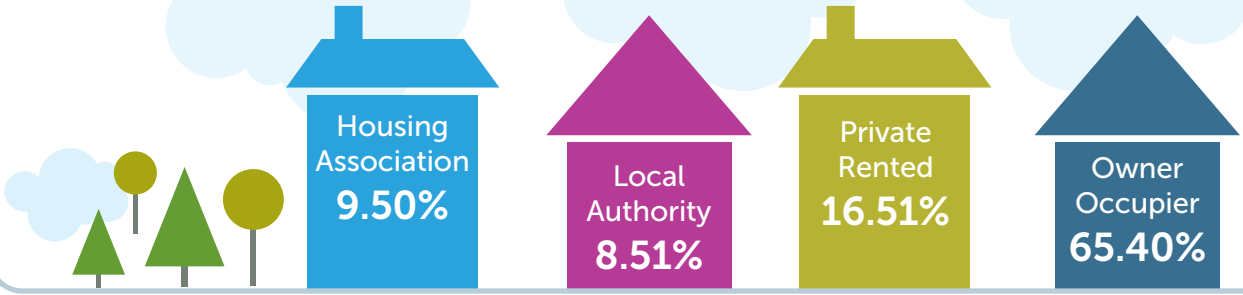
- Stock can be refurbished in blocks to deliver specification scale and a greater propensity for tenant support across a community
- Innovation is welcomed as evidenced in both the Renewable Heat Incentive and Low Carbon Network Innovation Fund programmes
- Access to cheap finance to support heat investment, although this is becoming squeezed by reduced funding and rent capping
- Can influence new building specification towards electrification if a developer has social housing obligations to fulfil within planning requirements

2. Private Rented

- A potential lost generation of innovation embracing professionals without the motivation or power to influence heating selection in the private sector
- Lack of tenant incentive to change heating systems in the private rented sector yet they pay the bills
- Non-existent framework of support policies to push change through the system and force landlords to seek low carbon or alternative heating solutions

3. Owner occupier

- The key decision makers can be easily identified
- Asset availability to stimulate finance opportunities
- Decision making powers but general inertia when it comes to heating system selection



[6] BEIS - Energy Consumption in the UK (July 2017)
[7] Office of National Statistics (2010) ... note figures have a total accuracy tolerance of 0.08%

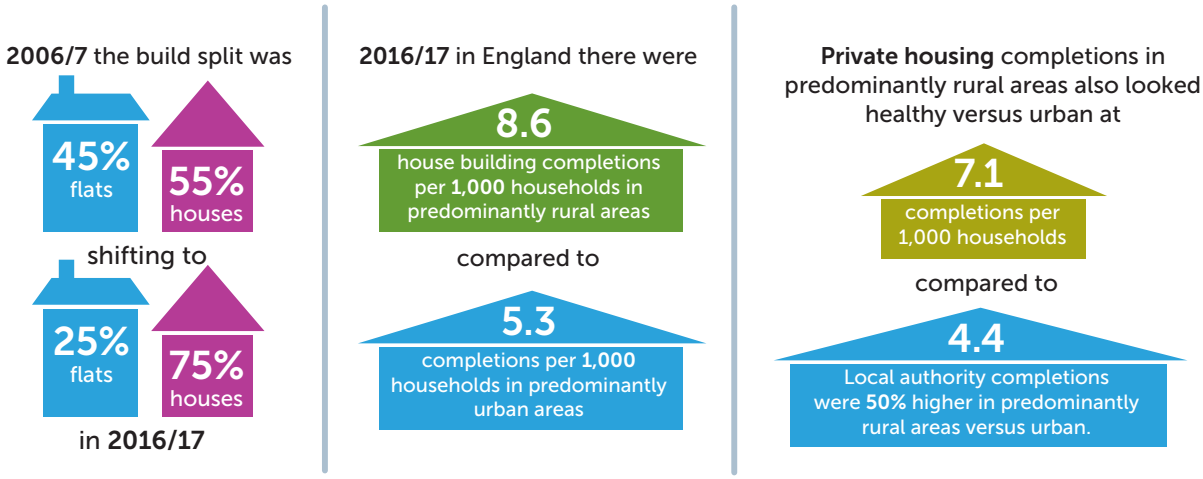
Alternative Segmentation

A focus on fuel type or housing tenure to derive market segmentation is perhaps too narrow. It can also be sensible to consider population density as well as some building characteristics to assess the carbon saving opportunities available through heat market transformation.

- Super urban and mixed-use sites lend themselves to Combined Heat & Power solutions or district heating for multi-residential developments (biomass or heat pump), regardless of available distributed gas
- Off gas areas in the short term offer significant energy bill and carbon gains versus alternative fuels for heat pumps (electric storage heating for smaller well insulated dwellings)
- Lower density 'one off housing' gas areas can be supplemented by hybrid or bivalent heating systems utilising boiler and heat pump combinations for energy and carbon saving
- Apartment blocks without the potential for CHP can utilise heat pump district heating technology or discrete dynamically controlled, charged and thermally efficient electric resistance heating with Heat Interface Units (HIUs) and/or electric hot water service

In addition to the above, a major grouping opportunity for driving householders towards low carbon and flexible heat technologies is new build. The UK has a recovering new build sector following the significant reduction in construction output post 2008. Housing starts and completions in GB show modest growth in actual and projected outputs:

	2015	2016	2017	2018
	Actual	Actual	Estimate	Projection
Starts	138,278	146,835	151,240	154,265
Completions	128,893	132,809	143,434	147,737



The breakdown of property type for this sector has changed dramatically in the last decade. In 2006/7 the build split was 45% flats and 55% houses, shifting to 25% flats and 75% houses in 2016/17.

In 2016/17 in England there were 8.6 house building completions per 1,000 households in predominantly rural areas compared to 5.3 completions per 1,000 households in predominantly urban areas. Private housing completions in predominantly rural areas also looked healthy versus urban at 7.1 completions per 1,000 households compared to 4.4. Local authority completions were 50% higher in predominantly rural areas versus urban.

Heat Electrification Market Relevance

- Density of the built environment (e.g. rural, urban, super-urban) and fuel availability can drive technology selection more readily than tenure type and fuel availability
- Government new build ambitions to build more affordable homes delivers potential scale for alternative heat systems, particularly in rural development
- The Government commitment to halve the energy demand for new build houses by 2030 creates an opportunity for super-efficient appliances such as heat pumps which can reduce in use energy demand by at least 2.5 times
- If new build is trending towards increased rural housing completions compared to urban, there is a great opportunity to use building regulations to promote heat electrification
- The Government has committed to halve new build energy demand and suggested using building regulations to influence off gas new build specification towards low carbon alternatives

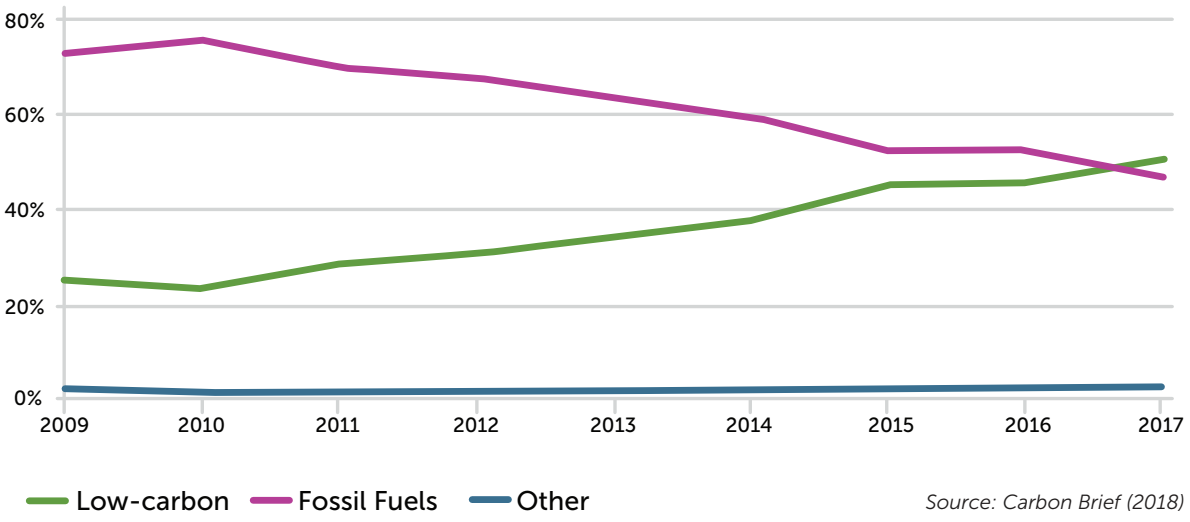
Decarbonisation and Smart Grid

The view of primary energy generation and carbon intensity has been changing dramatically since around 2004. Once perceived as a high carbon fuel, electricity has been on a decarbonisation journey that has seen the carbon content plummet from around 0.519kg CO_2/kWh in 2009 to the proposed 0.399kg CO_2/kWh in 2016[8]. With a rapidly changing generation mix, the actual CO_2 content is regularly below 0.250kg CO_2/kWh. According to Government data[9] in 2017 electric heating will have been more carbon efficient than gas heating (assuming 100% system efficiency for electric heating with an emissions intensity at 0.212kg CO_2/kWh versus 85% gas heating system efficiency with an intensity of 0.184kg CO_2/kWh).

A statement published by Carbon Brief at the dawn of 2018 explains the root of the change.

FOR THE FIRST TIME IN 2017, MORE THAN HALF OF THE ELECTRICITY GENERATED IN THE UK CAME FROM LOW-CARBON SOURCES…

A Shifting Generation Mix for Decarbonisation



Source: Carbon Brief (2018)

The decarbonising grid is borne from a growth in electricity producing microgeneration across the UK, along with an increasing amount of intermittent generation from wind power and large scale PV. The trend has resulted in smart grid technology investment by Distribution Network Operators (DNOs) that will increasingly underpin their shift towards Distribution System Operators (DSOs) as they tackle the challenge of balancing the distribution network through flexibility and storage solutions. These topics are covered in more detail in other reports in the Electrification by Design series.

Heat Electrification Market Relevance

- All electric heating technologies are becoming decarbonised at point of use, making them more favourable than higher carbon alternatives – including gas – from the perspective of climate change policy
- A declining trend in grid electricity CO_2 content will lead to favourable emission rate scores for all electric heating specified in new dwellings compared to higher carbon fuels
- A 'dash to electricity' needs to be carefully and sustainably managed to ensure we stay within the achievable limits of peak heat demand and available low carbon electricity supply
- Smart grid technology and DSO driven flexibility offerings will help balance the network and manage this peak heat demand by smoothing the load by at least 6% in the short term

[8] BRE – Consultation for CO_2 and Primary Energy Conversion Factors for SAP 2016 (June 2016)
[9] BEIS – Updated Energy and Emissions Projections (2017)

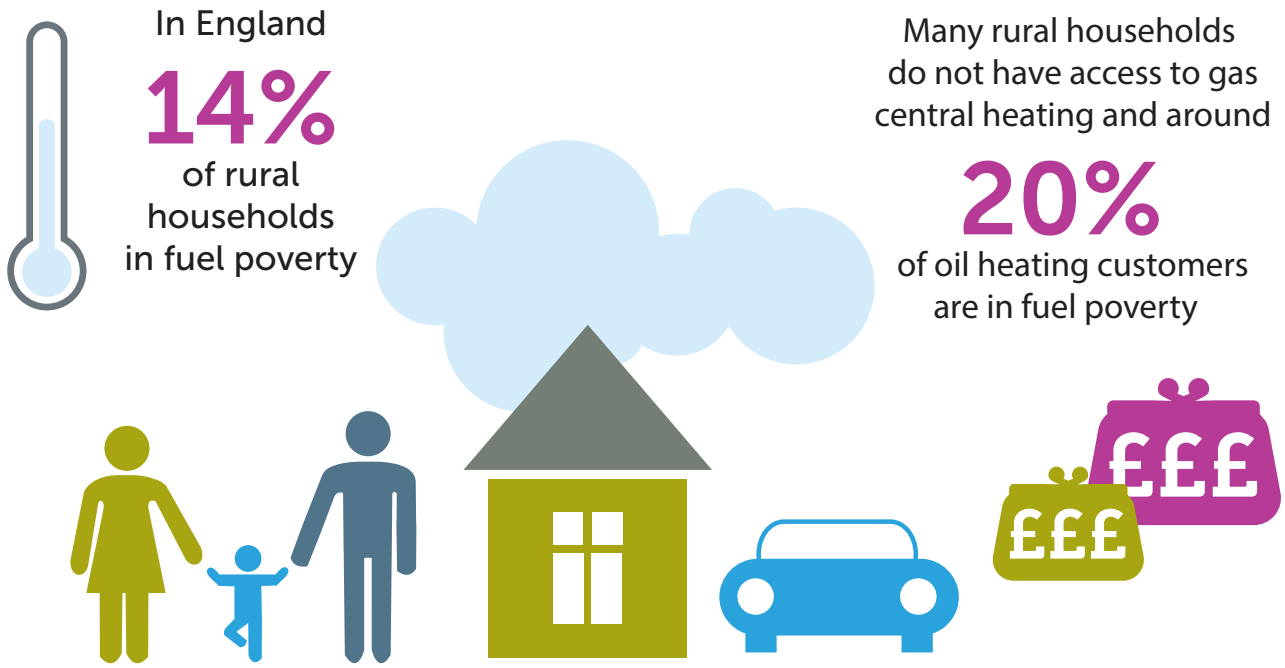
Fuel Poverty

The majority of UK households have access to affordable warmth, but the sad statistic of 4m households (nearly 15%) living in fuel poverty presents us with the biggest challenge of all for heat[10].

According to Government Fuel Poverty statistics (2018), there is an increasing prevalence of fuel poverty in rural areas in England with 14% of rural households in fuel poverty. Many rural households do not have access to gas central heating and around 20% of oil heating customers (that is over 1m households) are in fuel poverty[11]. Undoubtedly, the housing stock condition is a big factor, with many rural properties difficult to insulate, but the age and condition of existing heating systems also plays a role.

Heat Electrification Market Relevance

- With a high prevalence of fuel poverty in rural areas and over 1m oil boiler users within the catchment definition, there is a latent opportunity to deliver energy and carbon emission savings through system upgrades or switching to alternative low carbon systems
- Fuel poverty households, by any definition, are unlikely to have available finance to seek alternative low carbon heat solutions or upgrade their existing heat systems and therefore need enhanced support
- Housing stock in rural areas and linked to fuel poverty requires energy efficiency improvements to reduce heat loss in the first instance before specifying, again leading to an enhanced support need
- Network upgrades can be costlier in rural areas if for example transformer or cable upgrades are required to facilitate a connection
- The Government has a target to ensure all fuel poverty households in England reach a minimum EPC rating of C by 2030 which will lead to smaller sized and better operating heat pump systems



[10] NEA website based on BEIS and devolved administration statistics
[11] BEIS – A Future Framework for Heat in Buildings (2018)

THE STRATEGIC OUTLOOK TO 2030

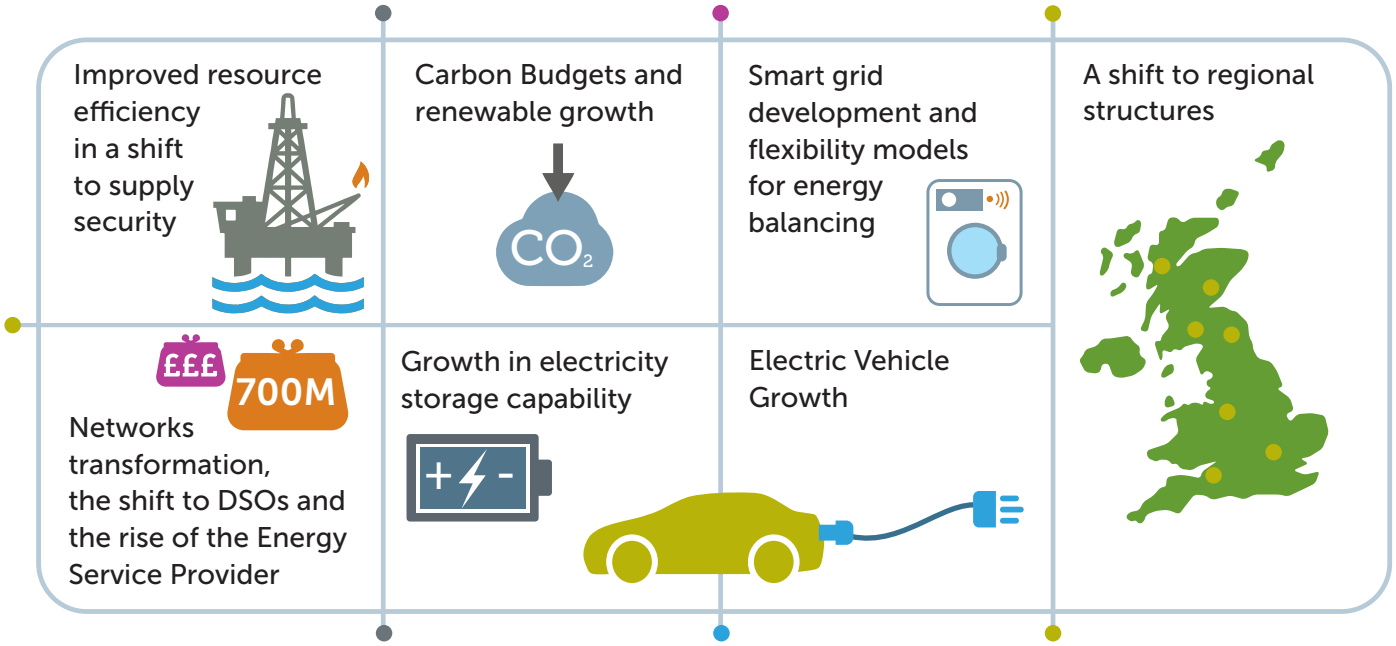
The Government's Clean Growth Strategy[12] lays a vision to 2032 but as an industry we look to 2030 as the Climate Change Committee made it clear that we will need 2.5m heat pumps installed by 2030, with progress to 300,000 by 2020. We are some way off this 2030 target but there are a range of policies and levers in place along with Government ambition to help us edge closer to this goal. This includes the Energy Company Obligation for tackling energy efficiency, the Prime Minister's commitment to halving new buildings' energy use by 2030, and the Government 'aim' to eradicate fuel poverty in England by shifting homes into Band C, also by 2030. Up until 2021 we also have the Renewable Heat Incentive, and the recent consultation *A Future Framework for Heat in Buildings* is hitting the mark regarding the phasing out of high carbon fossil fuel heating in favour of heat pumps or storage technology equivalents.

Many respondents to the Future of Heat consultation (which closed in January 2017) called for a role for hybrid solutions and renewables over the next 10 years and the Government has listened, with actions identified for the 2020s. Away from electrification, the Clean Growth Strategy identifies short term improvements for boiler installations but the longer-term future for heating beyond 2030, and after deep cuts into the 'low hanging fruit' of off gas electrification, rests in the outcome of research and development into hydrogen gas solutions and an impact assessment on the cost and feasibility of its deployment versus electrification.

CONSISTENCY OF AMBITION AND POLICY WORKS; 79% OF HOMES IN ENGLAND WERE BAND D IN 2015 COMPARED TO 39% IN 2005 WITH MUCH PROGRESS MADE IN 'DEEP CUT' EFFICIENCY IMPROVEMENTS THROUGH SUCCESSIVE AND SUSTAINED ENERGY SUPPLIER SCHEMES AND PROGRESSIVE BUILDING REGULATIONS.

[12] BEIS – The Clean Growth Strategy: Leading the way to a low-carbon future (2017)

THE CASE FOR HEAT ELECTRIFICATION



Improved resource efficiency in a shift to supply security

The initial drive for heat electrification was in response to growing concerns regarding security of supply. The UK became a net importer of gas for the first time and the sources of supply were politically vulnerable. Oil prices were trending upwards and a doubling in heat pump sales began in 2008 as the effects of winter fuel bills started to influence consumer behaviour.

More efficient energy end use, either through 100% efficient resistance heating or heat pumps which can deliver in excess of 250% efficiency and in many cases significantly more depending on design and installation conditions.

Carbon Budgets and renewable growth

The Government has a statutory requirement to reduce greenhouse gas emissions by 80% up to 2050 relative to 1990 levels and with carbon a significant contributor to greenhouse gas emissions, the Committee on Climate Change has set sequential carbon budgets including a target reduction of around 2-3% per year (10MtCO_2e) up to 2030[13]. Carbon emissions fell 19% between 2012 and 2017, including a 6% reduction in 2016 alone. Most of this came from low carbon power generation linked to our shift to secure and sustainable sources of energy supply, with a target to ensure 75% of generation from low carbon sources by 2050. However, despite success in generation emission reduction, building emissions rose in the 2 year period to 2016[14] suggesting a need for a more focused and targeted approach for initiatives in this sector.

Electric Vehicle Growth

New registrations of electric cars hit a new record in 2016, with more than 750,000 sales worldwide[15]. The UK Government target is that by 2050 almost all vehicles on Britain's roads will be Ultra Low Emission Vehicles (ULEVs). The Climate Change Committee has stated that by 2030, 60% of cars sold should be electric to enable the UK to meet its carbon and overall emission targets.

This shift in ownership patterns will by necessity change the way we manage our energy network. Flexible approaches to network management, charging, and consumer offerings, and new solutions and technologies such as smart charging infrastructure, are essential to provide consumers with efficient and cost-effective transport. The electrification of heat will be a beneficiary of this transport market transformation as the network approaches will also lend themselves to managing peak heat demand periods as we balance electric vehicle charging, storage and heat as inter-relational services.

13 Climate Change Committee: Meeting Carbon Budgets – Progress Report (2016)
14 Climate Change Committee: Meeting Carbon Budgets – Closing the Policy Gap (2017)
15 International Energy Agency (2017) Global EV Outlook 2017

Growth in electricity storage capability

Energy storage connected to the power networks is a rapidly growing area resulting from technology innovation and the dramatic fall in battery costs. In 2016 there was 60 MW od storage connected to the GB networks, although this figure has increased significantly following a surge in application to connect and connections during 2016 and beyond[16]. National Grid's 2017 Future Energy Scenarios predicts 10.7 GW of power storage by 2050 with 6 GW built by 2020. The Capacity Market Register published in June 2018 shows 5.9 GW of capacity pre-qualified and 8.9GW in total although this is not a confirmed actual commissioned figure. Future uptake of storage will depend strongly on the price and reliability of storage, both of which are evolving rapidly stimulated by electric vehicles and new technologies to compete with batteries. Consistent Government policy for flexible energy systems is also critical.

Smart grid development and flexibility models for energy balancing

The peak heat demand mentioned earlier presents a real challenge for heat electrification if we assume every heat appliance is operating from a 'live' energy supply on the coldest day of the year. The concept of smart grids has grown from the need to have a balanced energy network that can accommodate distributed energy, intermittent low carbon and other forms of electricity generation. Predictability of generation is difficult and if you couple this with the peak demand scenario, there needs to be a level of smartness, flexibility and technology accessibility to shift loads and potentially store energy for heat and hot water. A similar 'flexibility' scenario applies to electric vehicles, smart appliances and discretionary building services.

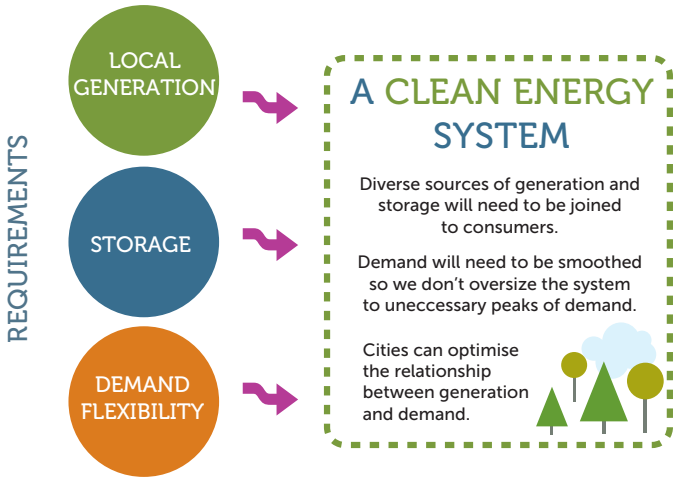
A shift to regional structures

The initial Electrification by Design report (2017) identified the need to shift to a regional support structure that encourages the necessary Business to Business (B2B) relationships and targeted approach required for electrification. The pathway to decarbonising heat and ensuring a smart and flexible energy system relies on a level of collaborative working that can help tackle some of the market imperatives such as supply chain capacity building, quality assurance, relevant and consistent marketing campaigns and integrated finance offers. Most importantly of all, with local authority involvement as a trusted access route to data and local demographics, strategies can be developed and implemented that promote finer targeting and essential B2B derived technology and service offerings.

There is a lot of activity in this space. Firstly, a number of Local Enterprise Partnerships have been allocated £40-50,000 each to develop local energy strategies. In turn, the launch of 5 Local Energy Hubs is expected in late 2018 with £4.8m total funding for 5 hubs (North West, North East, Yorkshire and Humber, Midlands, Greater South East and South West). Each will have a regional lead and small team of project managers with access to technical, legal and other relevant advice through national tools.

As well as the Hubs, the Energy System Catapult is promoting an Energy Town concept with increased interactions between business and public-sector bodies based on delivering smart and flexible energy system solutions.

Smart Power requires integrated thinking



Source: UK100 Financing the Transition

Finally, the Government has awarded £102m of funding for a basket of activities including the creation of 3 local energy system demonstrators. It should be hoped that this level of support will make major inroads into the major barriers faced by local authority and LEP teams i.e. lack of capital and sufficient scale to attract private investors[17].

Our view of the Local Energy Hubs is that they are the principle solution to resolving the issue of understanding local housing stock and fuel supply characteristics to foster the precise B2B relationships between the public and private sector that will create value added propositions which will engage customers and transform the local energy market.

Networks transformation, the shift to DSOs and the rise of the Energy Service Provider

Over £700m has been invested by the Distribution Network Operators since 2004, driven by the regulator and customer funded, through innovation funding and open bid competitions, the networks have been exploring smart solutions that can deliver flexibility, grid stability and manage predicted changing demand patterns and increasingly distributed generation.

16 REA – Batteries, Exports, and Energy Security: The deployment of 12GW of battery storage by the end of 2021 is achievable and can support post-Brexit growth (Dec 2017)

17 UK100 - Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy (2017)

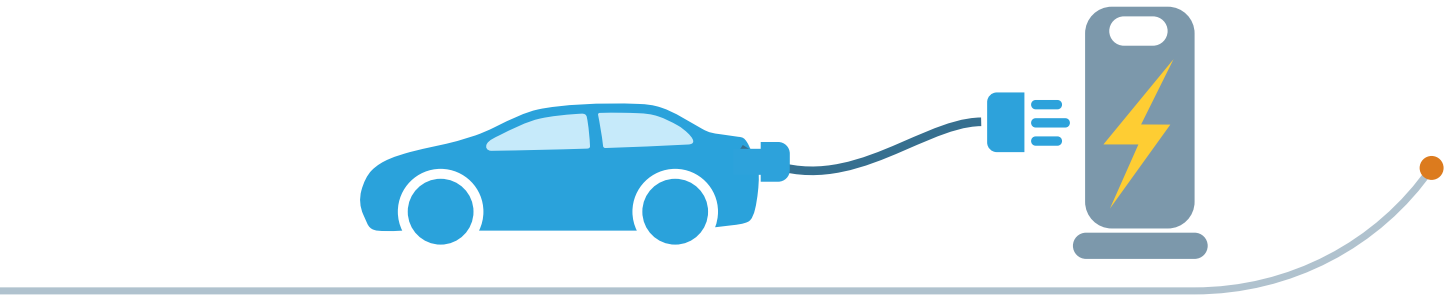
Recognising the changing nature of the DNO role as the traditional asset base increasingly interconnects with distributed generation, smart heat appliances and electric vehicles, there is already a positional shift as they become Distribution System Operators (DSOs) with a broader remit to manage the system and not just the network itself.

This opens up the market for flexibility, which is essential for heat electrification to ensure a smoothing of peak heat demand. Flexibility refers to measures used to contribute to a balancing of the system at both a local, regional and national level. An example of flexibility is energy storage, which can absorb electricity when there is an excess and release it when it is in short supply. Greater use of new sources of flexibility e.g. electric heating and transport is expected to be cheaper than relying solely on using traditional techniques in responding to the changes needed as we decarbonise energy demand and electrical generation.

Flexibility isn't new, at a base level the UK has had an Economy 7 tariff for decades to increase load at night when demand on the power stations was low. What is new is the need for much greater amounts of dynamic flexibility, the need for flexibility when the weather dictates or demand increases rather than at predetermined times such as overnight.

The adoption and delivery of smart solutions and associated technologies such as storage or smart electric vehicle charging will help to deliver the increased levels of flexibility required and this is under-pinning some of the agile Energy Service Provider business models. Moving away from pure energy supply and proving integrated finance and lease options for a range of technologies part subsidised by the value of flexibility managed through the B2B contracted relationship between the service provider and the DSO. More information on Energy Service Providers, flexibility and DSOs can be found in the main report[18].

THE ADOPTION AND DELIVERY OF SMART SOLUTIONS AND ASSOCIATED TECHNOLOGIES SUCH AS STORAGE OR SMART ELECTRIC VEHICLE CHARGING WILL HELP TO DELIVER THE INCREASED LEVELS OF FLEXIBILITY REQUIRED AND THIS IS UNDER-PINNING SOME OF THE AGILE ENERGY SERVICE PROVIDER BUSINESS MODELS.



18 BEAMA – Electrification by Design (2017)

Can customers champion a switch to low carbon heating?

Research[19] and market evidence suggests that customers are not willing to research alternatives to their existing heating system, despite the fact that the same research identifies that off gas customers are less satisfied with their systems. This inertia is not helped by the absence of a coherent supply route for heating beyond calling an installer when the current heating system has failed/regularly fails or conducting an internet research exercise to look at options that fit the incumbent system.

Despite this, recent experience has shown that customers will pursue a 'no brainer' financial offer, as was proven by the surge in biomass installations, when presented with very high incentives and very low barriers to switching. However, in the main, customers clearly do not see heat as an investment decision given the Renewable Heat Incentive's failure to attract significant interest with modest yet still 'better than High Street lending' rates of return. The forthcoming assignment of rights package in the new Renewable Heat Incentive regulations (2018) may open up doors to finance offers but there is industry uncertainty around the regulatory structure for AoR and whether it may create a 'race to the bottom' in terms of sacrificing quality for best price and rate of return for the lender.

The passivity of the customer was covered within the initial Electrification by Design report with less than 50% of respondents to a survey stating they would probably or definitely take up a smart tariff, which by definition means the presence of some level of smart appliance or technology. Research results released by Smart Energy GB paint a slightly different picture.

The research indicates that it is possible to build a service around a customer that they would desire and consequently use to support behavioural change generally. Furthermore, with heating ticking many boxes for demand side management, there is clearly scope for consumer engagement, especially if the proposition is well targeted and convenient to access at the right price point.

87% of all adults found at least one smart technology solution appealing

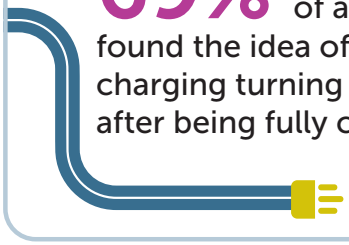
Over **60%** of people aged 55+ said that they would find technology which automatically turned off appliances not in use appealing

68% of people would like to receive cheaper energy for using appliances outside peak energy times

rising to **80%** of smart meter users

67% of people with children in the home said they would be happy for appliances to automatically turn on when energy is cheapest

69% of all adults said they found the idea of devices that require charging turning off automatically after being fully charged appealing



[19] DECC – Homeowners' willingness to take up more efficient heating systems (2013)

SOME MARKET CHALLENGES AND HOW TO RESOLVE THEM

Customer and Installer Confidence

Successful heat electrification requires customer confidence built on faith in performance claims and in use quality. Many of the technologies in scope are proven around Europe or through deployment in the UK. There have been some question marks over heat pumps in the UK due to field trials which measured the market in early stage uncontrolled growth rather than a managed growth line as a rising star.

No matter the technology, quality and customer confidence are dependent on scale of the market opportunity and associated supply chain confidence, particularly with regards to the installer. Scale encourages investment in training and certification backed by enforcement. Scale also has the potential to attract added value supply chain support services such as design services which can improve the quality of overall system design and specification, whilst having the add-on potential benefit of reducing the sale cost for one-off installers.

Therefore, the solution to increasing confidence through quality is related in part to certification of products and installation services, but more strategically through ensuring there is enough of a market opportunity to encourage investment. This scale does not necessarily need to be a macro market issue; the necessary level of market potential would more likely be at a regional or local level as the supply chain support infrastructure and associated investment in capacity is, by its nature, regional or localised.

Customer Awareness and Advice

There is a general lack of awareness regarding available alternative options for heat. Government promotion of energy efficiency has decreased during the last decade, and with no impartial multi-option vendor framework there is too much reliance on the installer to present a balanced case for a number of technologies. The result of this is an inertia to switch technologies and a probable 'like for like' specification driven by ignorance of the options and the safety net of experience with an incumbent technology.

Government, trade bodies and an impartial well-informed Information Hub[20] all have a role to play in delivering awareness and advice. The umbrella advice and options should be agreed within the Hub framework which includes peer reviewed Buyers Guides for heating technologies. These guides would be available through the Information Hub portal itself but also through relevant trade bodies. These are valuable tools to support the activities of any initiative that is aiming to drive market transformation, including any one of the regional and local approaches that are being rolled out in the coming years. Regional marketing communication campaigns also have a role to play, particularly when bringing local authorities into the discussion as they have an impartial and trusted status with consumers,

20 The Information Hub is a recommendation within the Each Home Counts Review (2016)

Price and Finance

Heating is a low interest topic for customers until it breaks down, underperforms or the counterfactual fuel price dramatically increases, at which point decisions need to be made which will inevitably be driven by technology price and the associated opportunity costs.

In all cases with heat, as opposed to hot water, the price of capital equipment is linked to plant size, which is dependent on heat demand which is dependent on heat loss. This in itself suggests that the starting point for tackling price is by tackling building fabric energy efficiency, as covered under the 'Building Based Flexible Energy Mix' section of the original *Electrification by Design* report.

The electrification of heat is therefore dependent on a well targeted ECO programme that provides a multi-measure approach. We cover this topic in a later section of this report.

In the case of heat pumps in particular, price is also a factor of scale as covered under confidence. From a technology perspective, there is little margin for price improvements with heat pump units as similar components are used in the much larger market for air conditioning and cooling, which has driven down prices already. Where there is scope for price improvement is design and installation which is again linked to scale.

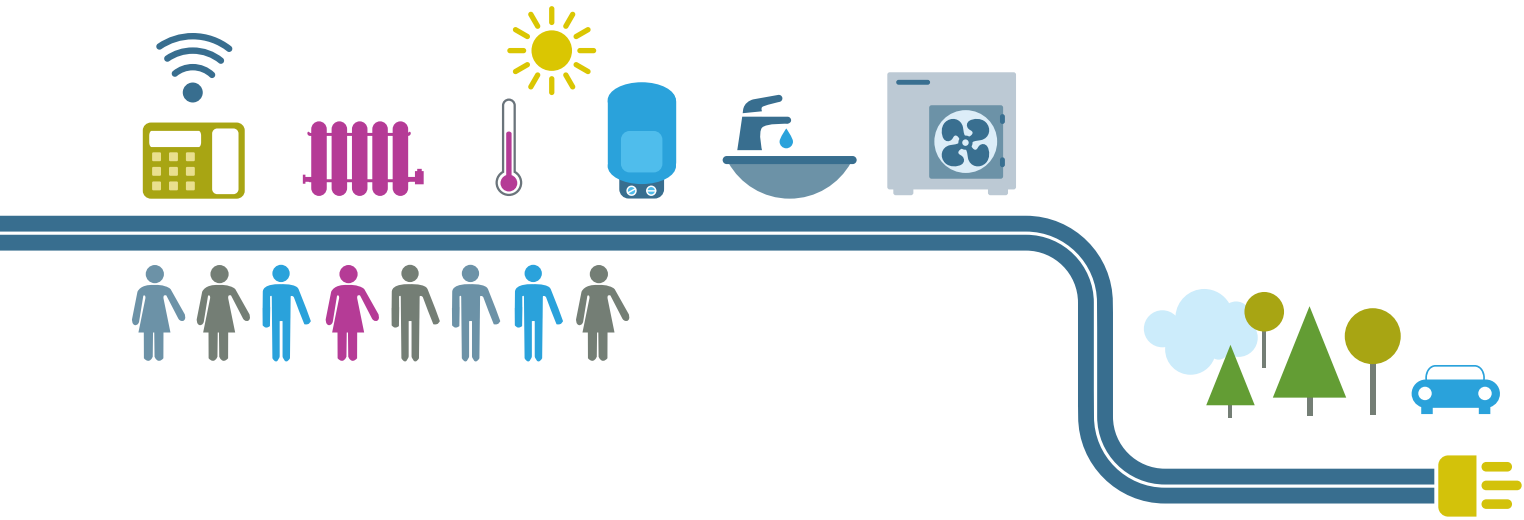
With technology price being finely tuned by optimising the heat and hot water service specification, the availability of finance to unlock the decision maker from low cost/low benefit options is essential.

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 demand side response and management.

A National Issue with a Regional/Local Solution

The original Electrification by Design made a strong case for promoting regional or local delivery, and within this paper we have identified a move in this direction already clearly being made with the creation of Local Energy Hubs. Throughout this paper we mention the essential factors that affect how you tackle heat, ranging from variable housing stock, tenure type, fuel mix and the availability of energy and flexibility services including finance offers. To try a national approach to this challenge would not reflect the fact that there are very targeted solutions required that may even need to utilise regional or local fiscal and regulatory levers.

Although the general direction of travel with the regional or local approach is positive, the activities in this space are too numerous and disconnected. Government intervention is required urgently to rationalise activity and ensure the focus is fixed on firm targets and deliverables including heat market transformation, preferably through a rigid and regulated Regional Energy Authority. Such an authority would provide oversight and strategic leadership for collaboration between the range of actors within any given clustered zone. 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 be able to create the right fiscal incentives framework for their own local energy ambitions and 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.



MARKET IMPERATIVES

The heat electrification technologies vary in their market maturity but a common link is the need for them to be backed by consistent Government policy support. We know this worked in other markets such as Germany and Sweden; we also know that whilst customers may be largely passive towards energy and building services measures, they do have positive views about the bundling of measures and services that will only become mainstream if Government can create the right policy and regulatory environment for their sustained existence.

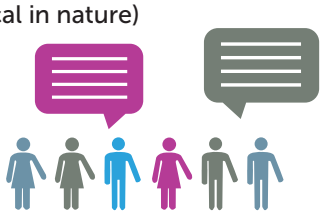
A targeted local approach to heat electrification, focusing on off-gas and rural areas up to 2030

Integrated finance packages linking private and policy stimulated incentives (e.g. ECO)

Confidence through quality and sustained policy support

Regulation, technology and markets working together to enable demand management

Marketing campaigns to raise awareness of the heat electrification benefits for all customer groups (targeted and local in nature)



Sufficient supply chain capacity

THE POLICY CONTEXT

Policy has an important role to play in heat electrification but there must be a common-sense approach to how policies interact or are targeted for best results. In fact, heat pumps and district heating markets have been successful in the EU not only due to long term policy stability over decades but also the combination and sequencing of policies[21]. In this section we approach this from the angle that the Renewable Heat Incentive will be phased out in 2021, but remaining policies such as ECO and Building Regulations, not only for new buildings but existing homes as well, can be enablers to open up the 'flexibility' value that can co-fund the take up of electric heat technologies. This section assumes the priority target of off-gas dwellings in the lead up to 2030 to satisfy Climate Change Committee targets and the ambitions set out in the Clean Growth Strategy.

The Energy Company Obligation (ECO)

The ECO programme has Government support beyond 2022 with the current level of funding – £640m per annum and applied up to 2028. With this level of support, ECO can play a significant role in heat electrification, particularly in tackling rural fuel poverty through the Affordable Wealth obligation and the rural sub-obligation. However, immediate action is required across 4 subject areas:

1. **Obligations to be applied to a larger supply grouping and/or DSOs**

   Government has already recognised that DSOs can play a role in delivering measures that are linked to network improvements e.g. heat pumps, electric heating or demand reduction i.e. insulation[22]. Allocating tradeable obligations at a regional scale linked to the Local Energy Hub structure can help improve targeting and maximise measure impact, particularly if working alongside the new and innovative energy service provider community. This latter grouping also need to have obligations as many will be under the 250,000 customer threshold ECO qualification level and this could erode the value and impact of the scheme.

2. **Take a different approach to first time central heating**

   The first-time central heating element of the obligation must be extended to allow for new intelligent high efficiency electric storage options as substantial savings can be made at equivalent installation costs to gas central heating[23]. Similarly, heat pumps should be deemed as equivalent first time central heating.

3. **Accept that innovation can play a vital role in market development**

   Innovation does not only encapsulate technologies in post-commercial trial phase. There are proven technologies such as heat battery stores that require recognition through ECO to encourage market development and capacity building.

4. **Avoid marginalising fuel poverty households by increasing renewable heating uptake**

   Fuel poverty households subsidise both ECO (through bills) and the RHI (through direct taxation) yet are alienated from both schemes as they are not allowed to co-exist and work together. There is not enough return on investment to open up private finance loans through Assignment of Rights unless a substantial element of a heat pump's cost is paid from ECO.

Building Regulations

The Government has used building regulations as a tool to encourage energy efficiency market transformation, but market feedback suggests the current target emission rating system has not been successful in increasing the specification of heat pumps. The Code for Sustainable Homes was more successful through the award of credits for specifying renewable technology. There has been some suggestion of a return to the Code but an alternative option is to follow the lead of EEWärmeG (the Renewable Energies Heat Act)[24] in Germany which requires 50% of heat demand to be met by renewable sources. There is certainly scope for encouraging early adoption of this level of semi-prescriptive specification for single residential dwellings off the gas distribution network, noting that multi-residential could be better suited to a heat pump driven heat network or electric storage heating. Additionally, with hot water storage potential such as key factor in flexibility services, there should be a minimum specification of hot water store per new dwelling.

Existing buildings can also be transformed through minimum requirements as evidenced in Baden Wurttenberg, Germany, where at least 10% of heat demand must come from a renewable source. This provides scope for deployment of hybrid specifications of boiler/heat pump systems or renewable heat storage technology. An alternative option is to link the regulations for existing buildings to minimum energy label requirements such that some form of renewable heat would be required under a system label.

21 UKERC – Best Practice in Heat Decarbonisation: A review of international experiences of policies to promote the uptake of low-carbon heat supply (2017)
22 BEIS – Call for Evidence: Building a market for energy efficiency (2017)
23 BEAMA – response to ECO Consultation (2018)
24 UKERC Technology and Policy Assessment - Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply (2016)

A final consideration for building regulations could be to consider how to create a stronger bond between new and existing buildings through the regulatory and fiscal incentive framework. For example, under the previously mentioned Local Energy Hub approach there is scope to trial and implement similar initiatives as considered for the 'Allowable Solutions' element of the Code for Sustainable Homes. This would set regional based targets for housebuilders in line with the Prime Minister's ambition to halve energy demand in new buildings, but allow an 'off set' option for housebuilder to buy out a maximum percentage of their obligation with funds used within the Local Energy Hub framework to improve existing buildings. With new build representing only a minority of our overall housing stock by 2050, this approach makes sense and ties in with the drive towards minimum EPC rated dwellings.

Fiscal Incentives and EPCs

There are opportunities to be creative with fiscal incentives and approaches could also lean towards the Local Hub structure. For example, the UK Green Building Council's proposals to utilise the stamp duty and council tax frameworks to encourage investment in better EPCs did not take off because the Government at that time remained committed to its Green Deal ambition. The use of these measures can also be difficult to administer and ensure revenues are not lost to Treasury or Councils.

With the Government now keen to improve the EPC levels to a minimum of C by 2030 it is now an opportunity to give the Local Hubs the opportunity to use these fiscal measures to drive behaviour change. If lost revenues are reclaimed through calculated gains from higher taxation related to lower EPCs, the motivation is maintained for any lead authority within a Hub. Similarly, under the Hub approach and using fiscal incentives, we can increasingly see the channelling of related investment in either ECO measures, energy service provider offers for heat electrification or private finance for improvements, again channelled through the energy service provider.

The targeted and B2B nature of this structure absolutely underpins the argument for greater investment, improved standards for buildings and the likely achievement of 2030 ambitions for heat market transformation.

The Regulatory Framework

The current regulatory framework focuses on regulating process rather than outcome, which leads to prescriptive approaches and similar results within a narrow range. As the energy system becomes more decentralised and complex, the various actors have less visibility of the market. We have no shortage of data but it is difficult to manage and use to our advantage.

Throughout this paper and the original Electrification by Design report we have focused very much on a changing market in which energy will become a business to business product that will be packages and delivered to customers in very targeted ways to suit their needs and optimise their service experience. As supporters of the Reshaping regulation: power from the future initiative we are aligned with the view of energy becoming a retail proposition built around servitisation and appropriate technology specification. The choice for services will multiply and be driven by data which begins to suggest that the regulatory framework increasingly needs to build around data rather than competition between energy service companies. It is data and its visibility to customers and service providers that will underpin a push not only towards the electrification of heat but every technology and solution group covered in the Electrification by Design series.

RECOMMENDATIONS

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

Create Regulated Regional Energy Authorities with autonomy for building regulations, infrastructure co-ordination, local heat targets and fiscal incentives utilising public/private collaborative approaches

Building regulation provisions are required to target off gas areas with suitable electric heat systems driven either by prescriptive levels of renewable content for new single unit buildings or requiring heat networks or electric storage technologies for new multi-residential buildings.

Undertake a fundamental review and update of advice for heating systems to ensure the present and future value of electric heating solutions is recognised and promoted by the Each Home Counts Information Hub

Develop an encouraging framework for the regional implementation of appropriate incentives and tax regimes linked to EPC ratings which will accelerate growth in heat pumps, storage heating and hot water systems

Ensure policy initiatives complement each other to promote heat electrification e.g. Energy Company Obligation working with the Renewable Heat Incentive to tackle up front costs and avoid marginalising fuel poverty households

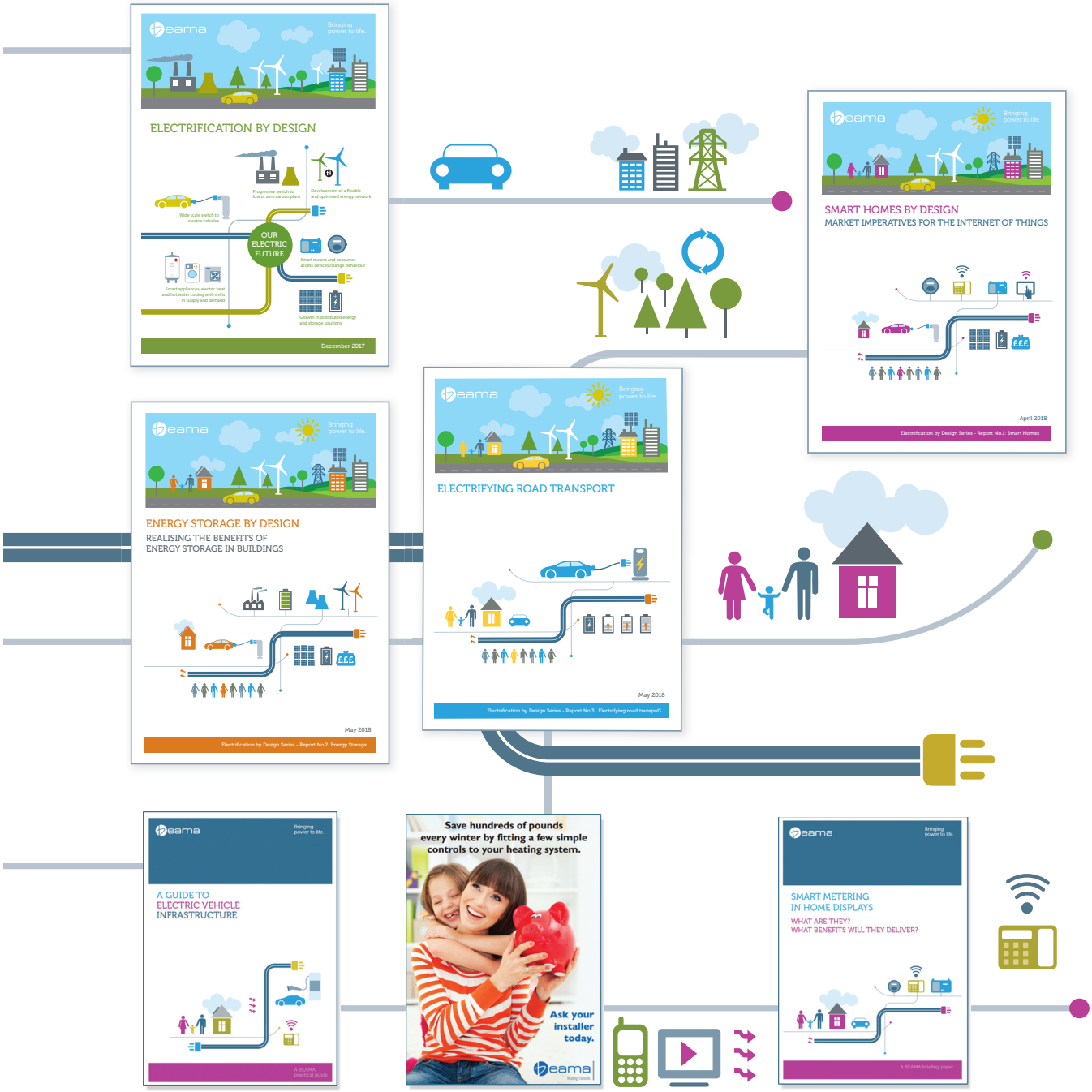
Fast track the publication and roll out of SAP 10 software to ensure new build developments can utilise the latest reduced CO_2 emission figure for electric heating solutions

Extend the Energy Company Obligation to DSOs and energy service providers as they grow their customer base but come within the 250,000 customers threshold

Regulate for data visibility and promote a regulatory environment based on outcomes rather than processes

Provide greater regulatory scrutiny over DNO activity relating to the speed and cost implications of network connections

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



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