Smart Systems and Heat programme:
Phase 2 Summary of key insights
and emerging capabilities

Contents

1. **Executive summary**

Digital technology has the potential to make low carbon heat a better, more consumer-friendly option for all UK households. The Smart Systems and Heat (SSH) programme has focussed on learning how to enable the market to deliver this.

Heating buildings accounts for nearly a fifth of UK emissions. The UK's 27 million households will need to rapidly adopt new low carbon heat solutions through the 2020s and 2030s if we are to meet our carbon budgets.

Attractive solutions will need to meet consumers' varied needs so that they will want to install them in homes and properties. The transition to low carbon heat will be challenging but the UK supply chain can benefit from major opportunities for innovation in technologies and business models.

The SSH programme addresses this challenge by building:

- deep understanding and evidence around consumer needs and how to harness low carbon solutions;
- to enable heat decarbonisation.

Consumer trials → Local area energy planning → Market transformation
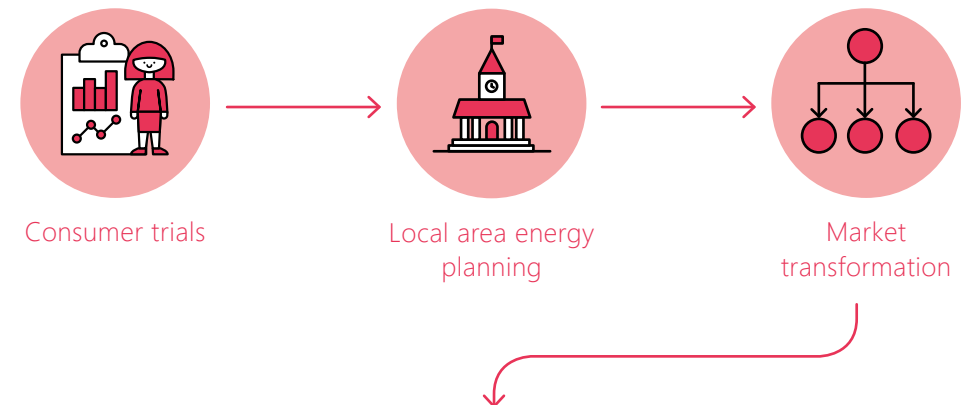
Building on the early work on consumers and local energy analysis delivered in the first phase of the SSH programme, Phase 2 (SSH2) has focussed on:

- building in-depth insights about consumer-focussed 'smart energy services' (i.e. tailored service propositions enabled by digital controls and sensors); and
- creating capabilities to support and accelerate the uptake of low carbon heating technologies across the UK.

SSH2 has delivered these insights and capabilities in three key areas:

- consumer trials of smart energy propositions
- local area energy planning
- market transformation (new business models and market structures)

The key insights and capabilities delivered by SSH2 are summarised on page 6, and in the content of this report.

Key insights

SSH2 trials confirmed that smart energy services enabled by digital controls can transform consumers' experience and control of heating at home, and thus better enable them to adopt lower carbon solutions.

Consumer trials of smart energy propositions

- Many consumers find low carbon heat futures difficult to imagine and there is low awareness of the need for change.

- Heat as a Service propositions (Heat Plans) were chosen by around half of trial participants and proved themselves attractive to a range of consumers and suited to varied home heating requirements.

- Trial participants valued better control of their domestic heat and how much it cost. They chose to use it in very different ways, depending on their priorities (cost, comfort, flexibility etc.), however almost all decided to heat fewer rooms.

- Participants who bought Heat Plans were much more open to alternatives to gas when replacing their boiler (only one third of surveyed owner-occupiers state they are open to them).
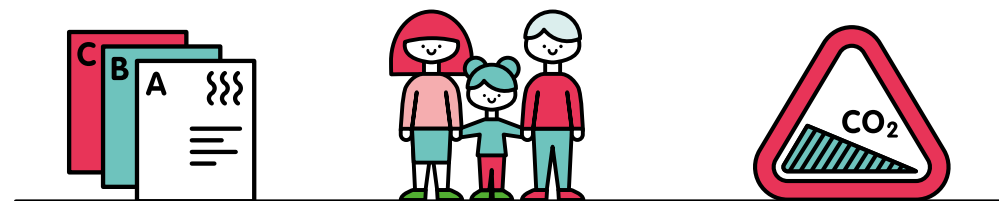
50%
Trial participants chose a Heat Plan.

56%
Participants enjoyed higher comfort.

85%
Participants open to low carbon alternatives.

- The 2017/18 winter trial demonstrated how a digital platform for home energy services can successfully integrate smart controls to deliver consumer-friendly, tailored smart energy service propositions. The trial used a proof of concept Home Energy Services Gateway (HESG) – an early version of a potentially interoperable digital platform developed by Energy Systems Catapult.

- This points to the strategic importance of establishing the genuine interoperability between devices, controls and service providers through open standards and protocols to enable consumer choice and competition.

- Usage data can reveal consumers' preferences and underpin improved design of low carbon solutions. Better design, integration and attractive propositions can address key barriers to the uptake of low carbon heating solutions and drive a stronger consumer pull for them.

- The trials produced a wealth of data (usage, temperature, energy consumption etc.), revealing a rich picture of individual household needs and the energy performance of their homes. Market segments based on temperature, space and timing of heat requirements were identified, providing an early indication of the potential for more sophisticated mass customisation.

- The Catapult's experience of running early trials confirmed the complexity, cost and challenge of building real understanding of the home environment, consumer needs and behaviour. However the trial experience equally demonstrated the value and insight generated by testing new propositions and technologies in consumers' homes.

- This suggests that the creation of a large-scale trial environment in consumers' homes will be a major national asset both for innovators and business in the UK supply chain, and to inform future UK heat decarbonisation strategy.
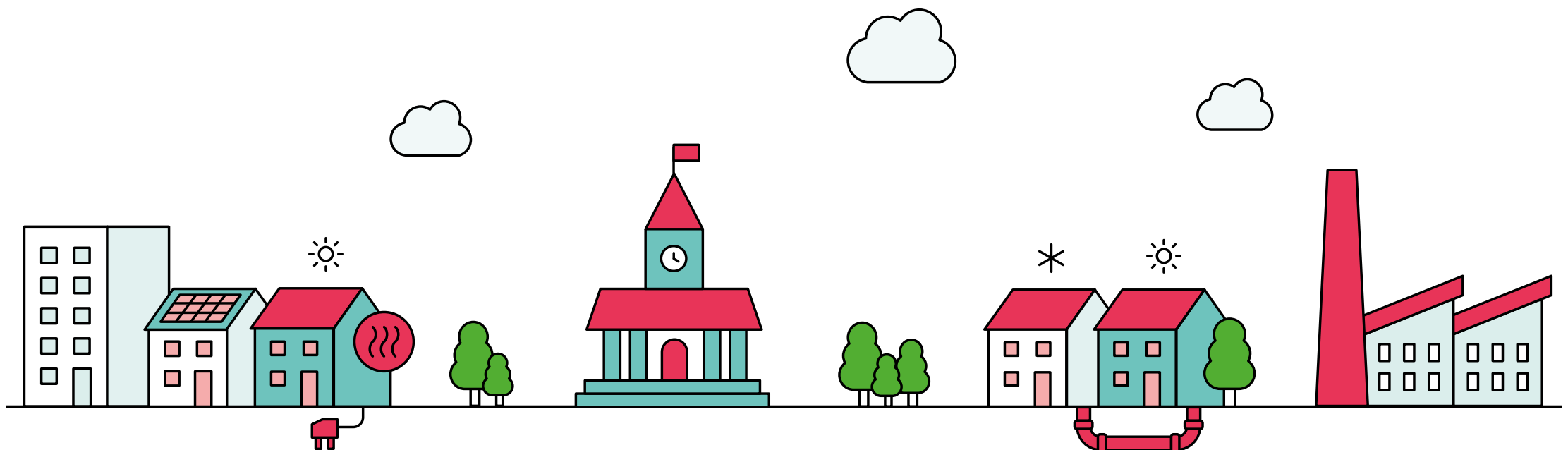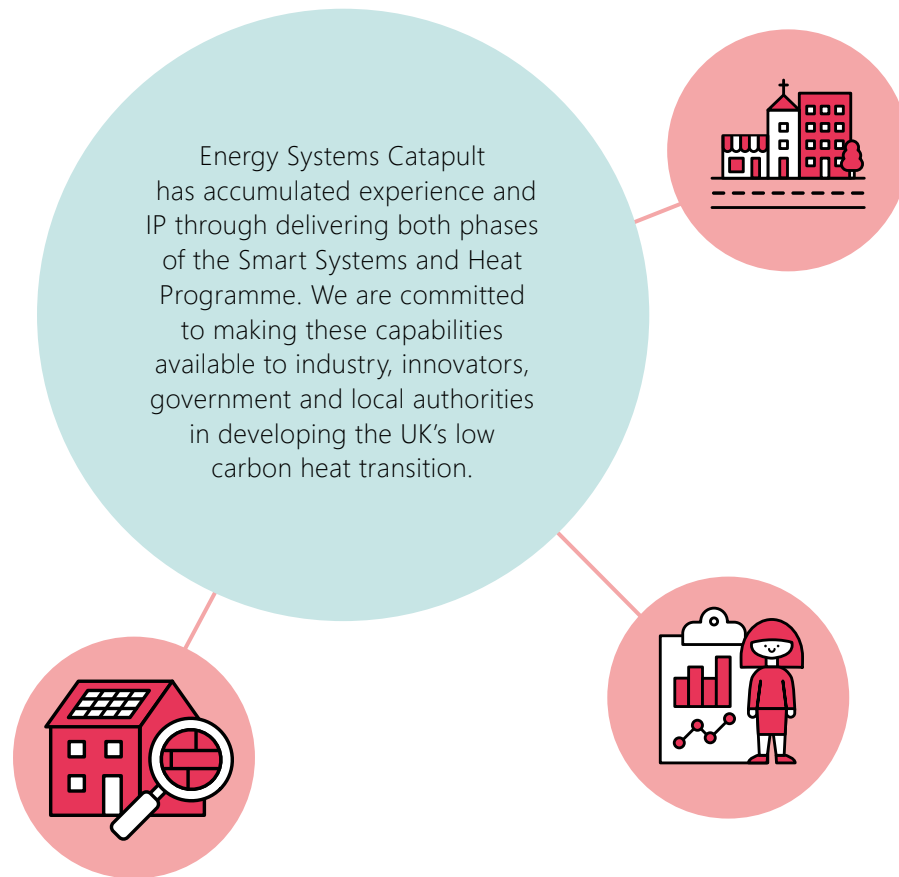
Key insights

Local area energy planning

- Local area energy planning could be a key tool to enable the UK's transition to a low carbon future, by enabling local government to identify the most promising, cost-effective options for decarbonisation while highlighting where investment is needed. There is a strong case to equip local authorities with the capabilities to shape and realise local area energy plans. Such plans can inform network investment plans and help deliver ambitious decarbonisation goals.

- Local area energy planning can build on the insight and understanding gained from whole systems analysis and modelling applied at a local area level.

- Informed by key modelling results, local authorities can develop actionable Smart Energy Plans that define a series of innovation and deployment projects designed to deliver near and long-term carbon reduction objectives in their areas.

- Developing an actionable Smart Energy Plan like those developed under SSH2 helps local authorities to define a concrete agenda for decarbonisation, aligned with the specific local infrastructure requirements, socio-economic priorities (e.g. job creation and fuel poverty) and emission reduction targets.

- Plans also establish engagement processes to build local partnerships capable of co-ordinating and delivering low carbon network and building retrofit investment on the ground.

- The experience of working with three local authorities (Newcastle, Bridgend and Great Manchester) has shown the value of planning at a local level to identify the most cost-effective mix of low carbon choices tailored to local circumstances. Further work is needed to consolidate evidence and establish formal decision-making frameworks, funding streams and planning processes, while ensuring that local actions meet regional and national priorities.

Analysing new business models and market structures

- Digitalisation of home energy can enable radical new smart energy service business models. These could combine deep and differentiated learning about consumer needs with smart and targeted control. Smart controls coupled with data analytics can reveal the varied detail of consumer preferences and building requirements, enabling better outcomes for households and for the wider energy system. This includes greater system flexibility, better management of peaks in the power sector and cost-effective decarbonisation.

- Smart energy service business models can also align incentives throughout energy product and service supply chains, to improve integration and deliver better consumer experience. The way that service propositions are presented to consumers, and their early experience with them, is crucial in building demand for smart energy services that can enable low carbon solutions.

- Ensuring interoperability between controls, devices and interfaces will be vital to support consumer choice and competition by reducing the risk of lock in to proprietary platforms. The example of other industries suggests some form of industry standards or regulation may be needed to unleash the full potential of a digitalised energy system.

- An outcome-based decarbonisation standard or obligation on future retailers or home energy service providers could incentivise the market to deliver tailored and integrated solutions that work for consumers, localities and the broader energy system. There is a strong case for further detailed exploration and trialling of policy options.

Emerging capabilities

Energy Systems Catapult has accumulated experience and IP through delivering both phases of the Smart Systems and Heat Programme. We are committed to making these capabilities available to industry, innovators, government and local authorities in developing the UK's low carbon heat transition.

Capabilities in local area energy planning

- Work under earlier phases of SSH built capabilities to analyse and model local area energy transitions and plans, taking specific account of local characteristics and building stock.

- SSH2 has created capabilities to translate local area energy modelling outputs into actionable Smart Energy Plans that identify projects tailored to local priorities.

- Understanding of the engagement processes and challenges in building the vision, roadmap and business case for early local low carbon action plans.
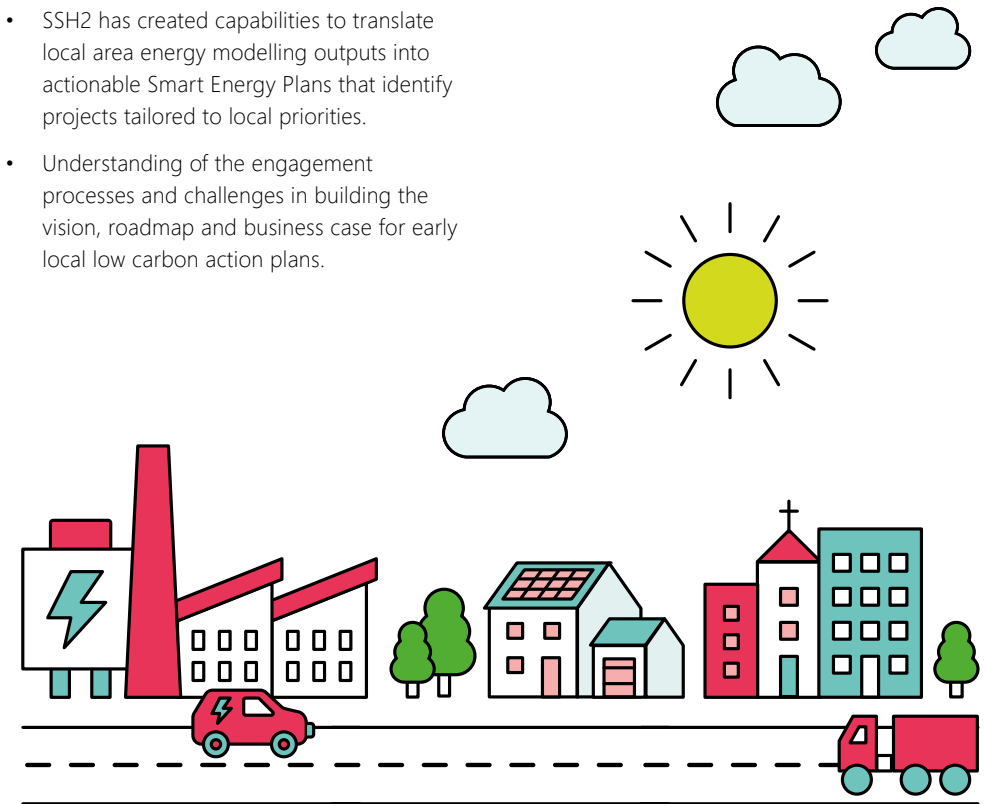
Capabilities in consumer trials of smart energy products and services

- Through working with the Department for Business, Energy and Industrial Strategy (BEIS), local partners and industry, we have created a first of a kind 'Living Lab' of connected owner-occupied homes willing and able to test new energy products and services.

- The Living Lab has been created to scope, design, build and run consumer trials. It is an important asset for UK innovators, enabling sophisticated trials in real-world consumer homes. There is potential to increase the scale of trials to enable testing of potential future market structures and policy incentives.

- Consumer trial capabilities are underpinned by the skills and expertise to build cloud-based digital platforms for integrating products and service offerings. This in turn enables collection and analysis of revealed to consumer preference data from large numbers of connected sensors, and the option to extend and deepen this as required for larger-scale more ambitious trial designs.

Capabilities in analysing new business models and market structures

- SSH2 has developed approaches to analysing the institutions, protocols and processes that have underpinned analogous market transformation and innovation across a range of industry and consumer sectors.

- Consumer-focussed approaches to design, testing and trialling of innovative products and service propositions.

- The use and analysis of revealed preference data to inform development of products and service offerings.

- The use of multi-vector modelling tools (EnergyPath Operations) to inform understanding of potential market interactions arising from new products and services.

- Analysis of incentive design and supply chain interactions in low carbon energy transformation solutions.

Conclusions and next steps

The programme has provided valuable insights to inform both the supply chain and policymakers in accelerating the decarbonisation of the UK's heat sector.

SSH2 has also enabled the sector to understand key themes for further development of low carbon heat business models, strategy and policy.

Energy Systems Catapult is ready to work with industry and innovators to shape product and service offerings and harness the capabilities described in this report and bring value to future projects.

Future work

Working closely with businesses and consumers to test low carbon product and energy service propositions in consumers' homes.

Industry

Digitalisation and energy service business models open new market opportunities to deliver value for customers and meet low carbon targets.

Local area planning

Further test development and scaling up of local area planning across a range of local authorities. Build actionable local decarbonisation agendas.

Policy

Test and build confidence in designs for an enduring low carbon policy framework (outcome-based obligations or standards look promising).

Interoperability

Develop industry-led processes for establishing smooth interoperability. Assess the case for intervention, and/or standards.

2. **Introduction**
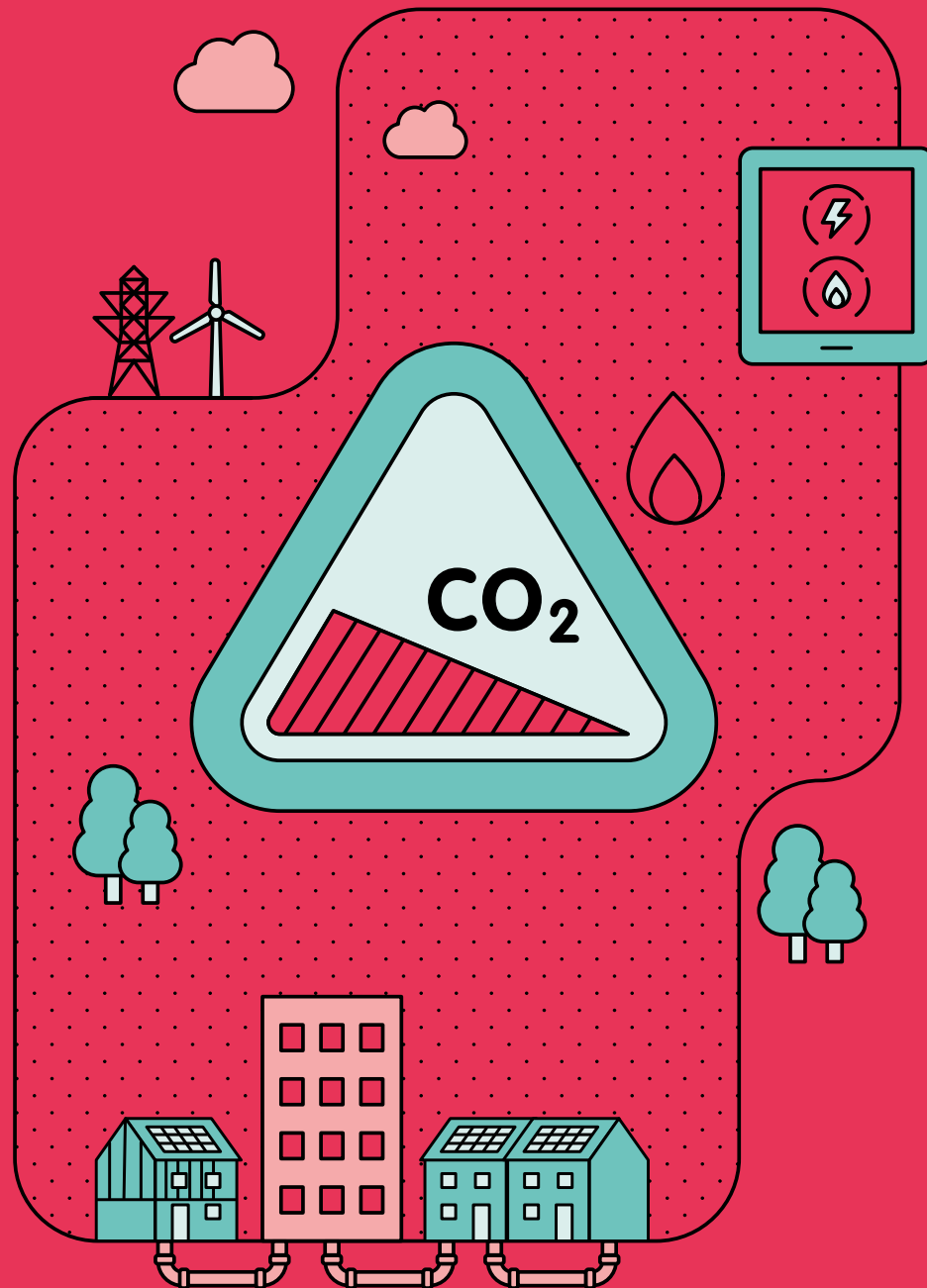
Direct emissions from UK buildings, including domestic, commercial and public buildings, account for about 19% of the UK's total greenhouse gas emissions[1]. Natural gas remains the dominant source of heating for most customers who are connected to the gas grid.

Decarbonising the UK's 27 million homes will be necessary if the UK wants to achieve the emission reduction commitments under the Climate Change Act 2008. However, enabling a fast, large-scale shift towards alternative low carbon solutions for domestic heating will not be without challenges.

There are several barriers which make the transition to a low carbon future for domestic heating particularly challenging. These include:

- **Dominance of gas in domestic heat**
  Heat supply to homes is dominated by natural gas, with fairly high levels of consumer satisfaction. Consumer pull for low carbon alternatives will only emerge if they can deliver better outcomes for households currently served by gas heating.

- **No one-size-fits-all technical solution**
  There is no single technological solution for cost-effective decarbonisation of heat; a portfolio of technologies (including heat pumps, heat networks, hydrogen, biomass and retrofits) and propositions that are tailored to the needs of different consumers, building types and local areas will be needed. Low carbon solutions are likely to require integrated investments in building fabric improvement, improved control and infrastructure, rather than a simple fuel conversion choice.

- **Poor thermal efficiency of UK building stock**
  Current UK building stock is generally of poor thermal efficiency – and most of it will still be occupied decades into the future. This means that bespoke integration of new heating technologies with building fabric improvements is likely to play a key role in enabling efficient decarbonisation.

- **Need to ensure protection of vulnerable customers**
  Different households have very different heating requirements, leaving many people living in poor quality building stock with the struggle of not being able to heat their homes properly during the winter time. The cost for making efficiency improvements varies significantly for each home, thus leaving vulnerable households more exposed to these costs.

Although the size of the heat decarbonisation challenge will require significant capital spending, it also offers a huge opportunity for UK companies to develop world-leading capabilities in digitalised consumer-focussed low carbon energy propositions. The UK is already the leading market in Europe for smart and connected heating products with well over €100M spent in 2017 alone. Building an open and innovative market environment which enables consumers to discover new value from smart energy could attract substantial investment into the UK as a growth centre for this market.

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1   CCC (2017) Meeting Carbon Budgets: Closing the policy gap [online]. Available from: https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf

2.1. The Smart Systems and Heat programme

The Smart Systems and Heat (SSH) programme addresses the challenge of heat decarbonisation in the UK by adopting a consumer-focussed, digitalised and market-driven approach that delivers benefits to consumers, the environment and the economy.

SSH is designed to tackle existing barriers and unlock the benefits of low carbon heat solutions in terms of improved comfort for all consumers (including vulnerable groups), and new market opportunities for UK businesses.

In particular, the programme focusses on supporting innovation in the domestic heating sector that will contribute to clean growth and a low carbon energy system in the UK, by:

- addressing the technical, regulatory, economic and social barriers that block new low carbon heat products, services and business models getting to market;

- establishing a range of platforms, insights and modelling tools to help innovators discover new low carbon heating solutions that consumers value;

- bringing innovators, businesses, local authorities, networks, policymakers, regulators and consumers together to create new markets that deliver low carbon heating solutions at scale.
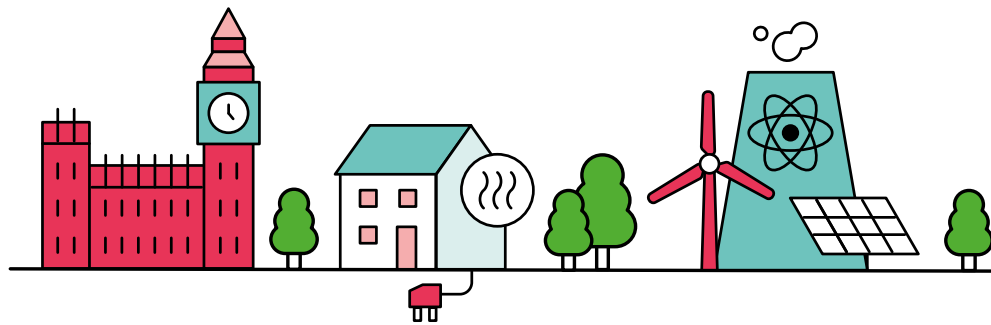
"The programme focusses on supporting innovation in the domestic heating sector that will contribute to clean growth and a low carbon energy system in the UK."
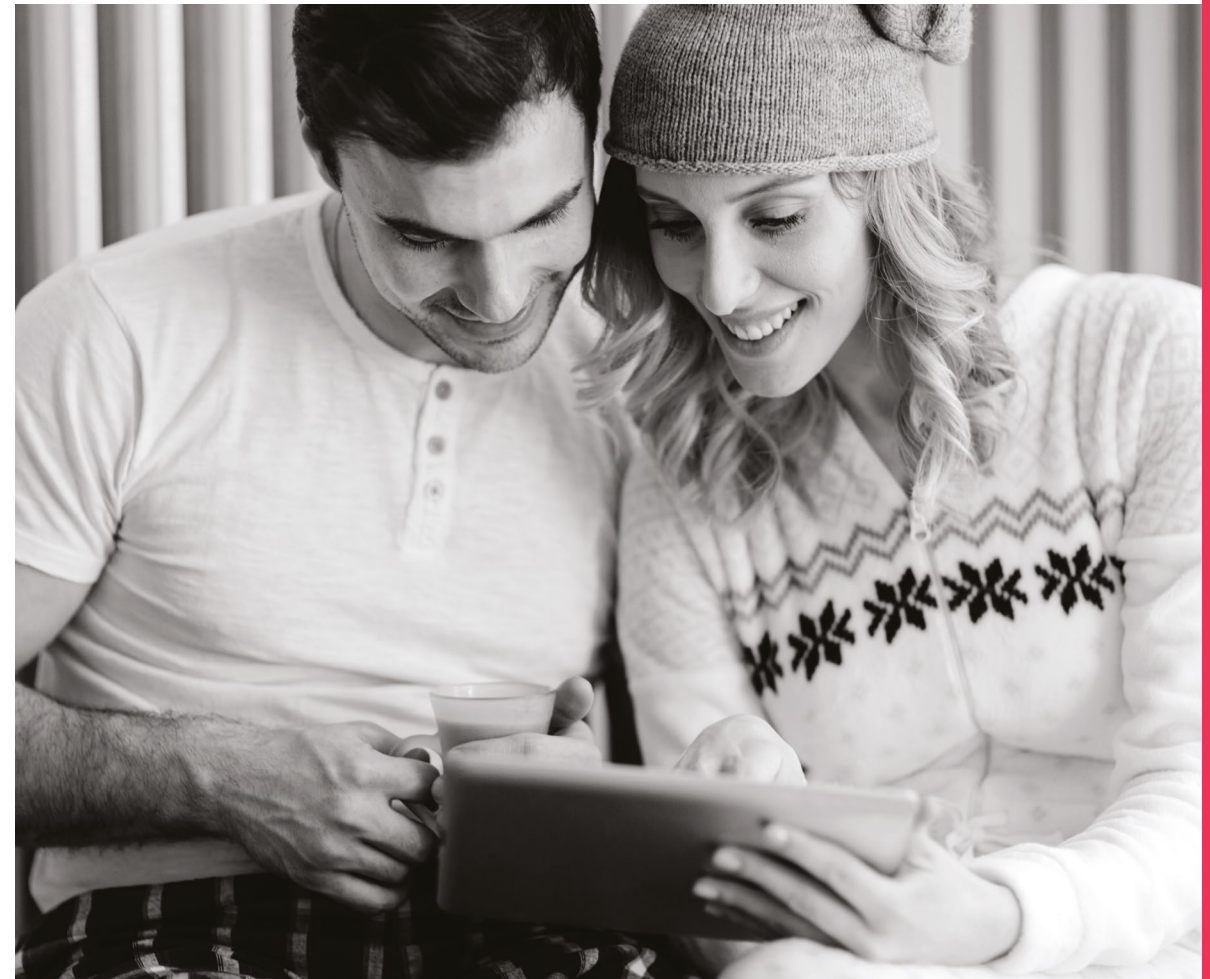
Phase 1 of the programme (SSH1) was launched in 2012, funded by the Energy Technologies Institute (ETI) with delivery by its partners including Energy Systems Catapult from 2016. Importantly, SSH1 provided initial insights into low carbon heat technologies[2] and how consumer preferences shape domestic heating use patterns[3]. Additionally, a comprehensive work programme has developed tools and guidance for local authorities to improve local area energy planning[4].

The initial findings helped build greater understanding around consumer energy use as well as building and heating system performance and laid the groundwork for the design of a complex consumer trial that goes beyond testing smart control devices. Underpinned by thorough market and policy analysis, the SSH programme broadens its scope to explore how digitalisation, consumer insights and new business models could provide a feasible, cost-effective and acceptable solution to scale-up the uptake of low carbon heating services and products.

2   ETI (2015) Decarbonising Heat for UK Homes: insights report by the Energy Technologies Institute
3   ETI (2015) Consumer challenges for low carbon heat: insights report by the Energy Technologies Institute
    ETI (2018) How Can People Get The Heat They Want At Home, Without The Carbon?: ETI insights report
4   Energy Systems Catapult (2018) Local Area Energy Planning: Supporting clean growth and low carbon transition

3. Smart Systems and Heat Phase 2
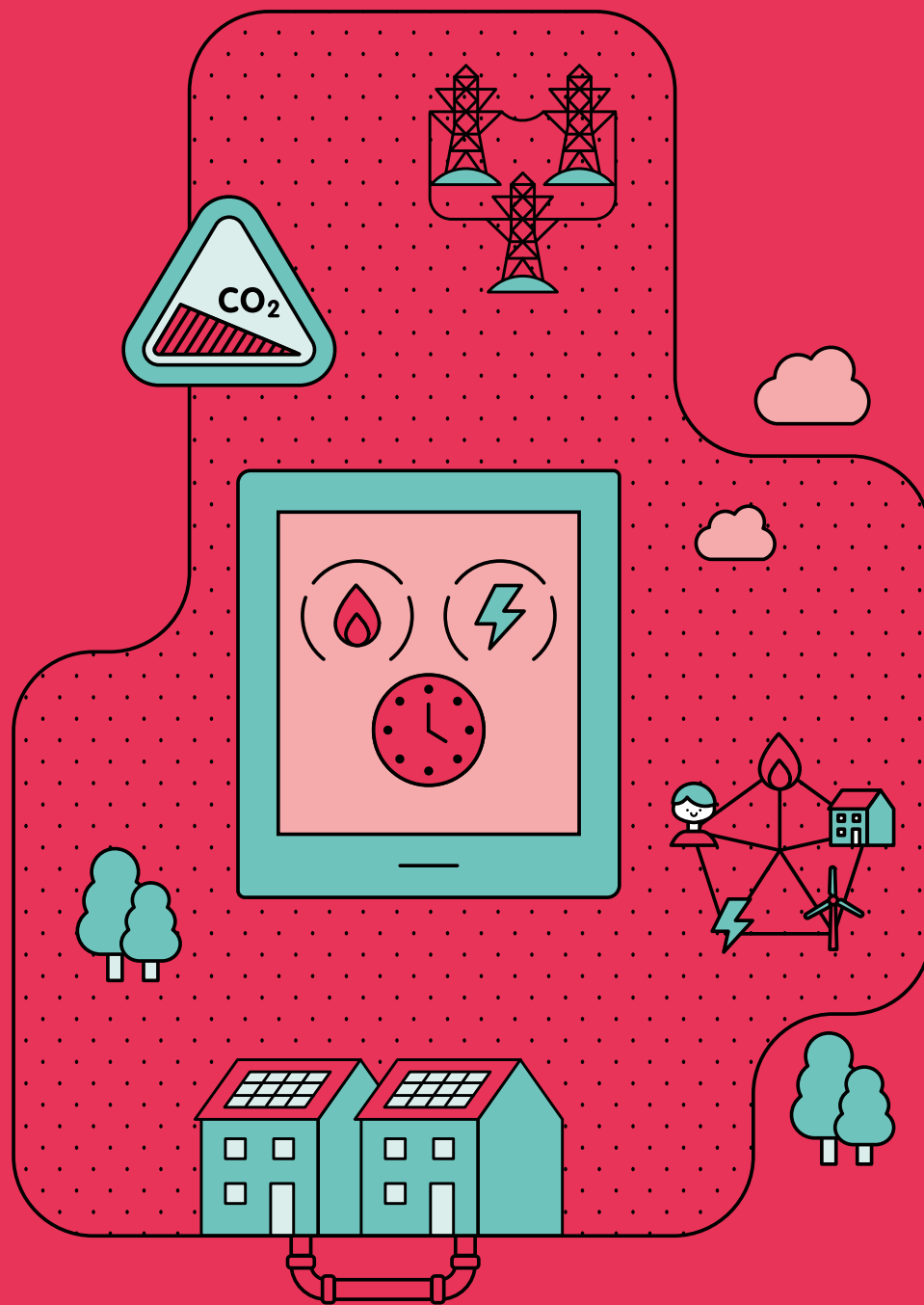
The Smart Systems and Heat Phase 2 (SSH2) programme has built on the initial evidence and concepts of SSH1 to deepen our understanding of consumer needs and how they can be met by combining new technologies and business models.

In doing so, the programme has developed a vision for an open shared trial environment that can bring together energy providers, product companies, networks, policymakers, regulators and consumers to interact both technically and commercially across physical energy systems, market systems and information systems. This kind of learning ecosystem offers potential to accelerate innovation and collaboration to accelerate decarbonisation of the domestic heating market.

SSH2 is funded through a grant agreement with Department for Business, Energy and Industrial Strategy (BEIS).
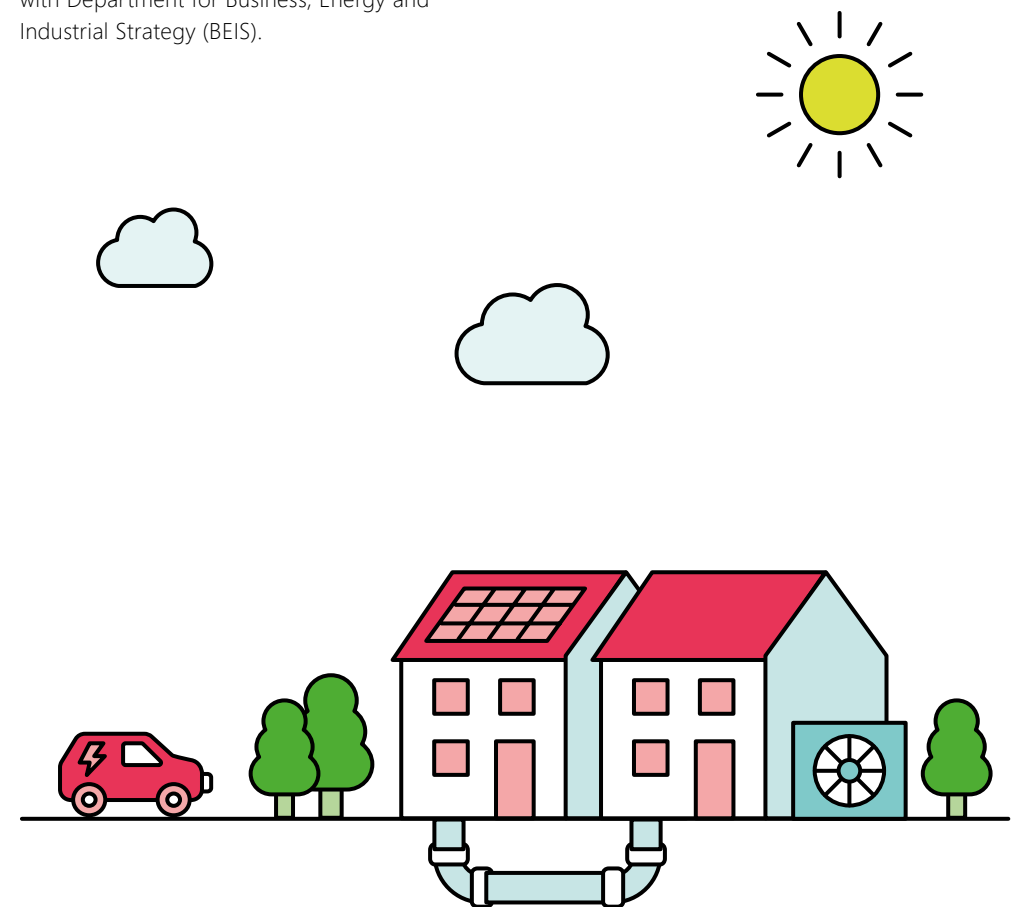
3.1. Decarbonising heat – our hypotheses

Building on the initial findings from SSH1, SSH2 aimed to test and build further understanding around five key hypotheses about the challenge of decarbonising heat in the UK. Through this approach SSH2 sought to strengthen the evidence base and strategic understanding of viable, consumer-friendly and cost-effective routes to heat decarbonisation.

Five key hypotheses

Start with the consumer, not the technology

Understanding consumers' energy needs and preferences is crucial to facilitate the uptake of low carbon technologies.

Digitalisation offers significant potential
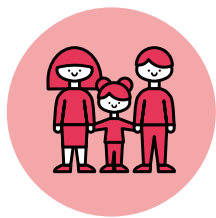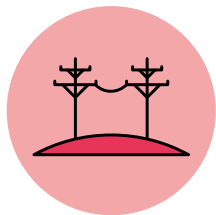
Smart connected home devices could reveal consumer preferences, enabling radically improved innovative energy products and services.

Heat as a Service could be a powerful proposition

New energy service business propositions have high potential to enable a smooth low carbon transition for consumers.

Understanding different local energy systems is essential

Developing a tailored plan for local energy systems is a crucial component of achieving cost-effective decarbonisation.
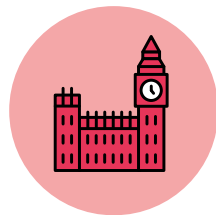
Heat decarbonisation will require market changes/ policy drivers

A clear low carbon policy driver is necessary to address market barriers and create the right incentives for businesses.

SSH2 comprised three main workstreams to test these hypotheses around the challenge of heat decarbonisation in the UK:

1. **Consumer trials of smart energy propositions**
   The design, development and implementation of sophisticated consumer trials, in particular to test Heat as a Service propositions in a real-world environment in constant engagement with consumers.

2. **Local area energy planning**
   The outputs of the modelling analysis and long-term strategic planning done at local level during SSH1 were used to identify viable, tailored project opportunities and spelled out in a live Smart Energy Plan document that sets out a near-term agenda for deployment and innovation projects to decarbonise the local energy system.

3. **Analysis of new business models and market structures**
   Detailed research into transformations happening in the market, analysis of new business models and potential decarbonisation policies.

Further details of the methodology, processes and key findings from each of the three building blocks are explained in the sections that follow.

3.2. Trialling smart energy propositions in real homes

Decarbonising heat will bring change for consumers in their home environment. Hence the design of low carbon solutions that can appeal to consumers will require deep understanding of consumer needs and preferences. Consumer research under SSH1 revealed the importance of finding ways to decarbonise domestic heating which consumers will welcome and reflects the different ways consumers choose to heat their homes.

SSH1 identified and explored three major consumer challenges to decarbonising heat, beyond the differences in cost between high and low carbon technologies[5].

1. People find it hard to control how much time/effort/money they spend getting what they want from their current heating systems (mainly gas boilers).

2. It is hard to deliver high-quality, low carbon solutions.

3. People often need to prepare their homes (e.g. with insulation, draft proofing, heat network connection etc.) to make low carbon heating a viable alternative when they replace their system.

The SSH2 (2017/18) winter trial built on that and sought to learn more about how consumer expectations can be understood, shaped and bound. It also considered the question of how to price delivering service 'outcomes' (e.g. the concept of 'warm hours') as opposed to the sale of commodity kilowatt hours.

The trial involved over 100 homes in Birmingham, Bridgend, Manchester and Newcastle and aimed to test a new service-based business model for the delivery of energy services to domestic customers i.e. Heat as a Service (HaaS), marketed to consumers as a Heat Plan.

We developed and then trialled in the participating homes Home Energy Services Gateway (HESG) (see section 3.2.2) – a proof of concept digital platform that, in addition to multi-zonal control, allowed participants to monitor their energy use and the status of their monthly Heat Plan (see section 3.2.3).

The data collected through additional sensors and control devices installed in the homes and the user experience feedback gathered through surveys and workshops with participants provided further insights into consumer preferences. This in turn can enable energy service providers and device vendors to formulate better service and product offerings. The findings also allowed us to build understanding of the potential for digitalisation and service-based energy business models to improve the acceptability and encourage adoption of low carbon heating solutions.

What is Heat as a Service?

Heat, or Energy as a Service (HaaS/EaaS) propositions involve consumers purchasing service bundles or 'outcomes' in place of 'commodity' kWh's. SSH1 consumer research identified that people use heat in different ways to get comfortable, clean, care for others, enhance their health and protect their home.

At present, consumers pay for their heating according to how much fuel they use. We explored the idea that consumers could instead pay for a service outcome that they get from their heating e.g. a number of 'warm hours' purchased as a Heat Plan from a service provider.

3.2.1. The trial

SSH2 built on the home energy management and building retrofit trials delivered earlier in SSH1, to create the 'Living Lab' of over 100 owner-occupied homes to test the concept of Heat as a Service. The increased complexity of the trial features and objectives required successful negotiation of several stages described in the figure below:

Design
- Define trial objectives: 1) understand, shape and bound customer service expectations; 2) price risk in meeting those expectations affordably and competitively; 3) design and deliver a initial 'Heat as a Service' proposition
- Update and add advanced functionalities to the HESG software

Recruitment
- Recruit 100 households by telephone
- Screen participants for basic requirements (e.g. presence of gas boilers, home ownership, not early adopters of smart home technology, workability of our system in their home)

Installation
- Install of smart control devices and HESG software
- Enabled participants to use the HESG platform and interface

Trial operation
- Collect data on consumers' energy use
- Design and offer heat plans to participants
- Research: surveys, workshops and interviews with participants (re. service choice & usage)

Decommissioning
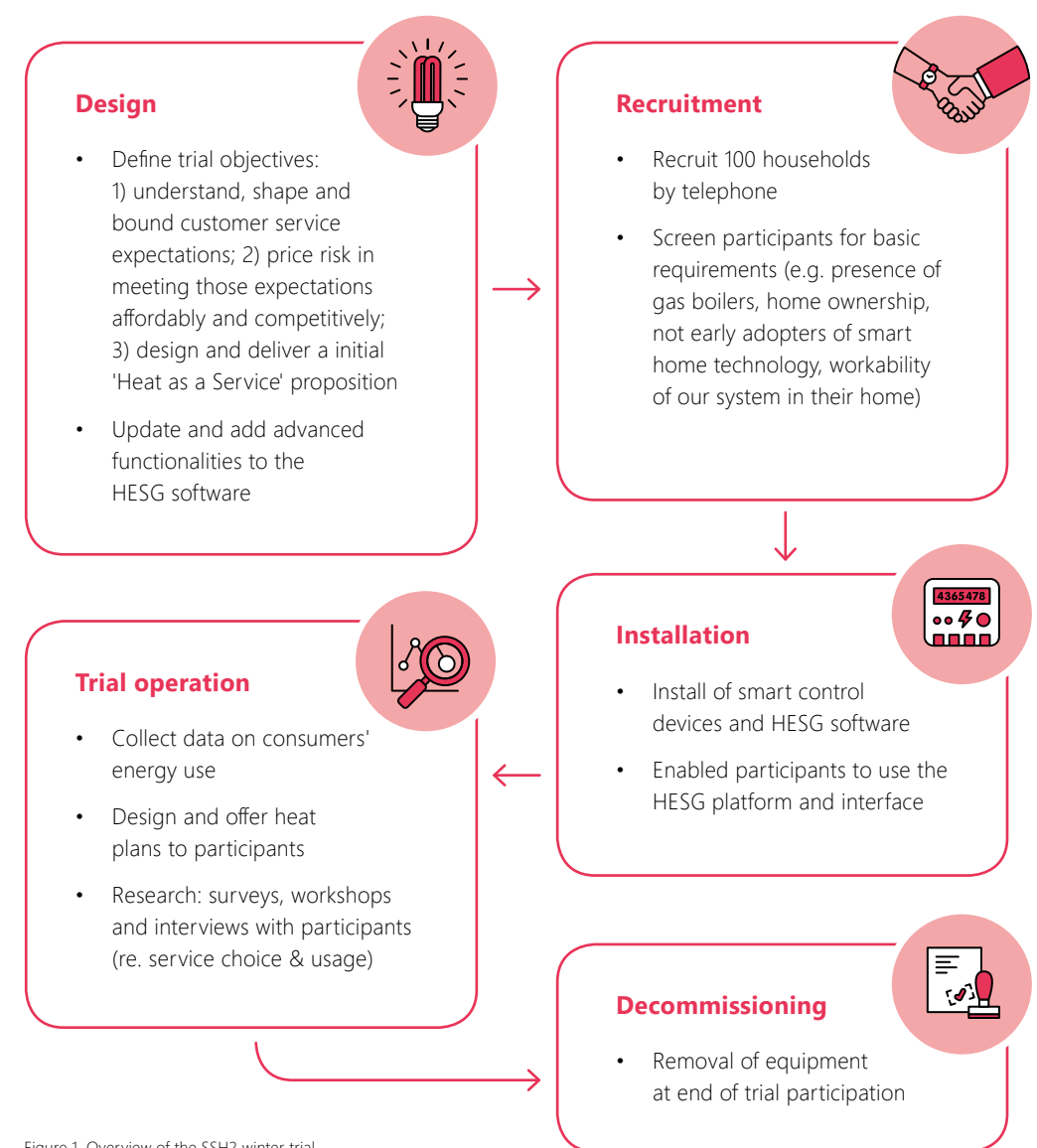- Removal of equipment at end of trial participation

Figure 1. Overview of the SSH2 winter trial

5   ETI (2015) Consumer challenges for low carbon heat: ETI insights report

3.2.2. Home Energy Services Gateway (HESG)

HESG is designed as proof of concept for an open, interoperable digital platform to enable many different businesses to collaborate so that they can discover how to deliver high value, low carbon energy products and services.

Individual radiator surface temperature sensors

Individual radiator controllers

Central boiler controller

Utility flow meter

Water pipe sensors

Individual room temperature and humidity sensors

Four million data points per home per day

Understanding consumer preferences

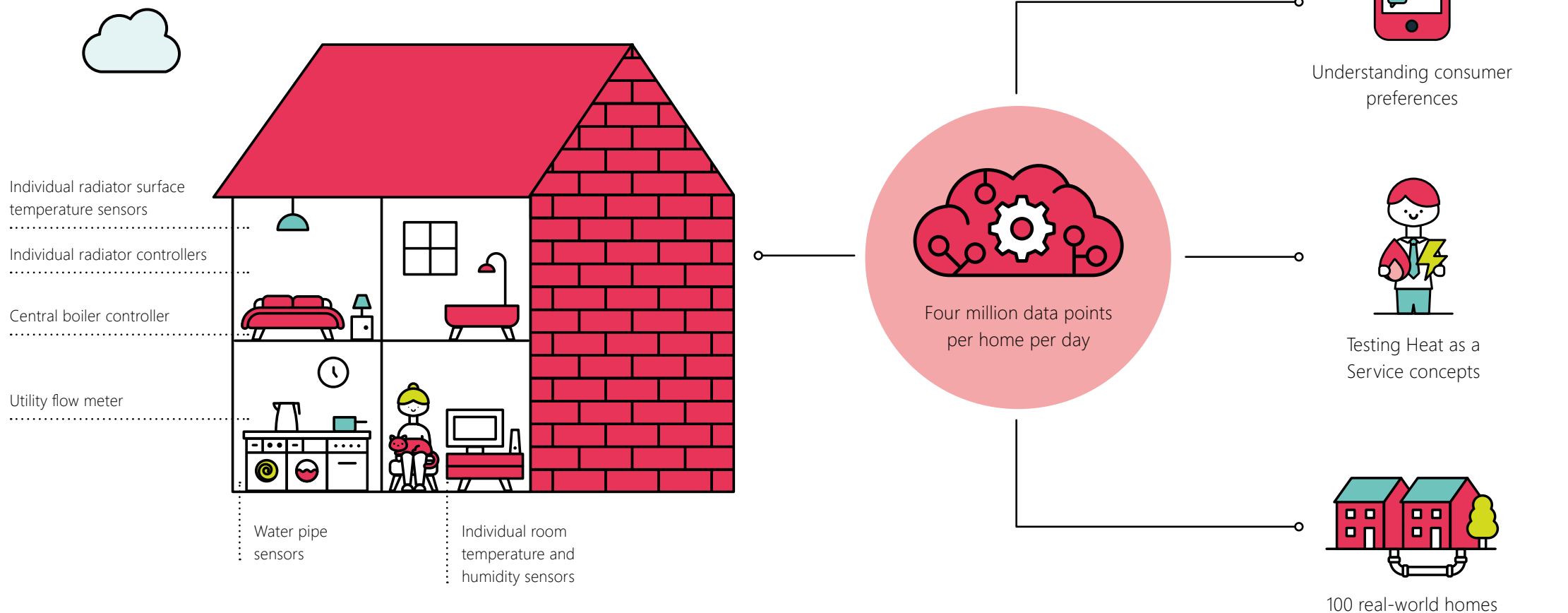Testing Heat as a Service concepts

100 real-world homes

Figure 2. Overview of the Living Lab

This trial used HESG to offer households smart energy propositions (notably Heat as a Service propositions or Heat Plans) and to understand their reactions to them. The main efforts in developing the HESG platform were directed towards the trial of Heat Plans (see section 3.2.3).

The platform served two main purposes:

Enhanced control over heating (for users): the user-friendly mobile app offered participants improved control over their heating system. HESG's four main functionalities allowed users to:

- set their desired temperature for each room

- schedule warmth by time of the day in each room of the house, with the system automatically taking the required actions (e.g. turn on the boiler) to reach the set temperature according to the schedule for each room

- monitor their heat usage via the app to help them discover which Heat Plan would meet their needs; and

- buy and use a Heat Plan.

Monitoring temperature and energy use: the data sent by the various sensors and devices enabled us to continuously monitor consumer energy use patterns (electricity and gas), building and heating system performance alongside data on external weather conditions.

Overall participants reported good experience with the heating control functionality offered through HESG and found that the improved interface design was easy to use and accessible.

3.2.3. Heat Plans

SSH2 explored the introduction of the Heat Plan concept to consumers, and the transition to paying for a set of desired outcomes.

Heat Plans when combined with smart controls are highly bespoke to each household. Each household can choose the Heat Plan that best matches its preferences. Smart controls then operate to deliver the chosen service outcomes, reflecting the specific performance of the household's home in terms of heating and cooling.

Heat Plans allow consumers to get the heating they want while paying a predictable fixed price for a specific outcome, for example an hour of heating (referred to as a 'warm hour').

Each offer showed (Figure 3):

- the number of warm hours included in the heat plan;

- whether the plan would allow the participant to alter their heat schedule and, if so, how that would work;

- the price of their plan each week;

- a breakdown of the cost of the plan in terms of the number of pence per warm hour;

- how much an 'extra' warm hour would cost should the participant like to use more hours than were on their plan.
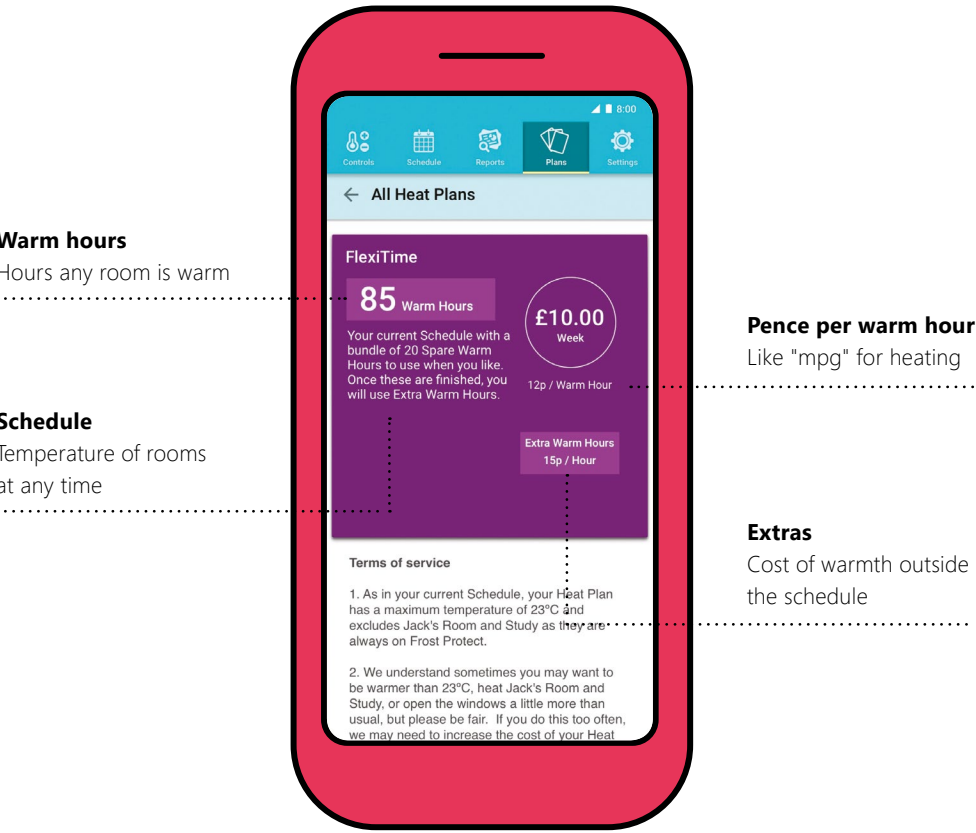
Figure 4 provides an overview of the uptake of Heat Plan during the SSH2 winter trial.

An important aspect of this research was to help develop a pricing model for heat services. Future energy service providers will need to determine how to price their services at a level that means they can afford to deliver the services, however one that is sufficiently competitive to attract customers. There are risks that make this a challenge.

For this trial, an experimental pricing model for the Heat Plans was constructed to explore how consumers would respond to them. This provided insights into what worked well, what did not work, and ultimately how to refine pricing models so that they work for both consumers and energy service providers.

Three different Heat Plan options were offered:

- **FixedTime**
  The least expensive and most restrictive plan – participants paid a fixed price for fixed heating schedule (priced at a discount to the commodity cost of weekly gas use).

- **FlexiTime**
  The mid-priced plan that allowed participants to change their schedule, including a number of spare warm hours (priced at a small premium to the commodity cost of weekly gas use).

- **Unlimited**
  A fixed price plan allowing for an unlimited number of warm hours (priced at a significant premium to the commodity cost of current weekly gas use to reflect the plan's flexibility).

Warm hours
Hours any room is warm

Schedule
Temperature of rooms at any time

Pence per warm hour
Like "mpg" for heating

Extras
Cost of warmth outside the schedule

FixedTime	FlexiTime	Unlimited
Popular plan choice (21 out of 47 households)	Most popular plan choice (25 out of 47)	Least popular plan choice (1 out of 47)
Pricing: ~ £10/week (avg)	Pricing: ~ £15/week (avg)	Pricing: > £30/week (avg)
Cost saving focus	Households willing to pay for freedom to change timing of warm hours	Six households chose to upgrade to this plan through a flash sale
Usage patterns generally consistent (i.e. most of planned hours)	Used fewer planned hours	Usage did not increase following upgrade from FlexiTime
More likely to use extras	Little use of extras, enough flexibility built in	

Pricing and consumer value

- Overall Heat Plan adopters were willing to buy Heat Plans at a premium to their prior average weekly spend on energy.

- However, price was one reason many participants chose not to buy a Heat Plan, implying that the plan pricing points used in the trial were too high for a significant minority.

Figure 3. Sample Heat Plan offer, as shown to participants through the HESG user interface.

Figure 4. Overview of Heat Plan uptake

The heat experiences people want and the choices they make reflect what they think is most important. Experience from the SSH2 winter trial suggested that consumers' priorities can be characterised as reflective of three main perspectives:

62%

Comfort focussed

- Liked the experience of comfort from new controls
- More likely to sign up for a Heat Plan
- Preferred FlexiTime Plan – the extra hours gave reassurance they could stay comfortable

17%

Value focussed

- Loved feeling in control of both cost and comfort – though they were less likely to change their settings
- Like to know what they are paying
- Not afraid to haggle (e.g. over summer payments)

21%

Cost focussed

- Know what they pay now and compare prices to this
- Switch frequently, so more open to something new
- Preferred FixedTime plan: helped them to fix costs
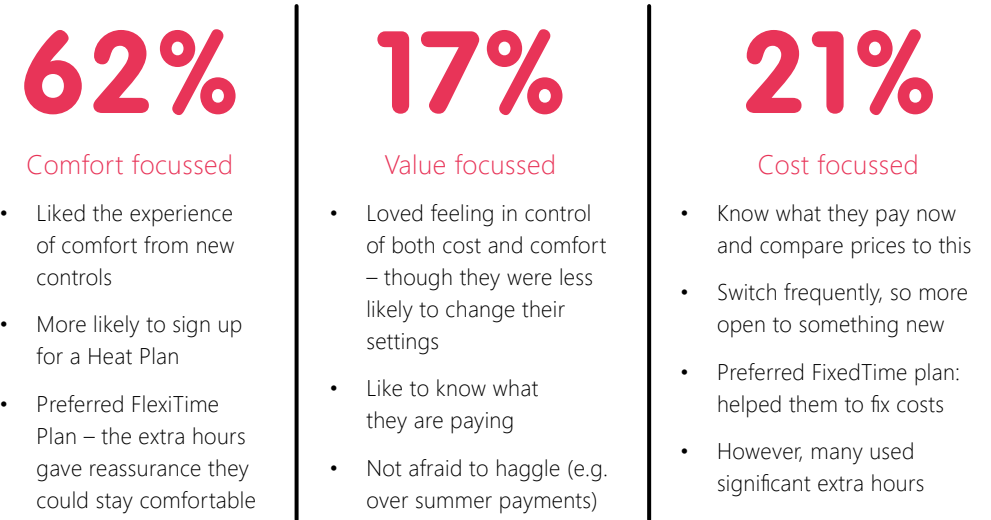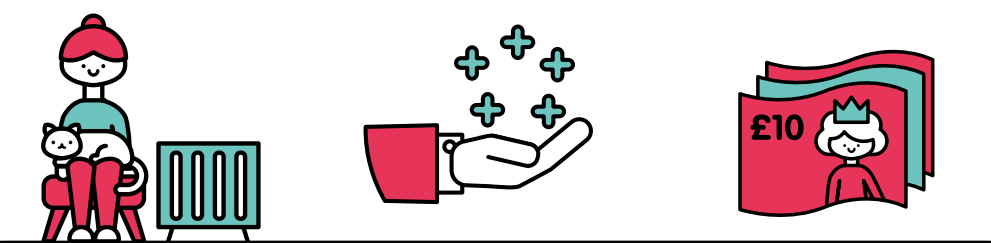- However, many used significant extra hours

Figure 5. Consumer priorities from SSH2 winter trial

The trial enabled us to validate earlier insights into consumer needs, building a richer picture of how consumers (owner-occupiers) think about and interact with their domestic heating. In particular, the trial deepened understanding of how consumers are likely to respond to new smart energy propositions, including Heat Plans.

Below, we summarise the key findings.

1. The trial confirmed wide variation in how consumers heat their homes

The digitalised nature of the trial made it possible to move beyond what people say they want from their heating system to seeing how they actually behave. This understanding was then supplemented by consumer research to understand people's motivations and perceptions.

The trial confirmed previous work showing the significant variation in how people heat their homes. Each household is unique in the amount of time and effort they are willing to spend controlling their heating, the rooms they choose to heat, the ranges of temperatures they use to feel comfortable, and how much money they are willing to spend on getting the heating experiences they want.

Although there was wide variation, some broad patterns were discerned about the duration, spatial character and temperature characteristics of household heat demands.

- In duration of heating demand, we identified three broad segments among participants: longer than 110 hours/week, 60-110 hours/week, less than 60 hours/week (Figure 6).

- In relation to the space that participants wanted to heat (i.e. how many rooms they wanted to be warm), again we identified three segments: circa one-quarter of rooms; one-half or two-thirds of the rooms in their home.

- In relation to the temperature participants were seeking to achieve, six profiles were identified and are described as: Cool Conservers; Hot/Cold Fluctuators; On-demand Sizzlers; Steady and Savvy; On/Off Switchers; Toasty Cruisers (Figure 7).

- There was wide variety in the extent to which participants changed their heating (i.e. from setting a schedule and leaving that largely unchanged to making numerous changes to the heating requirements according to their own schedules and the needs of the household).
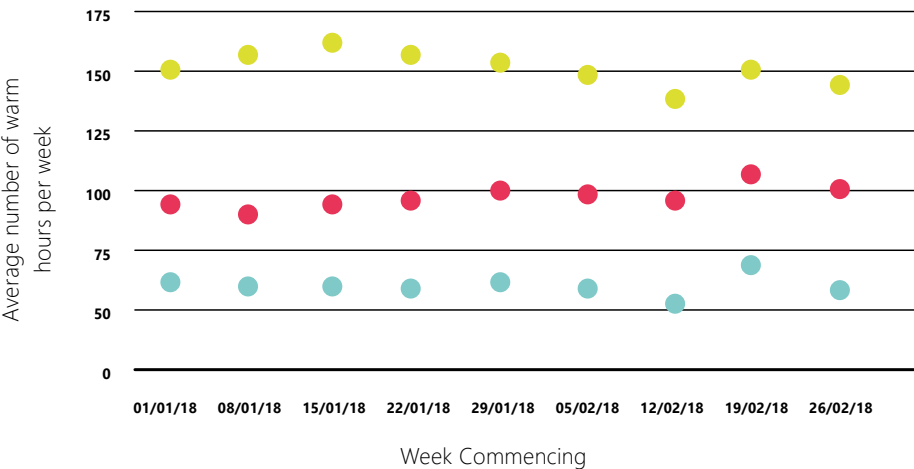

Figure 6. Duration of heating demand during winter trial

High	>110/week	approx. >15/day
Medium	60-110/week	approx. 8-15/day
Low	<60/week	approx. <8/day

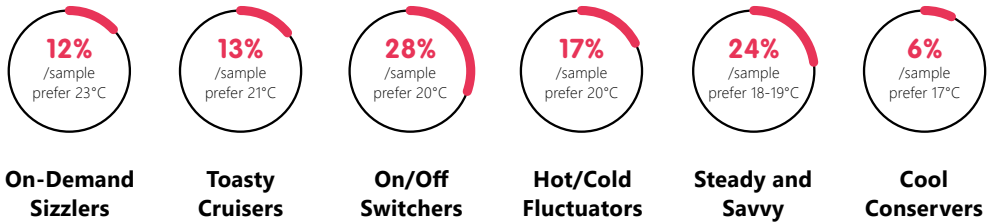| 12% /sample prefer 23°C	13% /sample prefer 21°C	28% /sample prefer 20°C	17% /sample prefer 20°C	24% /sample prefer 18-19°C	6% /sample prefer 17°C
On-Demand Sizzlers	**Toasty Cruisers**	**On/Off Switchers**	**Hot/Cold Fluctuators**	**Steady and Savvy**	**Cool Conservers**

Figure 7. Percentage of participants within each heating profile

2. The trial demonstrated that smart energy propositions can enable improved consumer experience and innovation

The evidence from the 2017/18 winter trial, which is consistent with previous research (see Figure 1 and Figure 3) is that digitalisation can help tackle key barriers to the adoption of low carbon solutions.

Participants enjoy improved control that comes from digitalisation. Figure 8 shows that most participants responded very positively to having better control over their heating. In some instances, this was because improved control had revealed limitations of their pre-existing heating system that restricted their ability to get comfortable, helping consumers to identify targeted improvements such as insulation or larger radiators.

In some cases, however, physical limitations of the buildings and technical issues experienced with the proof of concept HESG platform caused some households to report decreased level of comfort.

- Households used their new-found control in different ways (temperature, total number of hours of warmth, rooms they heated, how much flexibility they wanted). This reflected different preferences in terms of what they enjoy and how much they want to spend/use.

- The trial showed that data about the ways consumers used their heating could help improve design of low carbon heating solutions (by guiding the design of a heating system that integrates components to deliver an experience tailored to what the household wants).

- Data showed that there are problems such as damp, draughts and overheating, highlighting that many households' current heat experiences are sub-optimal. This indicates that, with careful design, there is potential for smart energy services to improve the way consumers experience heat at home, as they transition to low carbon solutions.

- Participants were open to upgrades such as larger radiators being included in the cost of their plan and, crucially, trusted tailored recommendations based on data from their homes.
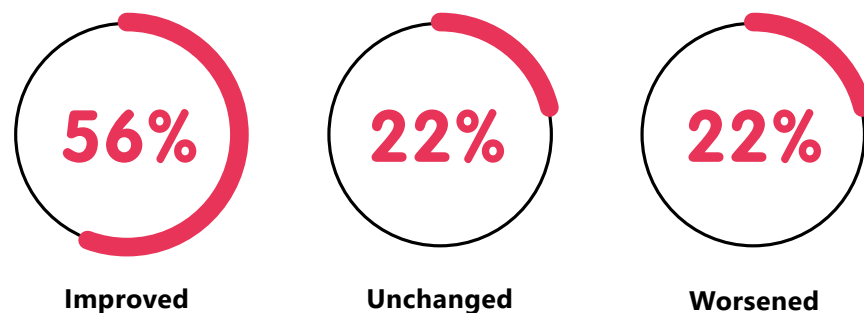
56% **22%** **22%**
Improved **Unchanged** **Worsened**

Figure 8. Percentage of trial participants whose comfort levels changed because of smart controls installation

3. Consumer-friendly smart energy propositions, such as Heat Plans, can enable adoption of low carbon heating

- Heat Plans were more popular than was originally anticipated (with around half of participants opting to buy one as opposed to a 10% expected uptake).

- On average, participants paid more for Heat Plans than they were paying for their energy. Two thirds said they would be more likely to recommend their supplier if it offered Heat Plans.

Participants receptiveness to low carbon heating solutions

Open	Unsure	Closed off

Figure 9. Participants receptiveness to convert their gas boilers to low carbon alternative heating solutions

- Participants were learning throughout the process. People need to experience how service offerings work before they understand the benefits and know exactly what they want. Feedback from participants included: "Well, put it this way. Now I know what they do, I would. … Now I'd definitely say to anybody, 'If you get the chance, pay a couple of pounds a week, don't worry about it. Do it.'"

- The Heat Plans that people purchased revealed their willingness to pay for different types of service. This kind of information can reveal how much people would pay for low carbon heating that improves their experience and comfort at home.

- As shown in Figure 9, 58% of participants who had purchased a Heat Plan were open to the idea of having an alternative low carbon heating system when it came to replacing their gas boiler (as opposed to 36% of households in our segmentation survey of the wider population, n=3,000). This increased to 85% if unsure participants could be given a guarantee that their current levels of comfort and cost could be met (which is what Heat Plans are designed to do). This implies that Heat Plans or other service propositions could increase consumers' openness to switch from gas boilers and adopt alternative low carbon heating upgrades.
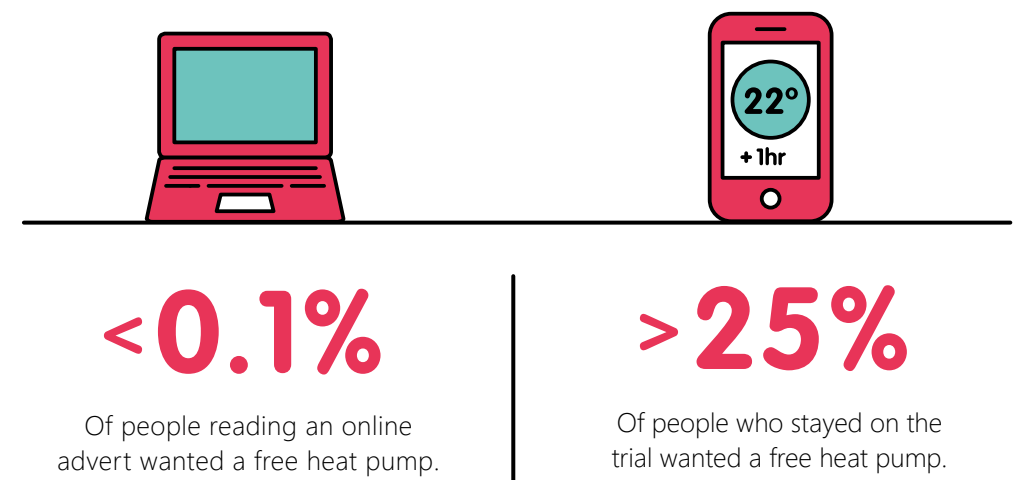
22°
+ 1hr

<0.1%
Of people reading an online advert wanted a free heat pump.

>25%
Of people who stayed on the trial wanted a free heat pump.

Figure 10. Openness to adopting a heat pump

Our efforts to recruit households to trial heat pumps also suggest that people who have experienced Heat Plans are more inclined to switch to low carbon (Figure 10).

When we tried to offer free heat pumps to households, it was extremely difficult to recruit participants through online advertising. Previous Heat Plan triallists were much more open to changing their heating system, and five agreed to having a heat pump installed.

3.3. Working with local authorities on Local Area Energy Planning

3.3.1. The concept of Local Area Energy Planning

Action at local area level has an important role to play in enabling the UK's transition to a low carbon future and decarbonising the delivery of heat to homes and buildings. The challenge of shifting homes and buildings to low carbon heat solutions will entail major changes to local energy networks, homes and buildings. Planning and effective delivery of change on this scale will require close collaboration, coordination and decision making involving different stakeholders at local and regional levels.

The concept of Local Area Energy Planning (LAEP) was developed under SSH1 to enable more effective analysis, planning and collaboration by local stakeholders on local energy transitions.

What is Local Area Energy Planning?

LAEP is a collaborative process to create coherent plans for local energy system change to achieve deep decarbonisation. Developed through SSH1, the process involves exploring a range of different future local energy scenarios based on a fusion of spatial planning, energy network planning and strategic review of building energy performance. It takes a whole system view, accounting for building energy performance, heating technologies, electrification of transport, the capacity of and potential for gas, power and heat networks, local spatial constraints and opportunities. It involves area-specific energy system modelling embedded in a process of collaborative dialogue between stakeholders and local government.

7 steps in the local area energy planning process

1. Identify and engage stakeholders
2. Set area vision, objectives and targets
3. Create and understand the local area energy system
4. Investigate future local energy scenarios
5. Produce a Local Area Energy Strategy
6. Lead and implement
7. Monitor and review

SSH1 piloted the process in three local areas[6] and developed a range of tools and guidance to support local authorities in formulating long-term strategic plans in line with local priorities and targets.

The SSH1 work also resulted in the development of EnergyPath Networks (EPN), an advanced local area energy system modelling and analysis tool to provide a firm analytical and empirical grounding for exploration of future scenarios and formulation of plans.

This kind of local area energy planning process can identify key projects and major investments through a transparent, consensus-based process involving all local stakeholders (residents, businesses, local government, energy network operators and politicians). A collaborative planning approach can bring significant benefits:

- A clear pathway to meeting ambitious national decarbonisation objectives, based on locally specific, viable and cost-effective plans.

- A focus on whole system and multi-vector planning that should realise system-wide efficiencies and secure value for money, while limiting increases in consumer bills.

- A credible local area energy plan that establishes a basis for assessing or contesting energy developments in local spatial planning applications.

- A framework for targeting investment and funded programmes directed at fuel poverty and improving building energy performance.

- A way of providing evidence to target investment in network infrastructure upgrades, meeting an efficiency requirement of Ofgem's network price-setting process that provides the capital for network investment.

- The potential to use local area energy planning as a basis for accountability, governance and performance management in this space.

- A compelling and locally specific narrative for meaningful engagement with local citizens and businesses in the national effort to decarbonise, adding a democratic element to the significant changes ahead.

Each local area is different in its geography, building stock, and current plans for network and retrofit investment, future emission reduction ambitions and priorities. All of these are factors likely to influence the shape and pace of future change to their local energy systems including solutions for domestic heating.

Currently, there is no structured planning process in place to manage this activity. A new approach to planning and delivering local energy systems is needed if we are to meet the challenge of climate change and deliver a resilient and low carbon energy system that works for people, communities and businesses.


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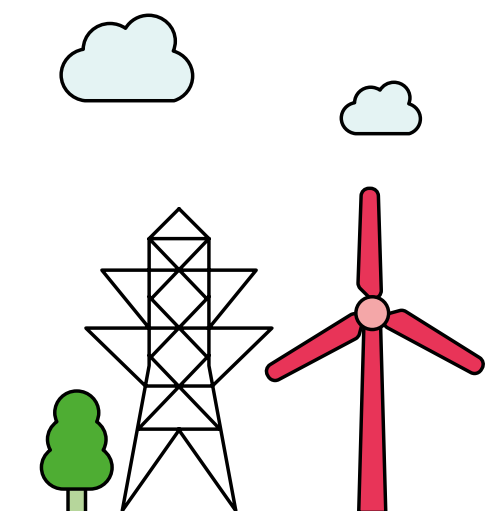
6   A range of guidance and reports on local area energy planning were published in 2018 and can be accessed via this link https://es.catapult.org.uk/news/6952/. The ESC document Local Area Energy Planning: Supporting clean growth and low carbon transition provides a comprehensive overview.

## 3.3.2. Developing actionable local Smart Energy Plans

SSH1 worked collaboratively with three local areas (Newcastle, Bridgend and Greater Manchester) to pilot LAEP. As part of SSH2 we continued to work with these three local areas to build on the SSH1 analysis and plans and to identify actionable near-term projects and investments.

Continued to collaborate with the three local areas
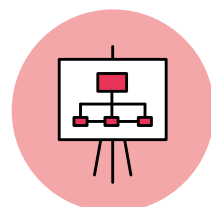
Supported developing their local smart energy plans
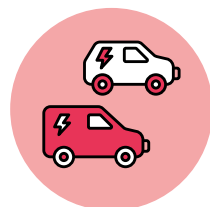
Connected to wider local priorities such as fuel poverty and transport

Used to stimulate a pipeline of near-term deployment and innovation projects

Figure 11. Overview of SSH2 local area energy planning work

The focus of the SSH2 LAEP work was to translate local whole system modelling and analysis into actionable Smart Energy Plans, focussing on a range of near-term (up to 2025) deployment and innovation projects targeted on addressing the technical, commercial, policy and consumer barriers to low carbon heat in each local area.

Each Smart Energy Plan defined a roadmap of projects and activities to enable each local area to progress its low carbon transition (for more information see the ESC website)[7]. In each case the strategy, priorities, objectives, success criteria and project pipeline are highly tailored to the local context and vision.

The process for developing the plan builds on the modelling outputs produced in SSH1 (included in the Local Area Energy Strategy documents developed for each local area under SSH1) and develops them further by identifying concrete project opportunities to enable deep decarbonisation of heating systems across the area. This allows the local authority not only to set up a clear agenda for near-term decarbonisation activities, but also to kickstart the engagement process with strategic stakeholders to deliver projects.

Overview of key elements of Smart Energy Plans developed under SSH2.

01

Bridgend County Borough

Deployment projects focussed on opportunities for establishing district heating networks to supply public buildings in Bridgend's town centre and connecting proposed new housing developments.

Other projects focus on improving fabric energy efficiency of existing homes through established public funding programmes.

Innovation projects include:

- targeting higher value retrofit measures in existing homes through better data and control

- better understanding of hybrid heating, informed by learning from the FREEDOM project

- utilising existing mine water resources to supply low temperature district heating in Caerau

- developing more affordable urban heat network solutions to support town centre expansion

- developing innovative Energy as a Service business models to transition gas heated homes.

02

Newcastle

Deployment projects focussed on the development of district heating in the city centre to supply existing high-density buildings and planned heat network developments at sites through an energy services partnership with Engie. The development of a Municipal Energy Services Company is also proposed.

Innovation projects include:

- understanding the potential viability of hybrid heating with demand side response

- demonstration of fifth generation low temperature district heating and cooling solutions

- developing Energy as a Service to support low carbon heating solutions for fuel poor households

- using better data and simulation to target heating and building fabric upgrades in social housing.

03

Greater Manchester

Deployment projects focus on development of district heating networks across the region. Decarbonisation of heat is identified as a strategic priority alongside generation and storage, low carbon transport, and diversity and flexibility.

Innovation projects include:

- connecting and managing hundreds of homes retrofitted with electric heat pumps, solar PV, electrical and thermal storage

- testing large-scale uptake of electric heat pumps in existing gas heated homes through Energy as a Service business models

Greater Manchester is also proposing a series of Innovation Zones to host scalable innovation projects and is investigating establishing an Energy Innovation Company.

3.3.3. Key findings

Local area energy planning identifies a diversity of solutions:

The local area energy plans for each area developed under SSH1 included a different optimal mix of heating solutions (including electric, hybrid and district heating) in combination with targeted retrofit, thermal storage and improved control as a cost-effective transition to low carbon heat. The three Smart Energy Plans developed by each of the three local authorities reflect this diversity in the roadmap of projects they identify.

For example, Figure 12 shows the breadth of potential heating solutions identified to decarbonise specific target areas in Bridgend County Borough Council (BCBC).
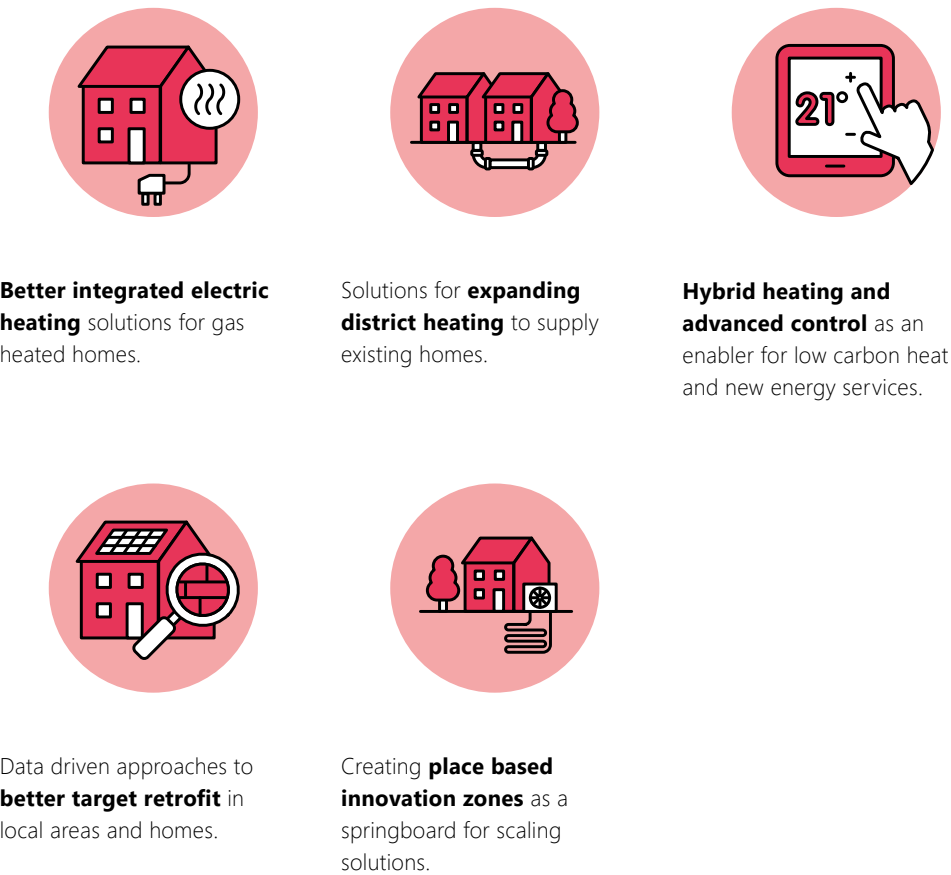
Better integrated electric heating solutions for gas heated homes.

Solutions for **expanding district heating** to supply existing homes.

Hybrid heating and advanced control as an enabler for low carbon heat and new energy services.

Data driven approaches to **better target retrofit** in local areas and homes.

Creating **place based innovation zones** as a springboard for scaling solutions.

Figure 12. Overview of potential heating solutions in Smart Energy Plans

Planning	Testing	Further testing and roll-out
2016	**Today** · 2025	**2050**

Bridgend Data

Local Area Energy Planning

Local Area Energy Strategy

Smart Energy Plan (2018-2025)

Smart Energy Plan delivery:

• Build strategic partnerships

• Deliver innovation projects

• Stimulate the local economy through investment and industry growth

Use learning from Testing period to:

• Devise future Smart Energy Plans

• Make confident decisions

• Encourage further economic growth

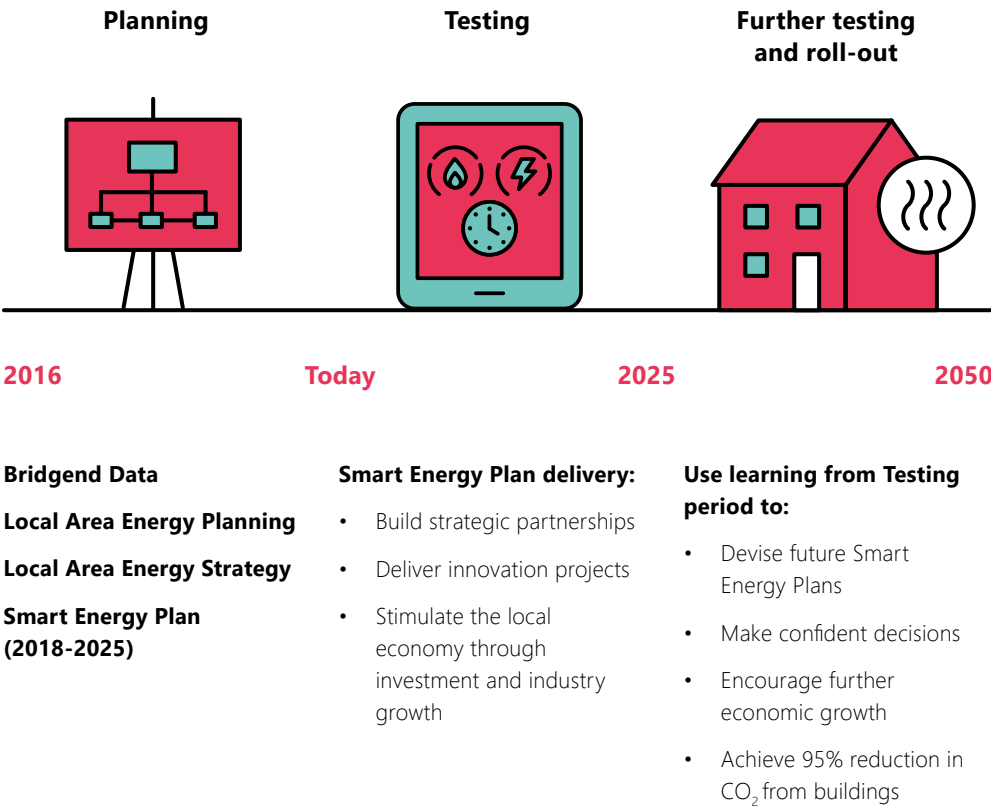• Achieve 95% reduction in CO_2 from buildings

Figure 13. Overview of local area energy planning phasing for Bridgend

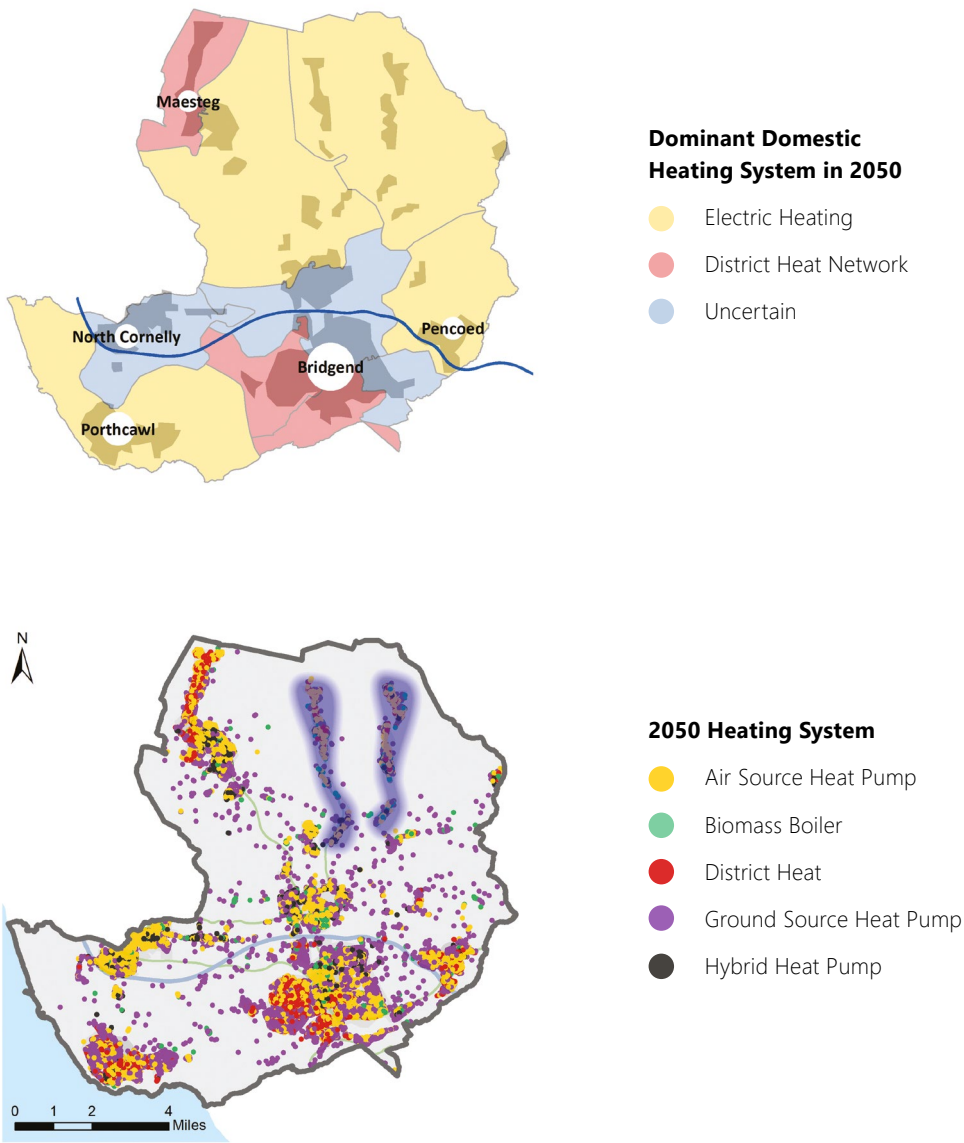**Local area energy planning can provide the evidence and focus to structure tangible action:**

The work carried out to develop Smart Energy Plans has shown how the longer-term strategic LAEP analysis (in SSH1) can establish a framework for identifying and planning tangible action and deployment projects to progress decarbonisation at local level. Detailed evidence based future local energy scenarios can be translated into more specific plans of what/where/when with near-term projects/activities aligned to longer term vision and targets.

Figure 13 illustrates the broad phasing of this process, with the smart energy planning carried out in SSH2 providing the link between strategic planning and action on the ground.
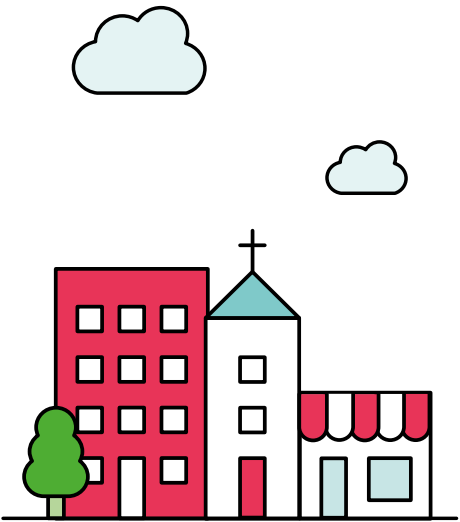
3.3.3. Key findings

Figure 14 illustrates how the long-term energy transition scenario outputs from detailed local area energy modelling (using EnergyPath Networks) were used to provide the longer-term context for the planning of nearer-term deployment and innovation projects (example drawn from the Bridgend County Borough Council Smart Energy Plan).

Dominant Domestic Heating System in 2050

- 🟡 Electric Heating
- 🔴 District Heat Network
- 🔵 Uncertain

2050 Heating System

- 🟡 Air Source Heat Pump
- 🟢 Biomass Boiler
- 🔴 District Heat
- 🟣 Ground Source Heat Pump
- ⚫ Hybrid Heat Pump

🟠 **Innovation Projects**

1. Fully Targeted Retrofit
2. Hybrid Heat Pumps and Full Electrification
3. Caerau Mine Water Gas-to-District Heating Transition
4. Affordable Urban Heat Networks
5. Electrification of Heat through Energy as a Service

🟢 **Deployment Projects**

1. Bridgend Town Lower Carbon DH Network Phase 1
2. Bridgend Town Lower Carbon DH Network Phase 2
3. Energy Efficiency Projects

🟣 **Approximate Project Areas**
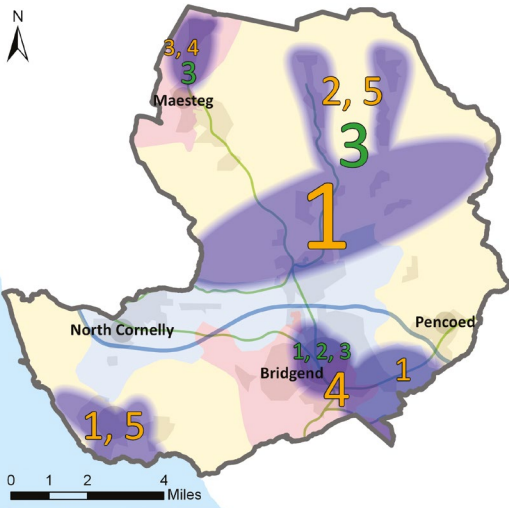
Building consensus and a shared view of the future is a key challenge requiring a structured and continual open dialogue and planning process

The SSH2 experience in facilitating the development of Smart Energy Plans clarified the need for continual and ongoing dialogue to build impactful local plans and consensus. The modelling, analysis and development of a long-term local area energy plan does not in itself drive action. The whole system analysis helps to identify and justify project types and locations, which helps to secure buy-in from stakeholders, potential partners and potential funders. But its translation, through collaboration and consensus, into actionable nearer-term projects and investments is crucial.

Local area energy plan evidence and documents need to be used actively to inform decisions on issues like:

- the targeting of public retrofit programmes
- near-term investments in networks to support carbon reduction goals
- planning and policies for new build, new growth and housing development (for example Bridgend is examining how the Local Area Energy Strategy and associated Evidence Base can inform policies in the next version of the Local Development Plan)
- the likely potential for future heat network development.

Ultimately local plans will need translating to detailed design solutions that are investable and implementable.

Figure 14. Translating long-term local area energy modelling into near term innovation and deployment projects in the Bridgend Smart Energy Plan

Smart Energy Plans reflected local priorities, opportunities and funding – they can become more integrated over time.

Local priorities and opportunities in Smart Energy Plans

01

Bridgend

- Local area energy analysis (using EPN model) provides evidence and affirmation of heat network projects.

- Business modelling has supported the Caerau minewater scheme, with the SSH team providing a sounding board and managerial capacity.

- Key local aims: enabling and hosting business developments which test new energy products and services, integrating heat, power and transport through digital platforms.

- Current funding is largely from the European Regional Development Fund (ERDF) and the public sector, with unresolved questions of finance for infrastructure such as heat networks.

02

Newcastle

- The LAEP report and evidence has informed planning for low carbon district heat and cooling networks; and work on domestic gas hybrid heat pumps.

- Integration of low income and fuel poor households into demonstration projects and addressing affordability of heat is a key priority focus.

- Plans for development of a municipal energy service company business model. Funding for this and other projects remains largely unresolved.

03

Greater Manchester

- The Smart Energy Plan situates the LAEP report and evidence, based on Bury, in wider plans for a carbon neutral city region by 2038.

- Proposed extension of EPN modelling to all areas of Greater Manchester, to inform plans for heat decarbonisation.

- Heat is treated as part of an overarching strategy to transform the city region through innovation across heat, power, transport, storage and digital infrastructures.

- Again, current funding is largely from ERDF and the public sector; routes to other financial investment remain largely unresolved.

Local area energy planning needs further support and development if it is to drive effective action

Despite increasing enthusiasm (often from local authorities) for mobilising local action on heat, the absence of a clear statutory mandate and limited capacity and capability are significant barriers to realising its potential.

Further work is needed establish the framework for local area energy planning to shape and drive action on the ground. This includes further action to:

- rationalise the planning system to meet local emission reduction targets by taking a holistic whole systems approach as a key component of the local planning process;

- support and create funding opportunities for local area energy planning and evaluate options for decentralising to regional energy hubs;

- consolidate insights from local area energy planning and undertake national-level analysis to ensure that local action aligns with and informs national strategy.

3.4. **Analysing new business models and market structures**

3.4.1. The scope of SSH2 'market transformations' work

SSH2 included a range of analyses and investigations designed to assess new business models and to build understanding of how the energy market may change to meet the challenge of decarbonisation targets through harnessing the potential of digitalisation.

In particular, the analysis sought to test the potential of Energy as a Service business models to act as a strategic, and consumer-driven, enabler of decarbonisation. We referred to these aspects of the SSH2 programme as the 'market transformations' work.

Consumer research under SSH1 revealed the importance of finding ways to decarbonise domestic heating that can support the different ways people choose to heat their homes. Current evidence suggests that low carbon heat options (e.g. heat pumps) will be less well-placed than gas boilers to deliver the service outcomes that consumers expect, unless they are assembled within new propositions and service bundles. Developing consumer-facing propositions that meet those demands is a key challenge for the UK's ability to decarbonise its economy.

Current market offerings make it hard for consumers to make low carbon choices. The current energy system, and related markets, is designed largely to enable the supply of an undifferentiated commodity (gas or electricity). Consumers looking to make low carbon choices face a lack of information on their home's suitability for new technologies, a fragmented supply chain and no clear financial incentive to choose a low carbon option (when on the gas grid) in the first place.

Faced with that challenge, the 'market transformations' components of SSH2 sought to address four key aspects of the low carbon transition:

- **Business models:** Characterise potential consumer-friendly heat/home energy propositions capable of enabling decarbonisation and making low carbon options attractive.

- **Consumers:** Identify low carbon heat service solutions and policy options that consumers find attractive or acceptable.

- **Interoperability:** Deepen understanding of the potential opportunities opened up by digitalisation and other new technologies, and what industry standards and processes may be required to unlock this potential.

- **Policy:** Define the broad characteristics of potential policy options that could best enable innovation and new propositions to support the transition to low carbon energy.

These questions were investigated using a mix of methodologies ranging from extensive literature review and research to consumer surveys, workshops and structured discussions with industry players and data analytics. Figure 15 summarises the range of approaches which underpinned the SSH2 'market transformations' analysis.

10 Business model families flow diagram produced

50+ Business models

28 Business model families

Business model canvassing

8 Business models evaluated in detail

6 Business models developed

EPO Demand Side Management simulation

NEDO New Energy Development Organisation data analysis

10 Workshops

4 Policy and stakeholder journey maps

6 Municipal Energy Service Company models studies

7 Analogous transitions

Figure 15. Key components of SSH2 'market transformations' work on new business models and market structures

3.4.2. Business models

A key theme emerging from our SSH1 analysis has been that building a better understanding of consumers and their homes is key to delivering the right solution to them. This underpinned our focus on smart energy service propositions as enablers of low carbon solutions.

We gathered a wide-range of information on possible energy service provider business models, starting with a literature review of the space which returned models ranging from 'off-grid cooperatives' to 'lifestyle services' (incorporating other aspects of life such as mobility). This list was distilled down to a small number of models with the greatest potential to deliver on domestic decarbonisation.

Trust is key to consumer acceptance of new business models

We developed detailed business model 'canvasses' around the models, and then tested their appeal in a workshop with consumers. The workshop revealed the importance of trust to consumer acceptance of new models, with transparency of motives and incentives key to consumer trust (e.g. it became clear that trust would be harmed if it was not apparent to consumers how a business model made money).

This highlights a risk that early negative public experiences could be hard to recover from unless we take a smarter approach to consumer protection in this new world. Large-scale trialling in a space where regulators can learn how to harness market forces to deliver products/services consumers value and protect them from the inevitable mistakes on the pathway to success would be highly valuable.

New business models can unlock flexibility

We also investigated how market signals could build financial incentives for delivering energy services, around heating. We analysed data from the GMCA project with Japan's New Energy Development Organisation (NEDO) project[8] where 550 heat pumps were operated in a demand-side response (DSR) trial, concluding that where there are strong incentives to do so (e.g. network constraints or short-term system issues) there is great potential for a business to deliver marked 'turn-down' of demand with relatively high consumer acceptance.

We also tested the potential for demand-side management business models, where actions are taken ahead of time to deliver the same outcome while modifying time of demand. We used our EnergyPath Operations™ (EPO) tool to simulate this for 1,000 electrically heated homes, using the proposed time of use network charges for one DNO (Green Amber Red banding) to pre-heat homes ahead of high peak energy use times. This demonstrated the potential to reduce network peak loading, while also modestly reducing and maintaining comfort outcomes for occupants. This small simulation demonstrates how a suitably incentivised service provider could deliver the same (or better) outcomes for a consumer while minimising system impacts.

Energy service provider business models could move the market to offer greater differentiation and better outcomes for consumers. Energy services create a commercial incentive for providers to learn how to deliver the outcomes consumers want while spending as little on energy as possible – for instance by using less or avoiding using energy at peak times.

Service provider business models can align opportunities and actors across the value chain

Our analysis of the current supply chain made clear that a step change in its capability to deliver low carbon heating will be needed to meet the level and pace of change needed. Key issues for the ability of the current supply chain to deliver low carbon exist around:

- **Scale:** there are 1.6 low carbon heat installers for every 100 registered gas installers.

- **Demand pull and incentives:** there is little demand from consumers and hence little current incentive for the supply chain to develop and offer low carbon solutions.

- **Quality:** with limited data on homes, there is a risk that low carbon installs are offered when they are not suitable, or not offered due to perceived risks in change.

- **Preparatory investment:** low carbon solutions may require preparatory investment in retrofit which is too disruptive or lengthy to deliver when a broken heating system needs replacement (distress purchase).

- **Lack of integrated offerings:** consumers are effectively expected to 'self-assemble' purchases and components of a complex system, with limited understanding or guarantee of the performance they can expect.

We studied the automotive industry where the supply chain aligns behind the primary holder of the consumer-relationship, the automotive manufacturer. Our analysis suggests that incentivised energy service providers could play a similar role in building capability and alignment through the low carbon heat supply chain. Energy service business models could open opportunities:

- for manufacturers to apply performance and usage data to improve their products

- for renovation businesses to offer energy retrofits that guarantee improved levels of comfort

- for networks to discover

  – how to warm homes, heat water and charge vehicles without using electricity when it does not suit the network (a much more appealing proposition to consumers than forcing them to navigate varying time of use tariffs to decide how to use energy at home)

  – how much consumers are willing to pay for additional capacity (note: the broadband and telecoms sectors discovered consumers were willing to pay for unlimited)

- to reduce transaction costs and commercial risk for investors in heat networks; they would be able to contract with providers to deliver consumers' energy services with district heat when they upgraded their heating systems, rather than working directly with thousands of households.

"Energy service provider business models could move the market to offer greater differentiation and better outcomes for consumers."

Market transformations in other sectors can offer important lessons for heat decarbonisation

In considering the risks and opportunities presented by new business models and the potential for market transformation, we conducted six studies of analogous market transitions in other industries (see table below for details of the specific issues considered in each case study). Overall, we found that the experience of market transformation in other sectors can offer rich insight for both policy makers and industry in thinking about strategic risks and opportunities.

	Topic	Industry example
1	'Open' interoperability development	Global System for Mobile communications (GSM) in mobile telephony
2	Consumer protection with auditable data stream	Uber/Airbnb
3	Change to a service-based offering from product-sales	Civil aerospace engine sales to services – aka "power by the hour"
4	Industry-wide carbon accounting	Automotive Industry Carbon Intensity Threshold
5	Additional willingness to pay for enhanced-value service(s)	Television – from fixed-price TV license service to differentiated cable/sat offerings
6	The rise in bundling of services	Telecoms – rise and rise of bundled services through telecoms

"We found that the experience of market transformation in other sectors can offer rich insight for both policy makers and industry in thinking about strategic risks and opportunities."

A range of consumer surveys and workshops were conducted to investigate and test consumer reactions to potential future decarbonisation policies as well as appeal to new energy service propositions.

Consumers are resistant to enforced change

We asked a group of over 2,000 owner-occupiers how they felt about a selection of policies to drive decarbonisation that we had outlined. People found change hard to imagine and were not positive about enforced change of any kind. They were potentially open to an energy service provider managing change for them, particularly when faced with necessary change.
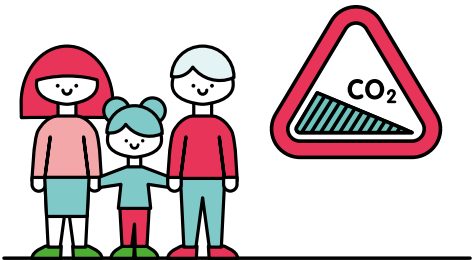
Consumers value both trust and certainty

We also conducted a further survey of 1,200 owner-occupiers around their willingness to consider installing a heat pump. We found that people welcomed the idea of cost-certainty when moving to a new heating vector (from gas to electricity). This meant that once cost was discussed, favourable responses towards heat pumps rose when bundled with a heat plan which would fix those costs.

Seeking to achieve decarbonisation through current market arrangements and business models could increase the risk of poor outcomes for many, be that through unserviceable costs, or a risk to their comfort at home. However, digitalisation also means that there is an opportunity for consumer protection to become smarter, if data is available to the regulator and they are set up to be able to use it.

3.4.4. Interoperability, choice and competition

Suitable standards on the interoperability of controls, data and connected home devices and appliances would support consumer choice and reduce the risk of lock in to proprietary platforms for home energy services or control. Suitable standards on the openness of data would support competition, allowing the consumer to compare offers from different service providers.

Open interoperability will maximise consumer choice and support competition

Open interoperability is a key feature of the market anticipated in this journey. At a very high-level, interoperability can be considered as the setting of rules, standards, and protocols that ensure systems, devices and interfaces work together, in a secure way that is not detrimental to the wider energy system, benefits the consumer and allows commercial value to flow. It may also extend to openness of data, allowing the supply chain to align and offer integrated propositions to consumers.
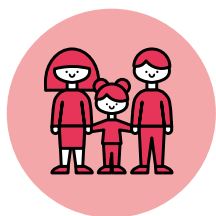
Consumer

ensuring that provisions exist for consumers to switch between both different commercial offers and technology choices.

Commercial

to ensure that incentives are aligned across the energy system to ensure that value can flow where it needs to, driven by market forces.
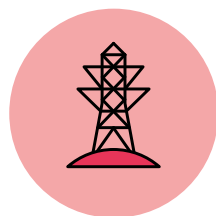
Data

to ease the sharing and portability of data between different systems.
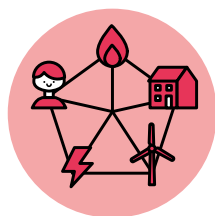
Devices

to ensure that devices are swappable, replaceable and exchangeable as needs change and technologies develop and to allow consumers to make informed choices between open and closed eco-systems.

Physical

to ensure that end-to-end systems function as changes happen to parts of the system.

Vector

to ensure that energy provision across gas, electricity, heat, transport fuels etc. are compatible with one-another and that coordination occurs in a timely fashion.

Standards that are not in consumers' interests could emerge

The ability to connect devices to one another to enable service offerings relies on them being able to communicate. It is likely that this will happen organically, but examples from other industries show that without some form of standard (voluntary or mandated) there is a risk that proprietary standards will emerge that are not in the best interests of the consumer, the government, or the energy system. Restrictive proprietary standards could limit consumer choice, lock consumers into products/providers, raise transaction costs and make data harder to access for service providers, reducing scalability and the opportunity to develop connected homes propositions that deliver value to the wider energy system.

We found that interoperability is recognised as a key ingredient of a prosperous and fair energy system by all parties. Supporting the development of standards, perhaps learning from the experience of the GSM transition in mobile telephony could be hugely beneficial, however the UK must ensure it does not 'go it alone' – any standard must not present a barrier to UK market entry.

The absence of standards or agreements on key facets of the digital energy revolution could result in a failure to realise some or many of the wider benefits and opportunities. Figure 16 helps understand the areas in which interoperability should be guaranteed and explains why it is particularly important.

Figure 16. Overview of interoperability considerations

Current market arrangements are not driving adoption of low carbon heating

An assessment of the current market and progress on low carbon heating, even with incentives such as the Renewable Heat Incentive (RHI) revealed that there is a clear need for further policy to drive the rate of adoption upwards. It was clear from our research that the supply chain for low carbon heating lacks the capability to deliver the level of change needed to meet our carbon obligations. Issues exist around:

- **Scale:** there are 1.6 low carbon heat installers for every 100 registered gas installers for example.

- **Incentive:** from our work it was clear that there is little demand from consumers and hence little current market value in low carbon heating.

- **Capability:** without data on homes, there is a risk that low carbon installs are offered when they are not suitable, or not offered when they might be due to perceived risks in change. Also additional/earlier retrofit work may be required which is not possible at the point of a pressing need to replace a broken heating system.

We studied the example set by the automotive industry where the supply chain aligns behind the primary consumer-relationship agent in the automotive manufacturer. Our analysis suggests that an incentivised service provider in energy could play a key role in aligning disparate components which consumers must currently buy and assemble for themselves.

An overarching policy intervention to incentivise reduction of carbon emissions will be needed to drive investment and innovation in new low carbon domestic heating delivery systems and consumer propositions.

An outcome-based decarbonisation obligation is a promising approach for policy development

Given that technology solutions and systems integration challenges are likely to vary across different locations, our analysis points to the importance of an outcome-based and technology-neutral approach in decarbonisation policy. From this perspective a policy obligating the provider of energy (or energy service) to decarbonise their supply portfolio of customers represents a promising approach for further exploration. Energy Systems Catapult is now exploring this issue in more detail through its Rethinking Decarbonisation Incentives project[9].

Policy design should harness the power of digitalisation for consumer protection and to drive incentives through the supply chain

A commonly recurring theme in our analysis of policy pathways was that a better understanding of consumers and their homes was a key asset to delivering the right solution to them. This supports the hypothesis that energy services could be a powerful proposition in smoothing the path for consumers to adopt low carbon heat solutions.

In addition to the potential benefits of digitalisation, energy and connected home data could provide a sizeable opportunity to plan and regulate the industry if data access/control/format rules are useful for all parties (secure, and with the right boundaries between shared and proprietary silos).

When incentivised to reduce carbon emissions, energy service provider business models could help better align the supply chain to ensure the power of digitalisation is harnessed to deliver a lower carbon outcome.

Building confidence in policy through trials

A process of co-design and shared learning through policy trials and experimentation would be valuable in testing policy design and trial regulatory arrangements, building confidence before legislating or putting in place enduring market arrangements.

Providing a test environment for new business models before changing rules and regulations would support commercial learning, as well as presenting an opportunity for regulators to work with businesses to shape the new rules. This could also provide a test bed for emerging interoperability standards.

Smarter energy products and services could deliver many consumer benefits, however there are complex issues the sector will need to work through to deliver this value. There is a risk that consumers will suffer if products and services are designed poorly, and these risks are higher at the outset, before new conventions form about how smart energy products and services work. For this reason, further work is recommended to consider how smarter consumer protection could work in practice, both in the early phase of testing/learning in a safe environment as well following on from that, at scale.

9   For further information, including international case studies and analysis of options for UK carbon policy reform, see the Rethinking Decarbonisation Incentives project website https://es.catapult.org.uk/impact/projects/rethinking-decarbonisation-incentives/

4. Key insights and future work
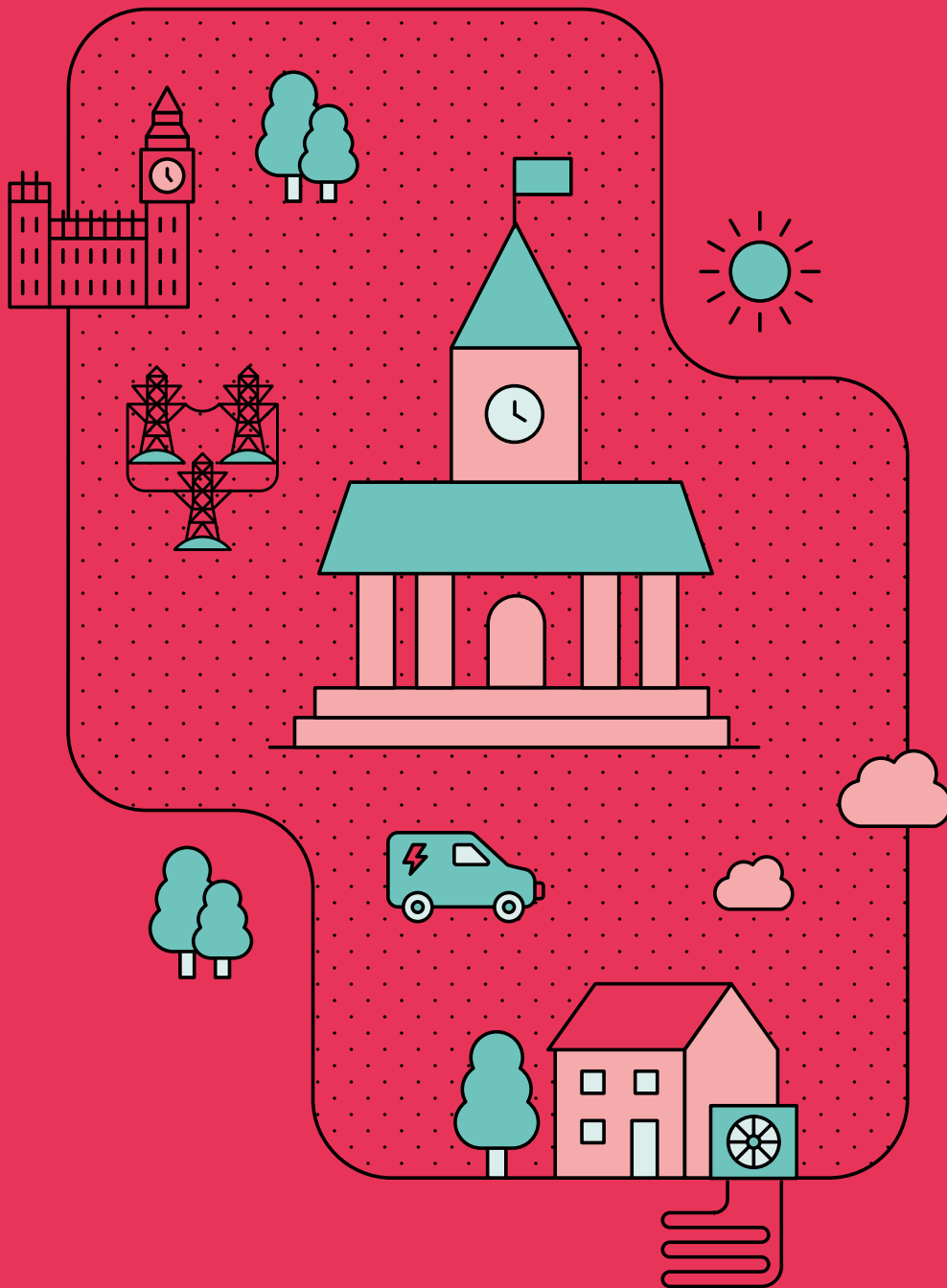

4.1. Key insights

The insights generated by the research and analysis within SSH2 are important both for innovators and companies that are trying to develop new low carbon heating products and services, and for policymakers in designing future policies and regulatory frameworks to drive heat decarbonisation.

The SSH2 research and analysis supports the hypothesis that new smart energy service propositions can play a central role in unlocking innovation and enabling the efficient transformation of the UK's heat supply infrastructure and building fabric for a low carbon future.

We can draw out the following key insights on the role of smart energy propositions:

- Individual consumers have a differing range of behaviours and heating requirements. Information provided by this trial can be used by industry and policymakers to design low carbon heating solutions and policy tailored to range of behaviours and requirements.

- Consumers are motivated by more than simply the cost of energy. While cost is important (particularly to a few), achieving comfort from their heating is the driving factor for most. Some are willing to pay more to achieve higher levels of comfort.

- Energy services could enable businesses to attract and retain customers. They will need to offer a range of Heat Plans or other offerings that allow customers to achieve a variety of heating experiences.

- The combination of energy services and advanced control provides a key opportunity to drive change. If supported by the right consumer market and regulatory conditions this could lead to a rapid adoption of low carbon technologies.

- Energy service business models can create opportunities across the value chain, for retailers, product manufacturers, renovation businesses, networks operators and network investors.

4.2. **Next steps and future work**
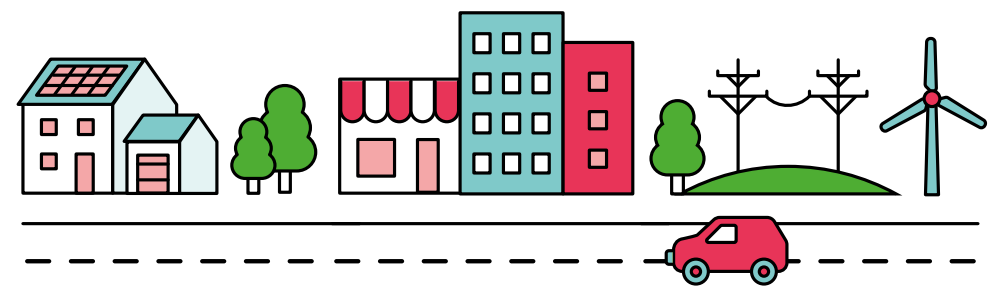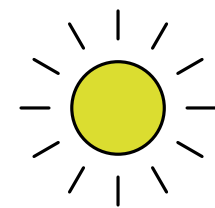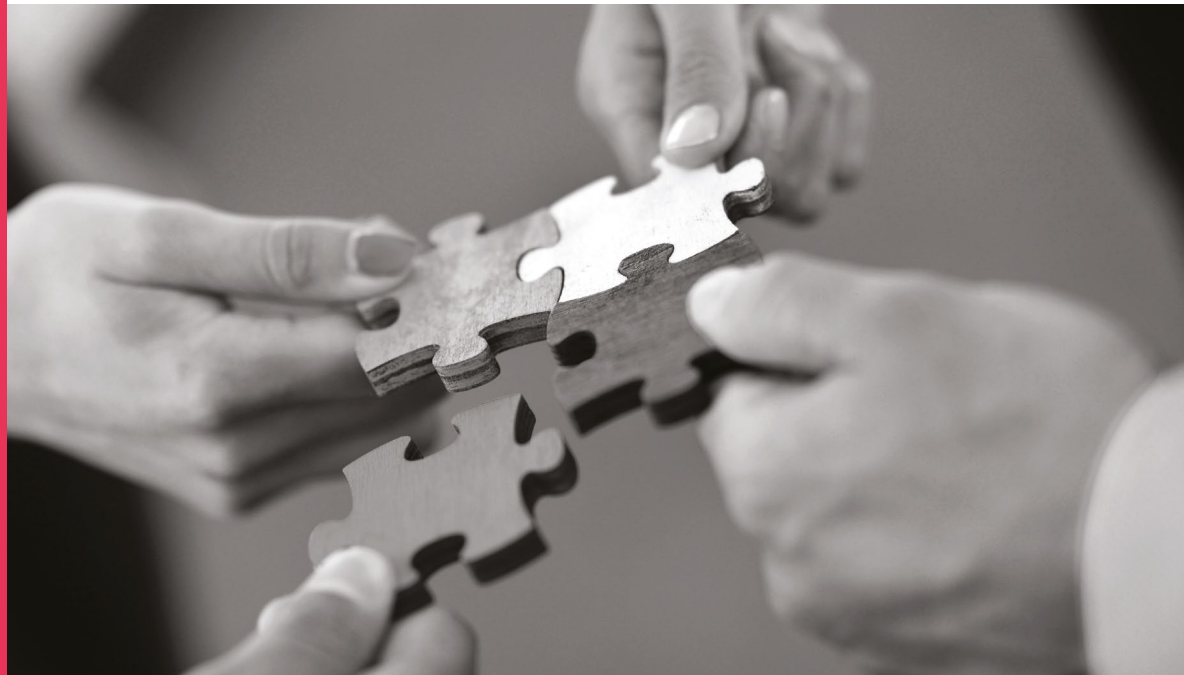
Local area energy planning has the potential to realise deep decarbonisation of heat by identifying cost-effective solutions for specific areas. SSH2 demonstrated how local area energy planning and modelling analysis can be translated into feasible roadmaps for nearer-term actionable innovative projects. More work is needed to establish a clear framework and processes to enable local authorities to take a more active role in planning and assembling the funding streams to deliver the projects identified.

The market transformations analysis of new business models and market structures to support low carbon heat roll out identified key learnings for shaping a consumer-friendly, market-led transition to low carbon heat.

- **Motive: businesses (and consumers) need a reason to act, prepare and invest in low carbon.** Investment and innovation will remain stifled until there is greater clarity about the shape of the enduring market framework and incentives to drive the low carbon heat transition. There is a great opportunity to harness the digital revolution to encourage the innovation and investment needed, provided that the market has clarity about rewards and the enduring framework.

- **Means: consumers will transition to low carbon if it is simple to manage and the outcomes are as good as (or ideally better than) high carbon.** Consumers would welcome low carbon heating if it solved common problems with their existing heating system, met latent needs and the transition is smoothly managed by a competent provider. The sector needs to learn how to deliver outcomes people want without carbon and to make it easy and straightforward for consumers.

- **Opportunity to test and learn: suitable innovations will likely emerge over time.** The potential of connected homes can be harnessed to test and rapidly build knowledge, for example through scaled up trial environments. A shared learning environment would enable regulators to work with businesses to accelerate the emergence of interoperability standards that deliver value to everyone and new smarter routes for protecting consumers.

- A process of co-design and shared learning through policy trials and experimentation would be valuable in testing policy design and trial regulatory arrangements, building confidence before legislating or putting in place enduring market arrangements.

- Providing a test environment for new business models before changing rules and regulations would support commercial learning, as well as presenting an opportunity for regulators to work with businesses to shape the new rules. This could also provide a test bed for emerging interoperability standards and smarter consumer protection arrangements.

- Smarter energy products and services could deliver many consumer benefits. However, there are complex issues the sector will need to work through to deliver this value, as has been beneficial in other sectors, such as mobile telecoms. There is a risk that consumers will suffer if products and services are designed poorly, and these risks are higher at the outset, before new conventions form about how smart energy products and services work. For this reason, further work is recommended to consider how smarter consumer protection could work in practice, both in the early phase of testing/learning in a safe environment as well as during wider scale up.

Energy Systems Catapult has created a Living Lab of connected homes to enable policymakers and businesses to discover how to harness digitalisation to deliver high-quality low carbon products and services that consumers are willing to pay for.

- Five hybrid heat pumps are being installed to explore whether and how consumers can achieve levels of comfort comparable with using their conventional gas boilers.

- We are exploring how to improve heat plan offerings (for example by including hot water or introducing a 'pay as you go' offer).

- We are working with energy providers (e.g. Bristol Energy) to sell Heat Plans to real household in our Living Lab.

- We are also exploring how to design a market place where consumers can compare offers in order to drive competition.

- We have been working with our three local area partners in Bridgend, Greater Manchester and Newcastle to develop projects and programmes that could build on the learning from the field trial by testing and demonstrating the concepts with residents at a larger scale.

Move five owner-occupied gas heated homes to heat pumps in our Living Lab.
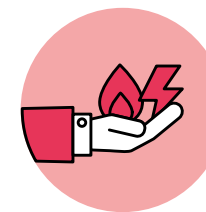
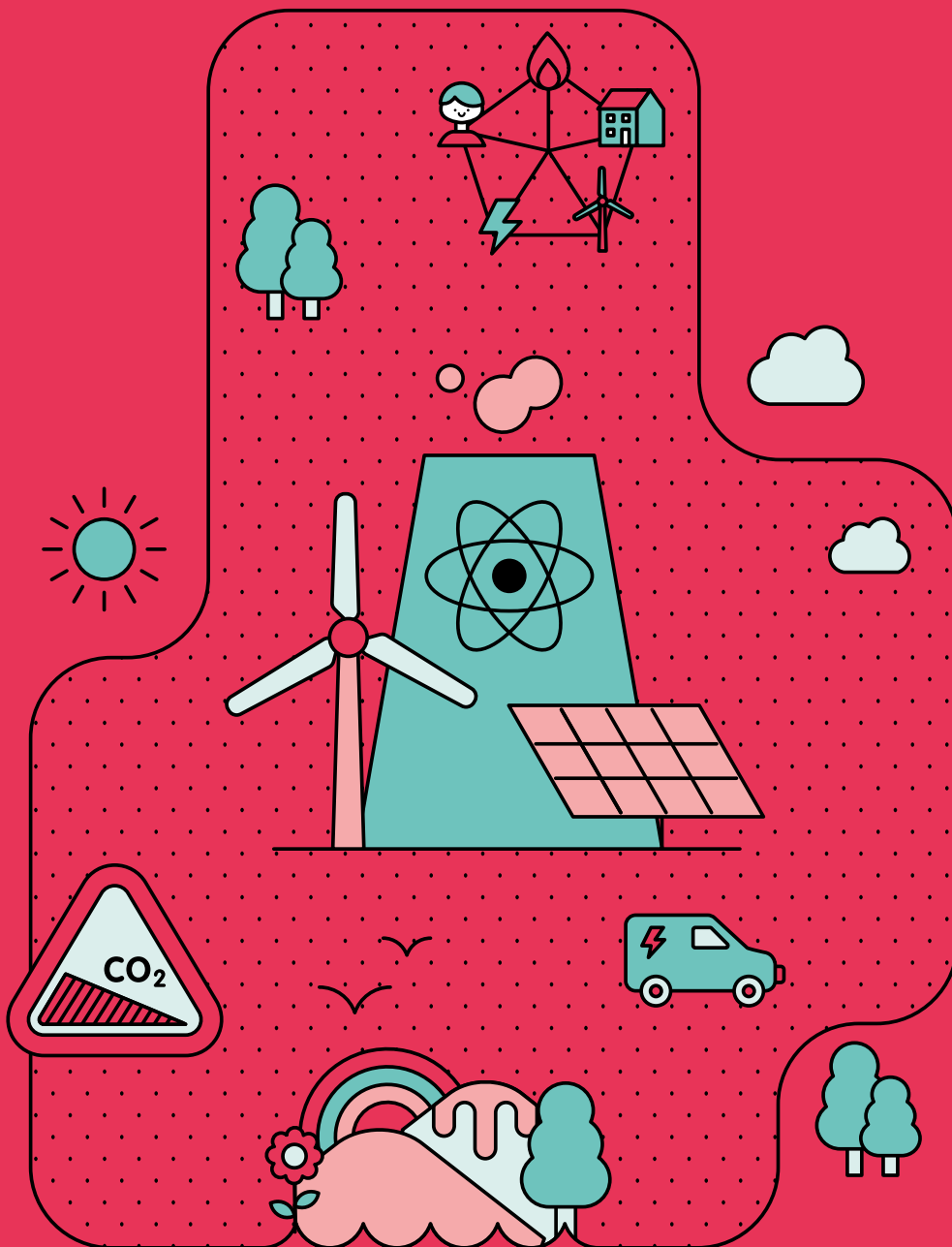Sell industry's Heat Plans in our Living Lab.

Support innovators testing new products and services.

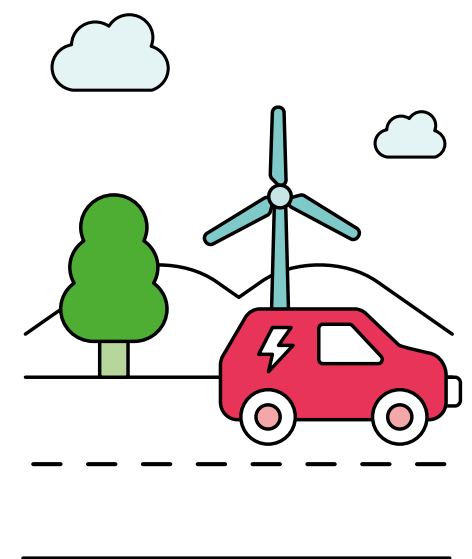Large scale Demonstration Programmes with partners.

5. Conclusions and recommendations

This report has shown that decarbonising the heating sector in the UK is a multi-faceted challenge that requires immediate action. However there are great opportunities to deliver benefits to consumers, the supply chain, the environment, and the economy.
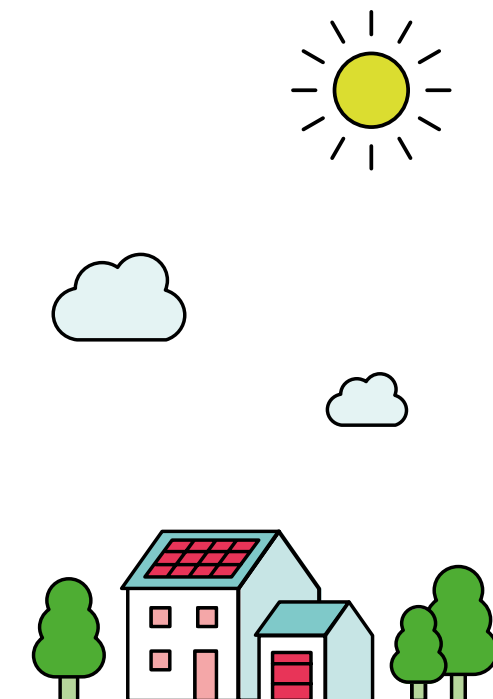
5.1. For industry

- Digitalisation may enable powerful future consumer propositions in heating. There are valuable opportunities for innovative companies to exploit, gaining first mover advantage in design and delivery of consumer-friendly low carbon solutions.

- Innovators can harness digitalisation to gain valuable insight into consumer preferences and behaviour, informing better design and targeting of investment in innovative new products and services. Learning through collaborative trial environments with real consumers is a key opportunity for innovative companies that want to shape the most attractive propositions.

- There is a strong business case for smart energy propositions including selling Heat Plans or Energy as a Service. Businesses may find it easier to attract and retain customers if they can offer a range of propositions to meet consumers' varied demands for heating experiences.

- Manufacturers will need to make heating devices that can meet this broad range of customer needs. Trialling connected home devices and smart appliances in a real home environment could help gauge consumers' interest and needs.

- Stronger collaboration with local authorities on energy planning could help businesses identify viable innovation projects and establish key partnerships with other local stakeholders.

- Businesses (district heat, electricity etc.) could work with energy service providers to decide how to invest and operate networks.

- Industry-wide cooperation on interoperability would bring significant benefits, including enabling ease of adoption for consumers, a level playing field for competition and better service offerings. Forward-looking industry players can start to identify the requirements needed to ensure interoperability of controls, data and connected home devices and appliances. Collaborative development of a set of industry-wide interoperability standards could help build consumer confidence and promote the development of a vibrant and competitive market.

5.3. **For policymakers**

- Decarbonisation policies will shape markets and the service propositions that suppliers develop and offer to consumers. It is important for government to build on the commitments in the Clean Growth Strategy and to make clear progress towards defining an enduring market and policy framework for heat decarbonisation.

- The design and implementation of potential policy instruments should take into consideration key characteristics:

  – meet the requirements of policy set out by government (e.g. not reliant on subsidy)

  – drive progressive decarbonisation efficiently

  – best enable markets and innovation to deliver attractive propositions focussed on consumer needs.

- Our analysis suggests promise in exploring the design of an outcome-based (technology-neutral) decarbonisation obligation approach for incentivising decarbonisation policy. This has the potential to drive emission reductions, by setting the right incentives along the supply chain and leaving open flexibility for innovation in technology or business models.

- The insight generated by the SSH programme and the consumer trial can help policymakers with the design of effective heat decarbonisation policies that:

  – are based around how people really use heat in their homes, ensuring they go with the grain of behaviour and needs (safeguarding the most vulnerable customers, harnessing the willingness to pay for better home heating experiences)

  – consider which types of homes and consumers may be best-suited for particular lowcarbon technologies

  – promote the emergence of new business propositions (e.g. Heat/Energy as a Service) that presents significant potential to enable the transition to low carbon heating solutions.

- Policymakers should consider the best approach to establishing open interoperability. There may be scope for this to be industry-led, but other forms of intervention may be required.

- Improving local area energy planning is essential to enable a cost-effective transition to a low carbon energy system, particularly for heat decarbonisation. By developing a shared vision of the areas for network investments, it encourages innovation, secures value for money and harnesses public understanding and support. Policymakers and regulators should assess the benefits and opportunities of strengthening and formalising LAEP processes, and empowering local authorities in this regard. Ofgem should also consider how the use of LAEP could improve the ability of network companies to take a genuinely whole systems approach to planning network upgrades. There is also a strong case to consider the interaction between LAEP processes and investment planning for RIIO price controls.

5.2. **For local actors**

- Local authorities and potentially other key local stakeholders can take a more proactive role in local area energy planning. SSH1 and 2 have delivered a significant knowledge base, along with tools and guidance to enable a structured, evidence-based approach. This can help to identify effective local solutions for low carbon heat and energy and foster greater engagement and collaboration with key local stakeholders.

- The uptake of local area energy planning modelling processes and modelling tools could help streamline the work of local authorities. While Energy Systems Catapult will continue working to take forward the pipeline of projects in the Smart Energy Plans, mainstreaming LAEP could help other local authorities to produce their own plans.

"Decarbonisation policies will shape markets and the service propositions that suppliers develop and offer to consumers."

CATAPULT
Energy Systems

Energy Systems Catapult supports innovators in unleashing opportunities from the transition to a clean, intelligent energy system.

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