Heat Street
local system planning

Scenarios to assess the impact of decarbonisation of heat on UK Power Networks' electricity network to 2030

Executive summary
April 2021
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To reach Net Zero by 2050 in the UK, major infrastructure decisions must be made in the near-term to support the uptake of low carbon technologies. The distribution network has a role in facilitating the transition to a Net Zero economy, given the uptake of low carbon technologies connected at the grid edge, such as electric vehicles and heat pumps. Decarbonisation of heat is a challenging area in which the direction of future policy is still under development, particularly with regards to the existing building stock.

This study was undertaken to strengthen our understanding the role of DNOs in facilitating the decarbonisation of the heat sector, and to inform UKPN’s heat strategy. It will help deepen the knowledge and evidence base that underpins UKPN’s investment plan over the next 5-year regulatory price control period, commencing in 2023 (ED2), to facilitate the uptake of electric heat. To achieve these aims, in this study we have modelled the uptake and corresponding network impact of a range of low carbon heating technologies and energy efficiency measures in the building stock in UKPN’s licence areas.

This modelling was carried out under a range of scenarios describing future policy and technological developments, allowing us to:

• Explore potential local heat decarbonisation pathways
• Assess the implications of energy efficiency uptake
• Identify high-electrification zones and consumers likely to take up electric heating, across different scenarios.

7.9 million domestic buildings in our areas
85% use natural gas boilers

770,00 commercial buildings in our areas
47% use natural gas boilers

26 mt CO₂ per year emissions from all properties, (6% of UK’s 2019 greenhouse gas emissions)

60% of buildings in our areas have an EPC rating of D or below

119TWh Total demand for heat and hot water in UKPN areas (37% of UK’s total 2019 generation)
Our approach

We draw on a wide range of sources to perform the analysis in this study. The methodology is summarized in the flow diagram above.

The outputs of three stakeholder engagement workshops are also integrated into this study. These workshops covered the potential role of DNOs in promoting energy efficiency and the drivers of low carbon heat uptake. Stakeholder feedback was also gathered on the study approach and the preliminary results of the modelling process. Key workshop attendees were BEIS, Greater South East Energy Hub, Cadent, Crew Community Energy, LETI and Passivhaus Trust, UK100, GLA.
### Table 1: summary of the modelled scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Levers</th>
<th>Impacts</th>
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<tbody>
<tr>
<td>Steady progression (BaU)</td>
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<tr>
<td></td>
<td>• No clear policy on heating and clean heat incentive schemes not extended</td>
<td>• Gas boilers remain dominant</td>
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<td></td>
<td>• Energy efficiency focused on fuel poverty</td>
<td>• Heat networks not decarbonized</td>
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<td></td>
<td>• Gas prices remain low</td>
<td>• Historical (low) uptake of energy efficiency</td>
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<td></td>
<td>• DNO provides energy efficiency information only</td>
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<tr>
<td>Consumer Transformation (High electrification)</td>
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<tr>
<td></td>
<td>• Ban on new gas boilers by 2035</td>
<td>• High electrification via deployment of heat pumps</td>
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<td></td>
<td>• National insulation programmes and minimum energy efficiency and/or carbon standards</td>
<td>• Hydrogen in hard-to-reach buildings</td>
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<td></td>
<td>• Fuel price mechanisms such as higher carbon tax</td>
<td>• High energy efficiency</td>
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<td></td>
<td>• High consumer engagement</td>
<td>• Earlier decarbonisation of off-gas grid properties</td>
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<tr>
<td>System Transformation (High hydrogen)</td>
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<tr>
<td></td>
<td>• Hydrogen compatibility requirement for new boilers</td>
<td>• Hydrogen dominates on-gas areas</td>
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<tr>
<td></td>
<td>• Reduced national insulation programme</td>
<td>• electrification of new builds</td>
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<td></td>
<td>• Low gas prices for hydrogen production via SMR</td>
<td>• Medium energy efficiency</td>
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<td></td>
<td>• Lower consumer engagement</td>
<td>• Earlier decarbonisation of off-gas grid properties</td>
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<tr>
<td>Leading the way (Early Net Zero)</td>
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<tr>
<td></td>
<td>• Ban on new gas boilers by 2030</td>
<td>• Regional mix of electrification and hydrogen</td>
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<td></td>
<td>• Ambitious local government targets for energy efficiency and low carbon heating</td>
<td>• Fastest roll-out of measures</td>
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<td></td>
<td>• Financial incentives for low carbon heating e.g. Green Homes Grants</td>
<td>• High energy efficiency</td>
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<tr>
<td></td>
<td>• Fuel price mechanisms such as higher carbon tax</td>
<td>• Earlier decarbonisation of off-gas grid properties</td>
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<td></td>
<td>• Electrolysis for hydrogen in late 2030s</td>
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Deployment of low carbon heating

All our scenarios see over 100,000 domestic buildings in the UKPN areas (1% of the stock) taking up low carbon heating per year by 2025, rising to above 400,000 (5%) per year by 2030. However, there are significant differences between scenarios in the choice of technology:

- **Heat Pumps dominate in Consumer Transformation and Leading the Way**
- **Hydrogen boilers dominate in System Transformation**

Figures 1 and 2 contrast the uptake of low carbon heating technology in the domestic sector between our high electrification (Consumer Transformation) scenario and our high hydrogen (System Transformation) scenario. While the scale and speed of heat electrification varies by scenario, there are some consistent trends. Geographic areas and consumer types highly likely to electrify in all scenarios include:

- **Off-gas grid areas**
- **New builds**
- **Urban areas**

The dominance of electrified and hybrid electric with bioenergy heating systems in off-gas grid areas is demonstrated in Figure 3, below.
Deployment of energy efficiency improvements

Energy efficiency deployment is found to be higher in areas where heating is predominantly electrified. This is because higher levels of energy efficiency improve the operating efficiency that can be achieved with low temperature heat pumps, and significantly decrease the costs of all types of electric heating.

Across the domestic stock, the average heat demand reduction per building due to modelled energy efficiency deployment is 10%, 8% and 10% under the Consumer Transformation, System Transformation and Leading the Way scenarios, respectively.

Slightly less reduction in demand is seen in the non-domestic stock, where the corresponding figures are 8%, 3% and 10%.

Individual buildings can see larger energy demand reductions (20-45%), but many buildings are unsuitable for certain measures so that the modelled average heat demand reduction across the whole stock is more modest.

Despite this, in our high electrification (Consumer Transformation) scenario, we model the installation of over 15 million individual measures across 8 million homes by 2030. This means many more buildings receive energy efficiency measures over the coming decade than low carbon heating systems, of which under 2 million are deployed in this scenario by 2030.

The domestic deployment of energy efficiency has a capital cost of between £10 and £14 billion, in our different scenarios. These amount to a per household cost of £1300-1700, but individual households can have significantly higher costs (>£10,000).

On the non-domestic side, deployment of energy efficiency has a capital cost of approximately £12 billion in Consumer Transformation and Leading the Way, and £0.25 billion in System Transformation.
Impacts of heat decarbonisation on CO\textsubscript{2} emissions

Our three Net Zero compliant scenarios achieve close to zero emissions from heating in the UKPN areas by 2050 due to the complete roll-out of low carbon heating, alongside energy efficiency measures. Such emissions reductions are premised on the near complete decarbonisation of the electricity grid, along with the provision of low carbon hydrogen.

In 2030, the differences in level of emissions mitigation between Net Zero scenarios are significant.

The high hydrogen scenario (System Transformation) sees slower reductions since the decarbonised gas network is only assumed to reach most buildings by the early 2040s. The off-gas segment of the building stock decarbonises ahead of the on-gas segment in all scenarios. This is due to an assumed earlier low carbon heating mandate for this segment of the stock, reflecting the generally greater cost-effectiveness of low carbon heating solutions in these buildings.

Figure 5: Annual CO\textsubscript{2} emissions under the three Net Zero scenarios and the Steady Progression baseline (Mt CO\textsubscript{2} per year). The bubbles indicate reduction by 2030.
Impacts of heat decarbonisation on consumers

10% of households in the UKPN licence areas are in fuel poverty. These are disproportionately households:

- with electric heating
- with uninsulated solid walls
- in the rental sector

The uptake of a low carbon heating system has the potential either to increase or decrease fuel bills depending on any efficiency improvements, the performance of the technologies, and relative fuel prices.

In all our Net Zero scenarios, the share of households paying >£1500 for heating falls from 13% to under 5%, mostly due to the deployment of more efficient heat pumps in buildings with existing electric heating systems which are costly to run, and energy efficiency improvements.

Changes to the average fuel bill vary by scenario, with reductions between 2 - 23%. In the System Transformation scenario, with high hydrogen roll-out, the average reduction in fuel bill is 2%. However, there are qualitatively different impacts on bills amongst different types of households.

Those initially using gas boilers see average fuel bill rises of 7%, due to an assumed Hydrogen price in 2050 that is 25% higher than the natural gas price today, but the average bill across the whole stock is still reduced due to large reductions in cost for those initially paying the highest bills i.e., those on direct and storage electric heating.

“"Stakeholder feedback

“If you’re looking for early wins, off gas grid definitely. Timing is critical, whether its in a household or business. The cycle of change is down to the customer in many ways (if it’s non-statutory, non compliance-based). Knowing when the best time for interventions is...is down to local knowledge. Trust element is very important to deliver programmes at scale.”

Peter Gudde, Greater South East Energy Hub
Heat Street Webinar, February 2021

“"Longer-term in London, heat will follow a more electric pathway. Electricity will play a key role. Target properties below EPC C - which is likely to be the minimum requirement. We are working with local authorities to hone in on social housing or fuel-poor areas. Be mindful of the digital exclusion angle. Ensure certain people aren’t left behind because of where their starting point is.”

Rick Curtis, Greater London Authority
Heat Street Workshop, August 2020
Discussion and conclusions

This study shows that under different scenarios of policy ambition, consumer behaviour, fuel prices and hydrogen availability for heat, a range of decarbonisation pathways can arise for the heat sector.

2030

- By 2030, we find an average heating demand reduction of between 4-10% depending on the level of policy incentives for energy efficiency. In combination with the replacement of direct electric heating systems with more efficient heat pump systems this results in a short-term reduction in total peak demand across all our scenarios.

2050

- By 2050, the scenarios see average heating demand reductions of between 9-12%. The highly electrified scenarios (Consumer Transformation and Leading the Way) see significantly less fuel used in total (approx. 50 TWh) due to greater deployment of high efficiency heat pumps and energy efficiency retrofits than in the hydrogen-led System Transformation scenario (approx. 105 TWh). Across the three scenarios we see an increase of electricity used for heating of between 60-125%. All the scenarios have around 1 Mt unabated carbon emissions in 2050 (approx. 4% of 2020 emissions from heat). This is due to the non-zero carbon intensity assumed for electricity and hydrogen, which will need to be accounted for to reach Net Zero.

Zoning

While the scale and speed of electrification varies by scenario, there are some consistent trends across all three scenarios. Geographic areas and consumer types highly likely to electrify in all scenarios include:

- Off-gas grid areas. Since hydrogen for heating is not available predicted to become available where buildings are not currently connected to the gas grid, off-gas areas use a combination of electricity and bioenergy to replace fossil fuel heating in all our scenarios.
- New builds. From 2025, all new builds are electrically heated.
- Urban areas. These also see higher electrification by 2030, particularly in space constrained city centre areas where direct electric technologies are attractive. More efficient and modern buildings (and those with standard construction types that can easily be treated with cavity wall and loft insulation) are likely to be early adopters of heat pumps since they can benefit from full potential of low temperature operational efficiency. These buildings tend to be located outside of city centres
Discussion and conclusions

**Energy efficiency**

- Energy efficiency deployment is found to be higher in areas where the heating predominantly electrifies. This is because higher levels of energy efficiency improve the operating efficiency that can be achieved with low temperature heat pumps, and significantly decrease the costs of all types of electric heating.
- Findings suggest there may be an opportunity for UKPN to support the deployment of energy efficiency to reduce costs for the network and consumers while facilitating low carbon heating deployment. Deployment of energy efficiency has the potential to reduce the cost of network reinforcement associated with the electrification of heat by £0.3-0.5 billion to 2050, which represents 3% of the total capital cost of the energy efficiency measures installed over the same period, within each scenario.

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**Stakeholder feedback**

“Excellent webinar and really good research coming through there. The Heat Street stuff looks like it is already doing a lot of the groundwork for Local Area Energy Planning. It would good to talk about how that data can be used with local authorities and community energy groups to inform projects going forward, including our LAD2 grants”

John Taylor, Greater South East Energy Hub  
Heat Street Webinar, February 2021

“This research is extremely helpful. Most councils have ambitions to deliver zero carbon plans but don’t have the money to deliver it”

John Morris, Huntingdonshire Council  
Heat Street Workshop, August 2020

“Very interesting topic and really useful information for rural LAs, such as ourselves.”

Anonymous, local authority employee  
Heat Street Webinar, February 2021
Appendix: case studies

**Insight 1: Hammersmith and Fulham - 2030**

The borough of Hammersmith and Fulham (outlined below) sees similar low carbon heating uptake across all three scenarios by 2030. One LSOA, which is the same across all scenarios, will have the heating demand dominated by heat pumps and there is a significant minority of LSOAs with district heat as the dominant technology, with greater DH uptake in System Transformation and Leading the Way. The rest remain dominated by fossil fuels. However, the energy efficiency picture looks quite different between our scenarios. The space heating demand is significantly lower in the Leading the Way scenario by 2030, and marginally lower by 2030 than at present in the Consumer Transformation scenario. While the scale of energy efficiency varies, a similar pattern can be seen in the relative levels of energy efficiency of LSOAs within a scenario due to the building archetypes in each LSOA.

![Dominant low carbon heating technology, Hammersmith and Fulham – 2030](image)

![Percentage reduction in space heating demand, Hammersmith and Fulham – 2030](image)
Appendix: case studies

Insight 2: Direct electric urban areas

A number of urban areas such as Cambridge and Brighton have the LSOAs in the centre of the city dominated by direct electric heating in the near term. In the case of Brighton, pictured below for the Consumer Transformation scenario in 2030, the central historic part of the city moves to direct electric heating by 2030. This area has a high proportion of retail and hospitality non-domestic buildings, as well as flats and other space constrained dwellings, all which result in a higher proportion of direct electric heating.

These areas tend to have the highest proportion of energy efficiency deployed in the LSOAs with direct electric heating. The same can be true of this area of Brighton, where the area that is dominated by direct electric heating has over 12% reduction in space heating (above the average in 2050 for the whole scenario).

Figure 8: dominant heating technology - Brighton Consumer Transformation 2030

Figure 9: space heating reduction - Brighton Consumer Transformation 2030
Appendix: case studies

**Insight 3: Central London electric zone**

Central London heating demand is dominated by district heating, direct electric and heat pumps across all scenarios. Even in the System Transformation scenario, much of the area surrounding the Thames will switch to heat pumps or hybrid heat pumps by 2050, with hydrogen heating more common in less central areas and suburbs. Central London is therefore likely to be highly electrified in all scenarios. This is due to several factors. This area has a high presence of non-domestic office, retail and hospitality buildings, which are already on a higher proportion of direct electric heating and tend to either remain on this form of heating or take up more efficient heat pumps in all scenarios. There is also a high presence of domestic flats not currently connected to the gas grid, and with higher energy efficiency levels.

![Figure 10: dominant heating technology – Central London System Transformation 2050](image-url)
Acronyms

- ASHP: Air source heat pump
- BAU: Business as Usual
- BEIS: UK Department for Business, Energy, and Industrial Strategy
- CO2: Carbon Dioxide
- EHS: English Housing Survey
- EPC: Energy Performance Certificate
- DFES: Distribution Future Energy Scenarios
- FES: Future Energy Scenarios
- GVA: Gross Value Added
- GHG: Greenhouse Gas
- GSHP: Ground source heat pump
- GW: Gigawatt
- H2: Hydrogen
- kt: Kilotonne
- kW: Kilowatt
- LA: Local Authority
- LSOA: Lower Super Output Area
- Mt: Megatonne
- MW: Megawatt
- ONS: Office for National Statistics
Authors
This report has been prepared by Element Energy.

Element Energy is a strategic energy consultancy, specialising in the intelligent analysis of low carbon energy. The team of over 60 specialists provides consultancy services across a wide range of sectors, including the built environment, carbon capture and storage, industrial decarbonisation, smart electricity and gas networks, energy storage, renewable energy systems and low carbon transport. Element Energy provides insights on both technical and strategic issues, believing that the technical and engineering understanding of the real-world challenges support the strategic work.

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