
Heat strategy



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A Net Zero ready network

In 2019 the UK became the first major economy in the world to pledge Net Zero carbon emissions by 2050 as a necessary and fundamental measure to end its contribution to global warming and fight climate change.

In order to reach Net Zero, major infrastructure decisions need to be made in the near future and quickly implemented in order to support the uptake of low carbon technologies (LCTs)¹. The size of this challenge is huge and we all have a role to play.

UK Power Networks operates and maintains the electricity distribution network for roughly a third of the country. The carbon intensity of electricity has reduced dramatically in the last decade. From 2011 to 2018, we connected over 6GW of renewable energy sources to our network as well as over 217MW of storage (with 2.6GW of accepted offers for connecting storage down the line). We believe that the distribution network is at the core of facilitating the transition to a zero carbon economy, as the uptake of low carbon technologies connected at the grid edge such as heat pumps and electric vehicles increases. More recently, we revised our industry-leading electric vehicle (EV) readiness strategy that explains how we are adapting our services to facilitate the electrification of transport to enable communities to unlock the benefits of decarbonisation².

While the energy and transport sectors are making progress in reducing their carbon intensity, there is still significantly more to do. Decarbonisation of heat is the most challenging area and as a result of its complexity, future direction and policy are still under development particularly when it comes to existing building stock. However, with heat being the single biggest source of UK greenhouse gas emissions, we cannot wait any longer to act.

Our regulator Ofgem has demonstrated leadership in the decarbonisation ambition with their recent decarbonisation programme action plan³. We fully support their approach on how we will meet the Net Zero challenge. Now our role in the decarbonisation of the electrification of transport has been defined, we are focusing our efforts on understanding how DNOs can support the achievement of Net Zero by facilitating the decarbonisation of the heat sector.

We are excited to be central to this transition, however we cannot do it without the valuable inputs of our stakeholders. That is why we have set a short term strategy to proceed with the least regret actions and support the early movers. We are developing the enablers that will help us understand, mitigate and prepare for the potential impact of electric heating. Ultimately, by deepening our knowledge and our evidence base, we will prepare a robust investment plan to facilitate the uptake of electric heat for our next regulatory price control period commencing in 2023.

This strategy has been developed based on the initial feedback from key stakeholders in our licence area. Now we want to engage with a wider stakeholder base to validate our direction of travel. This will enable us to define the improvements we need to make, and help us prioritise our actions. Therefore, your feedback is crucial.

Throughout this document, there are a number of specific questions where we are seeking your feedback, and we also welcome any general comments. All feedback can be sent to innovation@ukpowernetworks.co.uk.

Situation

The UK has used natural gas for heating since the 1850s⁴, with 88% of Britons using it as the primary method for heating their homes this past winter⁵. Recently, we have seen an increasing number of Government initiatives to reduce the carbon emissions associated with heat in the UK.

Renewable Heat Incentive (RHI)

The Renewable Heat Incentive (RHI) set up to encourage the uptake of low carbon heat technologies

Clean Growth Strategy

The Clean Growth Strategy commitment to phase out the installation of high carbon fossil fuel heating in buildings off the gas grid in the 2020s, starting with new buildings⁶

Future Framework for Heat in Buildings Call for Evidence

The response to a Future Framework for Heat in Buildings Call for Evidence setting out the first steps to phasing out the installation of high carbon fossil fuel (such as oil and coal) heating systems in off gas grid properties⁷

Future Market Framework for Heat Networks

A Future Market Framework for Heat Networks – setting out the Government’s priorities for regulation of the heat networks sector⁸

Future Home Standard Consultation

A consultation on the proposed changes to building regulations and on what the Future Homes Standard should look like in 2025

In December 2018 the Department of Business, Energy and Industrial Strategy (BEIS) published the Clean Growth – Transforming Heating report. This report looks to support the development of a long-term policy framework for heat and provides a review of the evidence base on options for achieving long term heat decarbonisation⁹.

It highlights that heat is the single biggest source of UK greenhouse gas emissions (37% of total UK CO2 emissions in 2016) and that electrification of heat has the potential to deliver significant reductions in carbon emissions. These potential reductions extend substantially beyond the levels needed to enable the UK to meet the reductions required by 2050 under the Climate Change Act¹⁰.

As society develops the pathways that are best placed to achieve the Net Zero targets, there are uncertainties around how decarbonisation of heat will occur and how much of it will be electric, which has led to an impasse in some areas. However, electricity networks have a great track record in decarbonisation of the energy system, and have more recently demonstrated to be a central player around supporting decarbonisation of transport. In a similar way, we aim to support the decarbonisation of heating, and we believe that now is the time to explore what role our stakeholders expect us to play.

One of the concrete measures taken since December 2018 was the government announcement to introduce a Future Homes Standard from 2025: in the Chancellor of the Exchequer’s Spring Statement, it was indicated that all new houses from 2025 onwards will have to be future-proofed with low carbon heating and to be installed with ‘world leading’ levels of energy efficiency. In 2019/20 the government is consulting on the proposed changes to building regulations and on what the Future Homes Standard should look like in 2025¹¹. These recent developments are increasingly important as the UK set in law a new target for the UK to bring all greenhouse gas emissions to Net Zero by 2050, compared with the previous target of at least 80% reduction from 1990 levels. According to the Commission on Climate Change (CCC) the Net Zero target will require the full decarbonisation of buildings by 2050¹².

In order to model the uncertainties in the pathway to a low carbon economy, we have recently developed a set of Distribution Future Energy Scenarios (DFES)¹³ describing the evolution of demand and generation across UK Power Networks' licence areas out to 2050.

As part of this work, we have developed different scenarios for decarbonisation of heat based on the following key drivers of the transition to low carbon heating:

Thermal efficiency

Heating technologies

District heat

For each driver, we have generated three to four scenarios that represent different levels of ambition of uptake, generally: Low, Medium and High, with a fourth variant for heating technologies. The High electrification and decarbonised gas scenarios represent two extremes of the future; in reality, the pathway for heat decarbonisation in the UK could be a mix of these components, with different regions opting for different technological solutions.

According to our DFES, in UK Power Networks' region there are two overarching 'scenario worlds' that are expected to meet Net Zero emissions in 2050: 'Engaged society' and 'Green transformation'. In 2019 there were more than 10,000 heat pumps in operation across our network. In the 'Engaged society' scenario 7.6 million heat pumps are expected to be in operation in our regions by 2050, compared to 1.83 million combined with decarbonised gas in the 'Green transformation' scenario.

These numbers demonstrate that decarbonisation of heat in mass scale is in its infancy; our first step is to understand our role in this journey. Until now, we have focused on forecasting and monitoring heat pumps connecting to our networks and exploring possible future scenarios for decarbonisation pathways in our DFES and through collaborative innovation projects such as Green City Vision¹⁴. However, we believe that there is more to do.

Trends observed so far may change significantly following the 2050 Net Zero target and the latest announcements on the Future Homes Standard. However, we recognise that the challenge associated with decarbonisation is much wider than building standards for new constructions. In order to achieve the Net Zero emissions target by 2050 we cannot afford to stand still on decarbonising heat, as CO₂ is constantly emitted. Therefore we will take a proactive approach to making our network ready and we will adapt to our customers' needs as they evolve. As such, this strategy seeks to set out near term interventions and areas of focus which are of low regret, e.g. defining zones to focus on, while identifying key stakeholders and working with them to define a long term approach.

The following sections outline the challenges and opportunities we see as an electricity distribution network and our approach to address them.

The challenge

There are 24 million buildings supplied by gas in Great Britain¹⁵, providing 85% of domestic heat and 50% of all cooking needs¹⁶. We face a major challenge in decarbonising heat, but it is one we can only overcome by working collaboratively.

To establish our strategy addressing the challenges and developing the opportunities that decarbonisation of heat brings to the electricity distribution network, we must answer the following questions:

How will decarbonisation of heat change electricity demand?

What technologies exist to decarbonise heat using electricity?

How will customer needs change? In the case of fully electric properties, there will be an increased dependency on the electricity system. How should DNOs best respond to this?

What guidance do early adopters of electrified heating require?

How many consumers, companies and developers have plans to install electric heat, and how might this change over the RII0-ED2 timeline? Who are the key stakeholders, and how can we best support them?

What is the expected role of electricity distribution networks to facilitate low carbon heat and energy efficiency? Does this require regulatory changes?

While the long term paths for decarbonisation of industrial buildings and existing on-gas grid building stock are being defined, what are the key measures we should put in place in the short term to support the transition of off-gas grid properties and the electrification of new builds?

Questions for our stakeholders

1. Do you agree that these are fundamental questions we need to answer as a DNO? What would you add and why?

Our approach

We have set out to overcome the challenges outlined in previous pages in a timely manner. Our objective is to be an enabler of the decarbonisation of heat for all customers. We are committed to facilitating the UK Net Zero carbon target by 2050 at the lowest cost possible.

We aim to prepare our network for the uptake of electric heat in RIIO-ED2 between 2023-2028 and beyond, while supporting government in identifying the best technical and economic solutions to decarbonise heat more widely. We will provide data and expertise where required to support wider policy discussions. In the meantime, we will continue to support our customers and facilitate the connections of electric solutions to our networks. This approach will make sure our networks are ready to accommodate the new load associated with the electrification of heat as it comes, whatever pathways are identified by government as the best course of action for the nation.

In recent years our extensive stakeholder engagement in the fast moving sector of electric vehicles (and more recently our initial engagement on heating) has demonstrated how important it is for us to work closely with all key industry players. We will set out to create partnerships and collaborate with government through industry change, ensuring the needs of all customers are considered and no one is left behind¹⁷.

As policy remains uncertain of when, where and how the transition to low carbon heat will occur (specifically around retrofits and existing buildings), our near term strategy is focused to prepare for electrification of heat across three main objectives as illustrated right.

Our overarching objective is to enable the decarbonisation of heat through best in class engagement, great customer experience and a future ready network.

OBJECTIVE 1

Inform heat decarbonisation policy through provision of data and evidence

ACTIONS

Inform the policy discussion

Refine our forecasts:

- Define segments and scenarios (e.g. zoning)
- Changing customer energy profiles

OBJECTIVE 2

Deliver a great service experience to customers wishing to connect low carbon heating solutions

ACTIONS

Engage with key heat stakeholders and review today's customer journey

Learn and educate around

- Energy efficiency
- Costs
- Challenges and opportunities

OBJECTIVE 3

Undertake least regret actions to ensure network readiness

ACTIONS

Review heat technologies and identify required standards and policy gaps

Develop a smart toolbox and robust plan for the next price control period

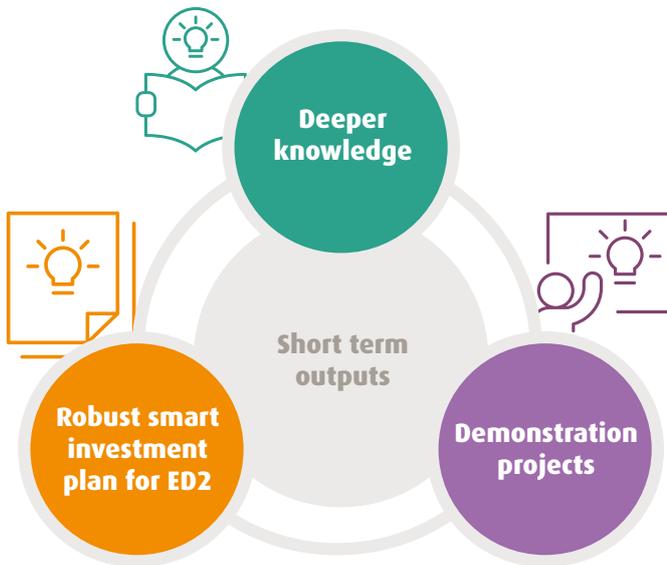
- Identify what the smart and flexible solutions for heat are through literature review, targeted research and innovation
- Prepare for RIIO-ED2

By segmenting our focus into these three areas, we are confident we are tackling heat in areas of least regret and maximising enablers at this early stage.

Ultimately, our short term Heat Strategy will deliver three key outputs:

1. **Deeper knowledge and understanding of the implication of electrifying heat for our customers**
2. **Demonstration projects to prove technical, commercial or social solutions that will form our smart toolbox to enable the transition in the short term at the lowest cost to our customers**
3. **A robust smart investment plan for ED2 and beyond**

All informed by our best in class stakeholder engagement.



Questions for our stakeholders

2. **Are these the right objectives for us to focus on in the short term? If not, what would you add or remove?**

Inform heat decarbonisation policy through provision of data and evidence

a) Inform the policy discussion

Decarbonising heat requires us to work with local and central government, as well as other industry stakeholders to ensure that we can continue to manage the network and the evolving requirements of our customers seamlessly.

Net Zero is very high on the agenda and decarbonisation of heat will have a significant impact on society. As regulated network companies DNOs must clearly communicate the role we play at the core of the energy system and work with government to understand the implications of electrifying heat. Once we understand the changes and the scale, we must be ready to adapt and respond to them. Having the right policies and solutions in place will facilitate the transition at the lowest cost to consumers.

Currently, there are different future energy scenarios to decarbonisation of heat¹⁸. We are going to work across all these scenarios as they are still uncertain and present some differences, and we are going to work together with the wider industry to converge on more certain pathways.

In any case, all credible future energy scenarios towards Net Zero will require a major build-out of power generation capacity and provision for addition network capacity to deal with the greater supply and demand of electricity. In order to plan for this, we need to gather the existing evidence-based recommendations specific to the electricity network, fill any gaps in terms of the evidence base on impacts and opportunities of electrification of heat and form specific recommendations on how DNOs can support achieving Net Zero in the short term.

It is clear that in order to meet the 2050 targets, the UK cannot afford to wait for technologies that may not be commercially viable for another decade. We must take action now, and define what mix and take-up of existing technologies is required as a minimum in the 2020s for us to be Net Zero compliant. As such, we have identified off-grid gas developments as the least regret option for intervention to facilitate the decarbonisation of heat. However, we also acknowledge that decarbonising off-grid gas properties and new builds alone will not be sufficient to meet the Committee on Climate Change (CCC's) forthcoming carbon budgets.

The decarbonisation of existing on-grid gas developments, on the other hand, is typically more costly and disruptive due to the nature of retrofit options. This challenge is further compounded by greater uncertainty in the policy regarding decarbonisation of on-grid gas. As policy and consumer acceptance remains uncertain on how decarbonisation of heat will impact the existing building stock in the UK, we will inform the political debate by sharing with the government and other stakeholders:

- the evidence base we will continue to gather on electrification of heat through research and development activities;
- the knowledge we are developing on heat through our stakeholder engagement and market intelligence activities; and
- the insights generated through our modelling and forecasting of electric heating future uptake, in coordinated and uncoordinated scenarios.

Questions for our stakeholders

- 3. Do you agree that DNOs must take actions now on low regret options such as off gas grid zones, while informing the political debate on the 2050 decarbonisation pathways?**
- 4. What evidence do you believe we need to gather to inform the policy discussion?**
- 5. What scenarios do you think we should explore further as a DNO?**

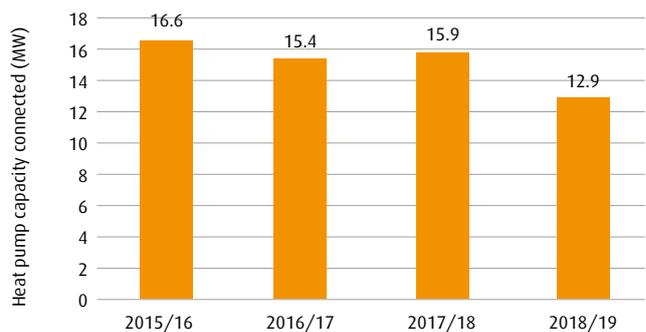
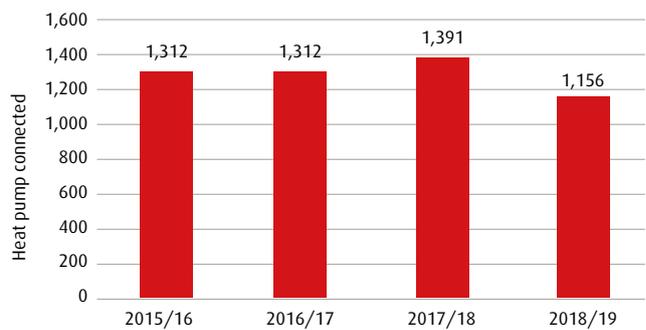
b) Refine our forecast

Our advanced modelling tools and forecasting capabilities will be very useful to inform industry and policy makers on the potential implications and cost of the uptake of heat pumps and other electric heating solutions. Within that work, we must understand the value and feasibility of a flexible energy system in the context of the heating sector.

In 2018 our project Recharge the Future¹⁹ delivered the most sophisticated EV forecasting tool in the industry. The objective of the tool was to reduce uncertainties associated with electric vehicle load growth, enabling efficient planning of interventions, informing reinforcement spending, and reducing risk of firm capacity shortfalls. In 2019 we went further by developing Distribution Future Energy Scenarios (DFES), which included highly granular regionally bespoke forecasts from now until 2050.

The same principles apply to heat. We began monitoring volumes of heat pumps connected to the network at the start of our current regulatory price control period, RII0 ED1, in 2015. We do not have full visibility of all technologies connected to our LV network, as we are reliant on installer notifications. However, we have now created a baseline from which we are able to start projecting the future uptake rates based on RHI data and heat pump installations notified directly to us.

Volumes of heat pumps connected to our networks based on RHI data (heat pumps installed in new builds as the original heating system are not included)



To improve visibility of our low voltage (LV) network²⁰, we are undertaking a strategic monitoring programme which will:

- 1. Use artificial intelligence (AI) and state estimation to assess when overloads are likely to occur**
- 2. Use grid edge devices and data such as Smart Meters data to provide additional visibility at household level to predict and proactively address potential constraints (our Data Privacy Plan will be key to this)**
- 3. Install monitoring equipment on our networks – we will be fitting over 5,800 monitoring units across our LV networks by 2023, and are developing plans beyond ED1**

As the level of electrified heat increases, we will have some visibility of where this is occurring, and our monitoring data will give us a better understanding of the hot spots and the actual impact of these units on our network. Additionally, it will help us identify locations that can benefit from smart, innovative and flexible solutions.

Currently, prioritisation of the location for the LV monitoring roll-out is mainly driven by the forecasted uptake of EVs. However, it is reasonable to expect that the prioritisation criteria will consider the uptake of both technologies (heat pumps and EVs) when the volume of heat pumps (or other electric heating technologies) connecting to our network starts increasing.

Questions for our stakeholders

6. Do you agree that our forecasting and monitoring approach to EVs is applicable to electrified heat? Would you propose any change, and why?

7. What other complementary datasets should we be analysing in conjunction with our LV substation data to help inform our investment plans?

Define customer segments and uptake scenarios

In order to improve our forecast, we need to define the heating customer segments associated with various low carbon heat technologies and the different uptake scenarios. From our initial engagement, our stakeholders told us that we should group heat customers in to at least three macro categories:

1. Off gas grid

2. On gas grid

3. New builds

We will then dissect these further by:

- Residential or industrial and commercial
- Type of buildings (size, age, material, existing energy efficiency levels, etc.)
- Existing heating solutions
- The way they use electricity, their network requirements and potential impact they may have on the electricity network.
- Occupancy status (rented, owned or uninhabited)
- Socioeconomic and other personal circumstances

From our experience with EVs, we expect that different customer segments will inform the different network enablers, smart solutions and investment they may require at different times and in different locations.

Alongside an accurate forecast, we are developing our knowledge of energy efficiency measures and their impact on local heating requirements. For instance, by improving the thermal efficiency of a property, the amount of energy required for heating is expected to decrease on today's levels. It also enables those in fuel poverty to have warmer homes without a significant increase to their energy bills. Therefore, considerations on energy efficiency are key to maximise the efficacy of our approach: ultimately, the more efficient the properties are, the more heating systems can be decarbonised within the existing network capacity.

Additionally, energy efficiency measures are perceived to be a key pre-requisite for the efficient and cost-effective use of some electric heating solutions such as heat pumps. Therefore it will be important to fully understand how energy efficiency measures can be coupled with existing and potential new electric heating solutions, and the impact this could have on our load forecast; such that we ensure that the network is prepared to facilitate the uptake of electric heating.

Questions for our stakeholders

8. Have we identified the right categories to base our more granular customer segmentation on? If not, what else should we consider?

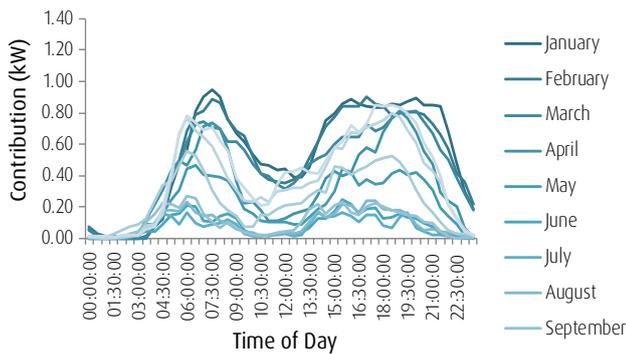
9. In the context of future electrification of heat, do you think networks should play an increasing role in terms of energy efficiency? If so, how?

Understand our changing customer energy profile

The impact of electric heat, such as heat pumps, on our customers’ energy profiles will be significant. Understanding the type of load profiles from electric heating will be critical to network planning going forward. We already have information about typical loadings due to heat pumps from our Low Carbon London (LCL)²¹ programme.

The profile in figure below for example shows an average contribution of a single HP utilising an operational regime programmed to switch on and off at certain times.²²

Estimated (i.e. average) contribution of one single heat pump (for London area, 2014)



For heat pumps, we found that there were definite peaks visible in the morning and evening, with the demand for all seasons nearing zero in the early morning. This would suggest the use of a boiler replacement model rather than other forms such as under-floor heating which would show a more consistent profile. The project also presented normalised profiles calculated by Imperial College London. LCL provided early insights into the indicative load profiles derived from heat pumps as well as a set of recommendations as to how to incorporate these into the forecasting, connections, planning and demand monitoring processes.

Since Low Carbon London, there have been learnings from other DNO projects which suggest that customers are hesitant to shift their demand.

- Freedom (WWU & WPD)
- Demand Scenarios with Electric heat and Commercial Capacity Options, Electricity and Heat (ENW)
- Assessment and benchmarking of low carbon heating technologies (WWU)

As part of our action plan, we reviewed in detail the insights generated by these projects and carried out a wider literature review to ensure that we have the most up to date knowledge and understanding.

Heat pumps have dominated the discussion around electrification of heat thus far. However, we will form a more comprehensive view of customers’ energy profiles for other low carbon technologies that may play a role in electrification of heat (e.g. electric boilers, storage heaters and underfloor heating) in addition to heat pumps, in order to assess the impact of decarbonisation of heat on the electricity network in a more holistic way. We will also broaden our knowledge of the context in which these technologies are most suitable, including considerations on fabric of the building, required temperature of heat, existing onsite renewable electricity generation and storage.

Questions for our stakeholders

10. Which technologies should we consider under the electrification of heat? Do you agree that we should broaden our knowledge to other low carbon solutions than heat pumps?

Deliver a great service experience to customers wishing to connect low carbon heating solutions

a) Engage with key heat stakeholders

As this is a relatively new load group for electricity networks, the first step in this journey is to understand the supply chain and the overall stakeholders of the heat transition. We will map out the key players in the electric heat supply chain. For example, housing developers, heat installers, technology developers, land owners, social housing sector and private rental sector, representatives of domestic customers and Industrial & Commercial (I&C) customers and trade associations should all be involved in this discussion. This will help us better understand what our role is in delivering this enhanced energy service. We are also closely following the development of the ‘heat as a service’ business model undergoing trials²³, and we will investigate what we can learn from other countries that are further ahead on the electrification of heat.

We also understand, from our initial stakeholder consultation, that we must engage local councils, consulting engineers, manufacturers, other DNOs and gas distribution networks (GDNs), government and policy makers, flexibility providers, service providers and Ofgem on this subject.

Our engagement is already underway through conversations with organisations such as, the Association of Decentralised Energy (ADE) and organisations focused on implementing energy efficiency and with experience in implementing carbon free heating solutions, BEIS, heat specialists, heat pump manufacturers, local authorities and consumer experts.

We have approached our housing developer community to understand the challenges they see in meeting potential government targets and what their concerns are. These types of surveys and engagement will continue to inform our direction and shape how we can best support our stakeholders.

64%

.....
of surveyed developers are likely or very likely to consider low carbon heating in their next development

40%

.....
of respondents think that the capital hurdle is the biggest barrier to deliver low carbon heat, and 30% consider there not being enough electricity capacity the greatest challenge

38%

.....
of them are considering heat pumps as a technology solution, 14% of them district heating with an electric source, 38% have no idea what option is suitable



.....
Some of them mentioned air-source heat pumps in commercial and residential buildings, large-scale heat pumps on ambient heat network, and some said they have no plans of installing any low carbon solution until it is mandated or until the cost is attractive



.....
Other barriers that were mentioned include lack of policy, lack of knowledge, public opinion or perception, co-efficient of heat, cost of new equipment, cost of infrastructure upgrade and capital provision for onsite/offsite arrangements.

Review today's customer journey

We believe that customers need and deserve choice to understand what clean heating solution is the best for them. If customers rely exclusively on electricity to provide all of their energy needs, they will need greater reliability, both in terms of capacity and quality of supply. This is likely to require a review of current reliability standards to ensure a switch to electricity does not negatively affect end users. Our fundamental goal remains the same, which is ensuring that the adequate infrastructure is in place for our customers' evolving needs and providing the best and most reliable service at the lowest cost possible. To do this in an evolving environment such as the Net Zero transition, we must explore our specific customers' needs and translate them into areas of business focus.

One of the key barriers highlighted by the government in decarbonising heat is the disruptive impact it could have during installation. For all decarbonisation pathways, there will be some level of intrusion, as equipment is either retrofitted or replaced. We must work with industry leaders to demonstrate feasible technologies and understand how we can help make this transition as seamless as possible, whilst also taking advantage of opportunities to deliver superior services. By collaborating with government and Ofgem we will understand the role of DNOs in serving local communities and reduce the level of disruption necessarily associated with any form of decarbonisation.

We are already working with other DNOs through the ENA Low Carbon Technologies working group to improve the process for customers who wish to install a heat pump²⁴. We believe there is more that we can do to improve the efficiency of the connection process and the overall experience. As a first step, we are mapping the journey of those customers that are electrifying their heating system today. This will allow us to understand their needs, the decision-making process that leads to the uptake of a low carbon heat source, the barriers they encounter on the way and our connection process.

We will review our customer journeys from initial engagement to connection and understand where we must improve our service. For example, we trained our customer service teams to offer tailored information to EV customers. We also streamlined and simplified our connection process for Vehicle-to-Grid technologies that are considered as load and generation at the same time. We will apply the same approach for the electrification of heat.

Questions for our stakeholders

11. What considerations should we take into account while reviewing our customer journey?

12. If you are familiar with our connection process, which aspects should we improve to support the uptake of electric heating?

b) Learn and educate

As we enter a new area of load which is not necessarily known to us, we must make sure that we engage with the right stakeholders and learn about the challenges of decarbonising heat from their perspectives. This will allow us to understand heating better and identify our role within the transition. We will then be in a better position to share this learning with our customers.

We see the education element as explaining to our customers, or partnering with associations that can explain to customers, what their options are and enabling them to electrify their heat if they so wish. When surveying the housing developers, 69% agreed that education is a key role for networks to play²⁵. For example, when engaging in more detail around what developers think electrification of heat means, responses vary from:

- Electric heating systems
- Increased efficiency of heat retention
- Battery instead of heat storage
- Conversion of gas boilers to electric
- Significant extra generation needed and increased capacity in the network
- EVs & battery storage may negate the increased demand
- Need to look at alternatives now as 2025 will be here soon
- Removal of gas boilers

Agreeing on what we mean by decarbonising and electrifying heat, as well as clarifying our targets, is a key first task. We see a vast need for education in this space, for example engaging with heat pump manufacturers, understanding their requirements and challenges, scoping in collaboration and promoting our innovation trials and developing the evidence base required to assess the network impact of heat pumps and other electric heating systems. We must help the industry and our customers understand the challenges of the energy transition and the benefits of achieving it together, providing our expertise on network capacity planning and the connection process.

We recognise that as a DNO we are not heating specialists. Therefore our role is to engage and coordinate with industry to work together in order to:

- Deepen our knowledge by learning from heat experts
- Work with trusted intermediaries and local authorities to engage with consumers and communities
- Collaborate with subject matter experts to deliver demonstration projects.

For example, working with trusted third parties will be key to understand which actions we should take in the short term to support customers in vulnerable circumstances or in fuel poverty that may increasingly rely on electric heating in the future. We will also gather the customers' views on the upfront capital costs to inform our uptake forecasts.

Finally, our website is one of the first ports of call for our customers. Our connections website²⁶ provides clear information on how to connect and who to contact for new connections. However, we will evaluate what additional information can support our different heat customers in their transition to electric heat.

Questions for our stakeholders

13. What agencies or associations would be best for us to share network education in this space?

14. What mechanisms and media are best suited to ensure heat stakeholders are informed and educated on network aspects for the electrification of heat?

Undertaking least regret actions to ensure network readiness

a) Review heat technologies and identify standards and network policy gaps

When it comes to electricity, low carbon heat is not just about heat pumps. As already discussed in Section 1, we will review existing and emergent low carbon heat technologies to inform the definition of heating customer segments and understand their different needs.

As with other technologies, we must consider standards that meet our connection policies. For example, UK Power Networks has an engineering design standard, EDS 08-0132 'Planning Guidance for Disturbing Loads' that outlines power quality requirements for connecting disturbing loads, including heat pumps. As part of our strategy, we must ensure we continue to update these documents to meet our evolving customer needs and keep connecting them in a safe and reliable way²⁷. Not only do we need to keep them updated, but we also need to review the way customers can access this information so that it is available to everyone. A total of 90% of our housing developer stakeholders told us that a document indicating various diversity factors for multiple heat pump connections would be useful to them. We will focus to understand how best to provide this information to our customers.

When we asked housing developers what a good guidance on decarbonisation of heat should include, their suggestions included:

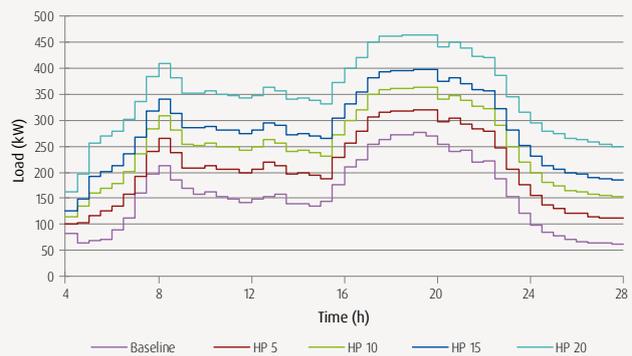
- Policy – rules of thumb & contacts for policy process
- Capacity need for different types of systems
- Focus on options, cost and capacity
- Benefits and drawbacks alighting to GLA/DLP policy
- Diversity and After Diversity Maximum Demand (ADMD)
- Real-time site feedback
- Alternative technologies

Technical information

Many of our customers are most interested in our technical advice. From on our LCL project trials, we have information on the potential impact of heat pumps on the networks. Figure 2 shows a modelled view of the effect of a cluster of heat pumps (HP) on the distribution substation and provides an example of the type of technical information we can share to inform customers and policy makers.

The Low Carbon London project was completed in 2014, therefore we will also look at the most recent advancements in heat pumps to ensure we have records of the various load profiles associated with different technologies.

.....
Loading on distribution transformer under extreme weather conditions (average temperature of -4 degrees)

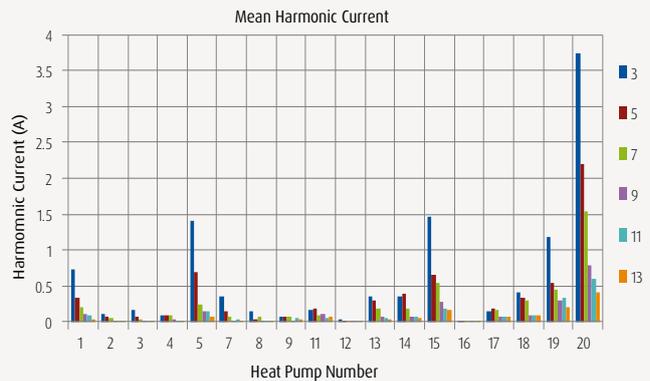


Power quality

In the LCL project, heat pumps were found to contribute various levels of power quality disturbance, with different unit types having differing impacts. A cluster of the “best performing” heat pumps showed no harmonic voltage distortions; but the opposite is true for the “worst performing” heat pumps. Further examination showed that an accumulation of heat pumps drawing significant harmonic current on local networks could lead to harmonic voltage distortion exceeding the planning standard G5/4-1 as show in Figure 3.

The maximum harmonic current recorded in the trial was 7.5 Amperes, measured in the third harmonic. This suggests that regulating the specification of the heat pump could directly affect the power quality that manifests on the network as a result of heat pump operation. Recommendations that these harmonic contributions are monitored have already been built into the ENA process, where some heat pump models can ‘Connect & Notify’ instead of the more onerous ‘Apply to Connect’. This is based on load and harmonic impacts.

.....
Harmonic measurements from 20 different heat pumps - Mean current magnitude for the third, fifth, seventh, ninth, eleventh, and thirteenth harmonics for all heat pumps in the trial



..... Questions for our stakeholders

-
- 15. Would you expect us to share technical network information and advice with you? What information and advice would be most beneficial?**
-
- 16. Would the development of an electrification of heat connections standard be of value?**
-
- 17. Did you know about the power quality issues heat pumps may create to the network? And do you agree with the 'Connect & Notify' approach set out by the ENA process under certain circumstances?**

b) Develop a smart toolbox and a robust plan for ED2

Smart and Flexible

At UK Power Networks we pride ourselves on our innovative culture. Just as with the uptake of electric vehicles, for the electrification of heat we must ensure that we have the best forecasts and that we support third parties to deploy new technology and business models. This will encourage the use of smart solutions alongside strategic investment in the network, right sized and just in time. As a result, this will ensure that we use what we have efficiently whilst enabling uptake.

We have a vast innovative smart grid portfolio that covers a range of commercial and technical solutions. Many of these solutions are based on technical equipment, software solutions and commercial arrangements that maximise the use of our existing assets and provide choice, affordability and convenience to our customers. Table 1 outlines some of the projects related to heat.

Innovation projects related to heat

Project

LCNF - Tier 2
Low Carbon London (LCL)

NIA -
Green City Vision

NIC -
Energywise

Description

LCL investigated the impact of a wide range of low carbon technologies on London's electricity distribution network completed in 2014.

- It focused on:
- Demand Side Response and Distributed Generation
 - Electrification of Heat and Transport
 - Network Planning
 - Future Distribution System Operator

A range of solutions are being researched and trialled which offer decarbonisation options for heat, light, power and transport. The increasing interaction between the networks from gas peaking power plant, hybrid heating systems and power to gas means that it is increasingly important to assess energy flows in both vectors in a more holistic approach. Green City Vision is about assessing a UK representative city, combining all the energy demands (excluding any very large industry that will have a bespoke plan) now and in the future and matching that against low or zero carbon sources.

Energywise explored how DNOs can work with trusted intermediaries to support vulnerable and fuel poor customers to maximise benefits of smart meters, energy saving measures and demand side response.

Relevance to heat

LCL provided heat pump load profiles and their network impact

Green City Vision used the Future Energy Scenarios to provide look-ahead capability with regard to those factors outside the control of the energy industry, such as general economic growth and public policy decisions. This work has laid the groundwork for further analysis to understand the opportunities and synergies available within a whole-system decarbonisation strategy to achieve compliance via low-cost, achievable pathways.

The highly tailored engagement strategy tested in energywise can be replicated in the future context of decarbonisation of heat to ensure that hard to reach communities maximise energy efficiency and participate in flexibility opportunities associated with heat.

Table 1 Innovation projects related to heat

NIA -

Firefly

Distribution networks should lead on the delivery of energy efficiency in order to reduce demand on the network, lower carbon emissions and save money for our customers by deferring network reinforcement. This project will help us understand the extent to which energy efficiency measures can be used to defer reinforcement costs.

If electricity increasingly becomes a heating fuel, thermal energy efficiency of the properties and energy efficiency measures such as insulation will start playing a critical role for the electricity distribution networks to ensure that the impact of decarbonisation of heat on the network is minimised and the transition can be delivered at lower costs for our customers.

BEIS -

Home Response

Home Response is a two-year trial, part of London's Energy for Londoners programme, which will test flexible energy solutions in around 160 London homes. This includes using solar panels with battery storage technology and electricity for heating water.

Home Response explores domestic customers' flexibility with electric water heating.

NIA -

Phase Switch System (PSS)

As demand of low carbon technologies connected to low voltage distribution networks is expected to increase significantly, this is likely to cause a larger phase imbalance than currently observed. Domestic load is normally connected to one phase. Once one phase of a transformer or underground cable reaches its maximum rating then LV network reinforcement needs to be considered. The project will demonstrate that the PSS is a solution to defer transformer replacement and/or LV mains cable overlays by improving the level of unbalance between LV phases.

Phase imbalance at LV level is expected to increase even further with the uptake of electric low carbon heating technologies. PSS is preparing the network for decarbonisation of heat scenarios that involve electricity supplied heat appliances.

NIA -

Urban Energy Club

Urban Energy Club is testing how the virtual allocation of shared assets can support a more inclusive approach of procuring network flexibility from domestic customers living in blocks of flats.

The more inclusive approach tested in Urban Energy Club is expected to become increasingly important as domestic customers may switch to electric heating, as shared asset such as communal co-located distributed generation and energy storage will mitigate the impact of electrification of heating on the distribution network. This approach will also make sure that domestic customers will be able to participate in the Net Zero transition at lower costs.

It is reasonable to expect that decarbonisation of heat may have some common challenges with the uptake of other low carbon technologies. Therefore we may be able to deploy some of the smart solutions already in place or are under development for EVs in order to minimise the impact of low carbon heat on the electricity network whilst maximising customer benefits. We will review our current suite of innovative and smart solutions to identify such existing solutions and will adapt them to serve the purpose of facilitating electrification of heat.

At the same time, we are expecting heat to have unique challenges that remain unexplored so far. We will work closely with internal and external stakeholders to identify the most appropriate solutions to these challenges and trial them via innovation projects and demonstrators where they deliver value for our customers.

Finally, we must investigate in depth the potential for flexibility services²⁸ associated with low carbon heating technologies to minimise their impact on the network and optimise the use of existing capacity before investing in network upgrades. This includes understanding:

- What flexibility means in this context
- What connection arrangements work best for facilitating new electric heat technologies
- How flexible the load of electric heating appliances can be
- What technologies and commercial solutions already exist to shift heating loads, particularly in the case of electric storage heaters and hot water tanks
- How reliable flexibility is in the context of domestic and Industrial & Commercial (I&C) heat
- How the levels of resilience change for this load group
- How our cold start scenarios should be reviewed for electric heating

Given that the decarbonisation of heat will involve more than one type of fuel in the 2020s, we will continue to work closely with gas distribution networks to identify and develop appropriate whole-system solutions that can deliver benefits to both electricity and gas customers.

Similarly to what we have done to enable the uptake of EVs, as a result of this strategy we will develop a smart toolbox of technical and commercial solutions that will allow us to accommodate more low carbon heating technologies within our existing capacity, where possible.

Questions for our stakeholders

18. Which technical and commercial solutions should we investigate to enable the electrification of heat in the short term?

19. How flexible is heat-related load based on your experience? How do you think this could change in the future?

Prepare for RII0-ED2

In addition to developing a smart toolbox, we are preparing the learning to develop our approach to network upgrades required by our customers within the next regulatory price control period (RIIO-ED2). In order to support the decarbonisation of heat we intend to continue to do the following:

- 1. Use Artificial Intelligence (AI) and state estimation to assess where and when overloads are likely to manifest on the network due to electrification of heat**
- 2. Utilise grid edge devices and data such as smart meter data to further inform our assessments**
- 3. Fit monitoring onto the low voltage network**
- 4. Install additional protection to the low voltage network to improve our load monitoring and automation capabilities**
- 5. Deploy smart solutions and procure flexibility where possible; and**
- 6. Plan timely investment when and where needed in alignment with our DFES**

Ultimately, we will focus on understanding what the most appropriate and reliable interventions are for RII0-ED2 considering the right mix of certainty and uncertainty, and the role of smart solutions play in risk mitigation. Ahead of submitting our RII0-ED2 Business Plan we will engage with stakeholders to understand what we should be doing between April 2023 and April 2028 and therefore what activities should be within the next price control period. This will therefore be a key process in establishing our level of our ambition for the mid 2020s.

Questions for our stakeholders

- 20. Do you agree with our approach to prepare for RII0-ED2? Should we be doing more?**
- 21. Given the potential for energy efficiency to alleviate some of the stress on our network caused by electrifying heat, what can we do in RII0-ED2 to help facilitate such measures?**

Action plan

Our Heat Strategy identifies the key areas we need to focus on to enable decarbonisation of heat and overcome the challenges associated with the increasing uptake of electrical heating solutions. In the near term we will take a series of practical actions:

Inform heat decarbonisation policy through provision of data and evidence

Refresh our literature review to gather the existing evidence base and identify gaps in terms of the impacts and opportunities associated with electrification of heat

Inform the policy debate by sharing the evidence base, knowledge and insights with the government and other organisations

Refine our forecast of electric heating solutions uptake in our licence areas to reduce uncertainties, enable efficient planning of interventions, inform reinforcement spending, and reduce risk of firm capacity shortfalls

Continue to increase LV visibility to ensure we can monitor the uptake of grid edge low carbon solutions

Define the heating customer segments associated with various low carbon heat technologies and the different uptake scenarios

Develop our understanding of energy efficiency measures and their impact on the demand of electrified heating systems

Form a more comprehensive database of customers' energy profiles for all low carbon technologies that may play a role in electrification of heat

Define how we can best collaborate with authorities to deploy infrastructure

Understand the supply chain constraints associated with heat electrification and define what is possible in terms of uptake

Define a least regrets Net Zero heat scenario for ED2

Deliver a great service experience to customers wishing to connect low carbon heating solutions

Engage with key heat stakeholders and review today's customer journey

Understand how we should tailor and simplify the connection and notification process for heat pumps by continuing to consult with key heat stakeholders to inform our direction and how best we can support them in the transition to electric heating

Map the journey of those customers that are electrifying their heating system today to understand their needs, their decision-making process and the barriers they encounter on the way

Educate and inform our customers (directly or through partnerships) about energy efficiency, the challenges and opportunities of the energy transition and the benefits of achieving it together

Assess the additional information to go on our connections website to support our different heat customers in their transition to electric heat



**Undertaking
least regret actions
to ensure network
readiness**

Review existing and emergent low carbon heat technologies

Define and develop connection policies and standards, e.g. whether three phase supply is more cost efficient for new buildings

Review our current suite of innovative and smart solutions to identify and adapt existing solutions that can already facilitate electrification of heat

Work closely with internal and external stakeholders to identify the most appropriate solutions to address those challenges that are unique to heat

Work with gas distribution networks to identify and develop appropriate whole-system solutions that can deliver benefits to both electricity and gas customers as an interim solution

When there is a high level of uncertainty about new solutions, we will seek to trial them as innovation projects

Use forecasts, AI and state estimation to assess when the LV network limitations could be reached

Use grid-edge data along with our own LV monitoring and smart meters to inform next steps

Fit additional network protection devices in addition to monitoring to proactively manage the network configuration

Investigate potential flexibility associated with low carbon heating technologies to minimise their impact on the network and optimise the use of existing capacity through smart solutions before investing in network upgrades

Understand how we can ensure electric heat customers can benefit from our flexibility markets

Develop a framework to trigger appropriate reinforcement of the network

Create a robust ED2 investment plan as a result of all the actions above to make sure our network is ready to support decarbonised heat

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Questions for our stakeholders

We value your feedback. Please help us shaping our action plan by sending us any further comments you may have at:

innovation@ukpowernetworks.co.uk

Conclusion

Our heat strategy sets out the way we are preparing for the low carbon transition. We intend to use it as a live document, which will be reviewed and updated regularly to ensure we remain focussed and continue to work on the right areas, and that our priorities are aligned to those of our customers.

Please send ideas, suggestions and answers to the questions in this document to:

innovation@ukpowernetworks.co.uk

We look forward to hearing from you!

- ¹ <https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf>
- ² <https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/11/UK-Power-Networks-Electric-Vehicle-Strategy-November-19.pdf>
- ³ https://www.ofgem.gov.uk/system/files/docs/2020/02/ofg1190_decarbonisation_action_plan_web_0.pdf
- ⁴ <http://www.nationalgasmuseum.org.uk/gas-industry-chronology/>
- ⁵ <https://www.gov.uk/government/statistics/beis-public-attitudes-tracker-wave-32>
- ⁶ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
- ⁷ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762546/Future_Framework_for_Heat_in_Buildings_Govt_Response_2_.pdf
- ⁸ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774586/heat-networks-ensuring-sustained-investment-protecting-consumers.pdf
- ⁹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf
- ¹⁰ <https://utilityweek.co.uk/gas-connections-new-homes-banned-2025/>
- ¹¹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/843757/Future_Homes_Standard_Consultation_Oct_2019.pdf
- ¹² <https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf>
- ¹³ <https://innovation.ukpowernetworks.co.uk/2020/02/06/distribution-future-energy-scenarios/>
- ¹⁴ <https://innovation.ukpowernetworks.co.uk/projects/green-city/>
- ¹⁵ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/678653/Sub-national_electricity_and_gas_consumption_summary_report_2016.pdf
- ¹⁶ <http://www.energynetworks.org/assets/files/news/publications/GAS%20FAST%20FACT%20CARDS%20-%20ALL.pdf>
- ¹⁷ Stakeholder Engagement Submission 2019: https://www.ukpowernetworks.co.uk/internet/en/have-your-say/documents/20064_UKPN_Submission%20reports%202019_Part_2_WEB%20-%20final.pdf
- ¹⁸ For example: UK Power Networks' Distribution Future Energy Scenarios; National Grid's Future Energy Scenarios; ENA's Gas Decarbonisation Pathways Project.
- ¹⁹ <https://innovation.ukpowernetworks.co.uk/projects/recharge-the-future/>
- ²⁰ Most residences and small business are connected to the low voltage network
- ²¹ <https://innovation.ukpowernetworks.co.uk/projects/low-carbon-london/>
- ²² <https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/05/B2-Impact-of-Electric-Vehicles-and-Heat-Pump-Loads-on-Network-Demand-Profiles.pdf>
- ²³ <https://es.catapult.org.uk/impact/projects/bristol-energy-heat-plan-trial/>
- ²⁴ <http://www.energynetworks.org/electricity/futures/electric-vehicles-and-heat-pumps.html>
- ²⁵ Based on our engagement.
- ²⁶ <https://www.ukpowernetworks.co.uk/electricity/new-connection>
- ²⁷ This will include the standardisation of policy/engineering standards to facilitate the customer experience.
- ²⁸ <https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/07/futuresmart-flexibility-roadmap.pdf>



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