Regional modelling in FES

Discussion of the results from our new Regional Heat Model

Key Messages

- To decarbonise our energy system and meet net zero, it will be essential to lower emissions from how we heat our homes and businesses.
- The unique nature of each consumer and their homes means a range of low carbon heating technologies is required to minimise the cost of decarbonisation.
- Decarbonisation of heating will happen at different rates across the country. Understanding local and regional development rates and factors is essential to understanding energy system requirements.
- Policy decisions around the future of hydrogen for heat and transition of the current gas network will have significant implications on the regional deployment of low carbon heating technologies.
- Analysis for our 2021 Future Energy Scenarios shows that consumers in some parts of the country may have more choices available to them for decarbonising their heating. Urban areas, for example, are more likely to be connected to District Heating and Hydrogen when compared to rural areas. This will influence how technologies are rolled out or supported.

Introduction

Currently over 83% of GB residential heating is generated by natural gas, with current demand for residential heating at 404 TWh/yr. Considering the emissions this represents, the decarbonisation of residential heat in GB will have a significant role in ensuring we reach our net zero goal by 2050. [1]

Evolving how we heat our homes is going to play a key role in the decarbonisation of Great Britain's energy system. This is a complex area of energy policy, which will require action from national level to local and individual level, so it is important to understand the factors and differences that could emerge across the country to deliver more comfortable, energy efficient, lower carbon homes.

Given the importance of the future of heat to the UK's target for net zero greenhouse gas emissions by 2050, as well as the uncertainty regarding the different technology options, we have introduced a new spatial heat model. This will help us better reflect the different potential ways we can decarbonise heat in Great Britain, as

[1] To find out more about the different heating technologies discussed here, 'Energy technologies for net zero' is a recent guide put together by the IET which provides a useful reference to the different technologies that can be used to decarbonise the UK energy system.

part of our modelling of the Future Energy Scenarios (FES). This new modelling capability has allowed us to create new, more granular insights - from national to local authority level – including how heat could decarbonise at different rates in different parts of the country. It has enabled us to understand why a broad range of technology choices are required, driven by key factors such as housing density and stock; proximity to infrastructure; climate differences and the cost of alternatives available to the consumer.

In this update, we provide more detail on the results from our spatial heat model and explore the main drivers for regional variations in the uptake of low carbon heat technologies between now and 2035. This allows us to better reflect regional factors in our analysis and show how heat decarbonisation could happen .

If you are interested in how the model works, our main assumptions and how the modelling allows us to perform calculations to a much greater level of detail than in the past, please see our previous note.

We want to hear from stakeholders as we further develop our regional assumptions, modelling and outputs both in relation to heat and more broadly across the energy sector. Further information about how to engage can be found at the end of this note.

What are the different heat decarbonisation pathways between now and 2035?

The Government's Heat and Building Strategy 2021 set out the key actions and ambitions that are required in the coming years to 'transition to high-efficiency low-carbon buildings', across homes, commercial, industrial, and public sector buildings. This included the £450 million boiler replacement scheme to support the sale and installation of heat pumps and the hydrogen heating trials which will involve heating a neighbourhood by 2023, heating a village by 2025 and heating a whole town by 2030. The government also set outs its ambition to phase out the installation of natural gas boilers beyond 2035.

Figure 1 shows the potential pathways for the domestic heating technology transition between now and 2035 according to our four Future Energy Scenarios[2]. Our three net zero scenarios *Leading the Way*, *Consumer Transformation* and *System Transformation* show that heat pumps, district heating and hydrogen boilers will all be needed on the decarbonisation pathway but to different degrees, depending on the scenario. The technology mix across the scenarios by 2035 also demonstrates that technologies that require large scale infrastructure investment such as hydrogen and district heat will need time before large numbers of properties transition to these technologies.

Our Future Energy Scenarios set out different, credible pathways that could emerge to deliver the UK's net zero by 2050 target. The types of changes that may emerge vary across the scenarios:

- In *Leading the Way*, the scenario that achieves net zero before 2050, the most progress is made by 2035, with over 12 million homes transitioning from gas boilers to other low carbon technologies.
- In *System Transformation*, where hydrogen plays a greater role in domestic heating, over 4 million homes have hydrogen-ready boilers installed by the mid-2030s
- In *Consumer Transformation*, where electrification of heat dominates, over 9 million homes will have heat pumps installed by 2035.

Our new spatial heat model also shows that the way these technologies are adopted varies depending on key drivers in each region within each scenario. We explore these drivers further in the next section.

[2] These totals will vary from those published alongside our FES 2021 analysis due to our analysis and modelling being updated. This includes an enhanced representation of how technology stock varies on a regional basis. This is in readiness for our FES 2022 analysis. We have also grouped hybrid heating systems for ease of presentation.

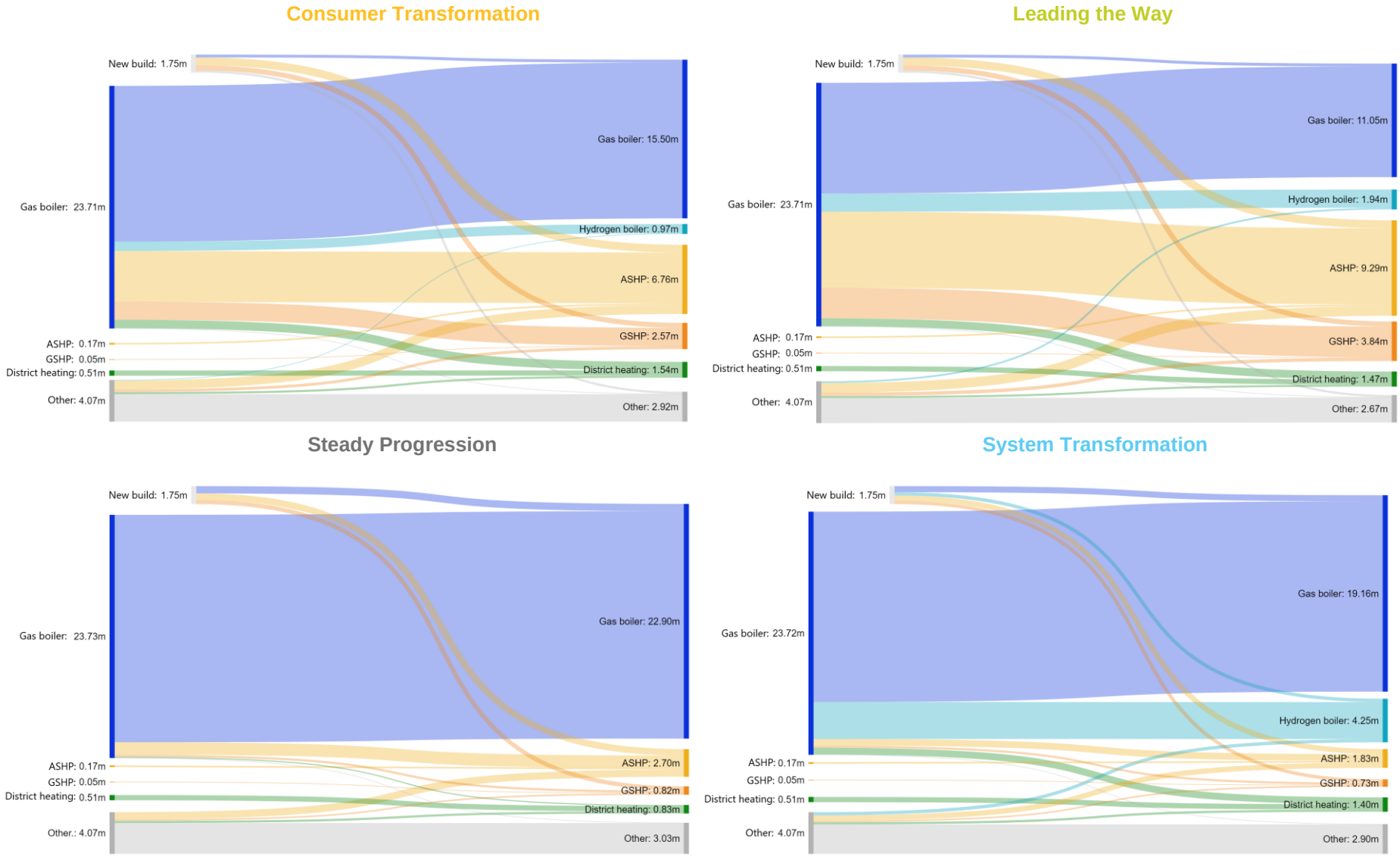

Figure 1 Sankey diagrams showing the heating technology transition between now and 2035 for our four future energy scenarios.

How and why will the uptake of different low carbon heat technologies vary across the country?

Our new spatial heat model allows us to explore how suitable low carbon heating technologies are in different regions. The model is driven by value for money for the end consumer and our modelling allows us to apply policies that would encourage adoption of particular technologies as well as policies that incentivise certain behaviours or indeed policies that discourage certain technology uptakes. We have assumed direct financial incentives such as LCH (Low Carbon Heating) with different technologies and direct financial disincentives for certain technologies (analogous to sales tax).

Our analysis has found that there will have to be appropriate technologies for different types of housing in each region across GB and this will be driven by a number of factors including:

- housing density
- proximity to infrastructure such as the current gas grid or future hydrogen networks
- the cost of alternatives available to the consumer
- housing stock
- if local policy drives technology choices in a particular direction.

We describe some of these key drivers in more depth below.

Key drivers for regional variations in low carbon heating technology uptake

Housing density

Housing density is an important factor for different technologies in different ways. Particular heating solutions are preferred in urban areas due to more limited space, potential economies of scale and availability of heat sources.

District heat, for example, has the greatest potential in the most densely populated areas of the country. District heating is a community-based heating solution, which uses a single central hub to heat water, which is then pumped around a number of different homes and buildings. Future district heat schemes not served by waste heat sources are powered by heat pumps or biomethane depending on the scenario. Figure 2 shows how many homes could be connected to district heat networks across all four FES scenarios in 2050, compared to the number of connections as of 2020.We found that the cost-effective capacity of district heating is limited to about

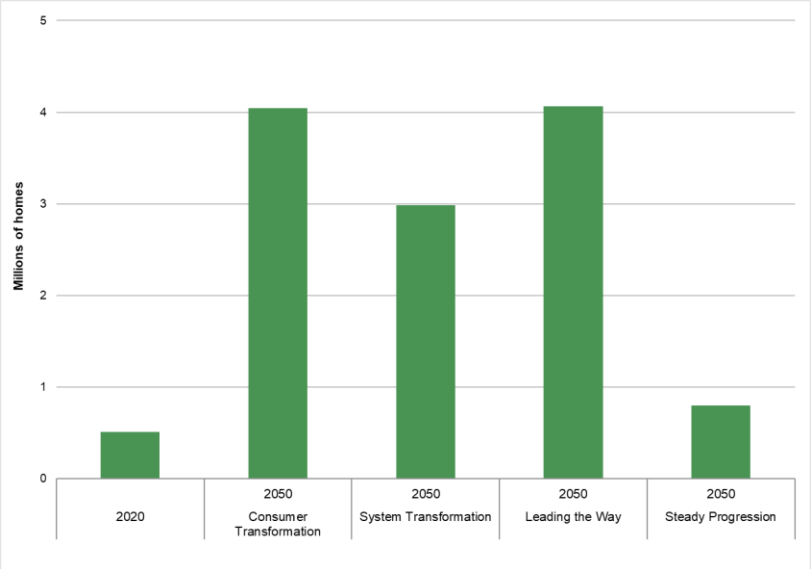

Figure 2: District heat network connections in 2050

20% of residential connections within any Local Authority area across GB, beyond this capacity other alternative technologies become more cost-effective.

Figure 3 shows the proportion of housing stock connected to district heat in our *Consumer Transformation* scenario by 2035. This shows that some of the higher population density regions have higher proportions of district heating under this scenario.

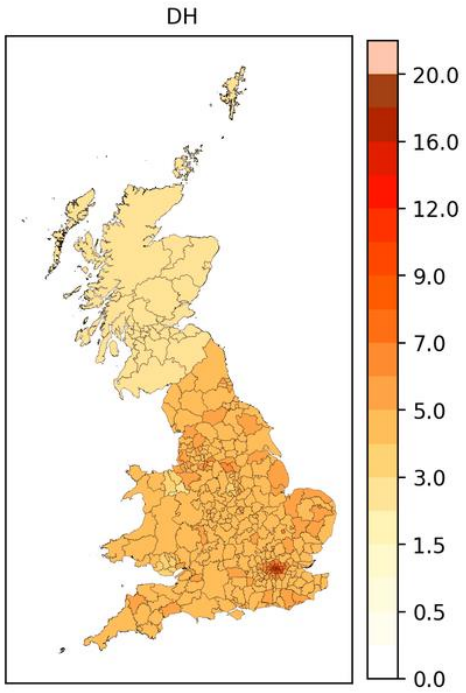

Figure 3: Proportion of housing stock connected to district heat by 2035 in Consumer Transformation

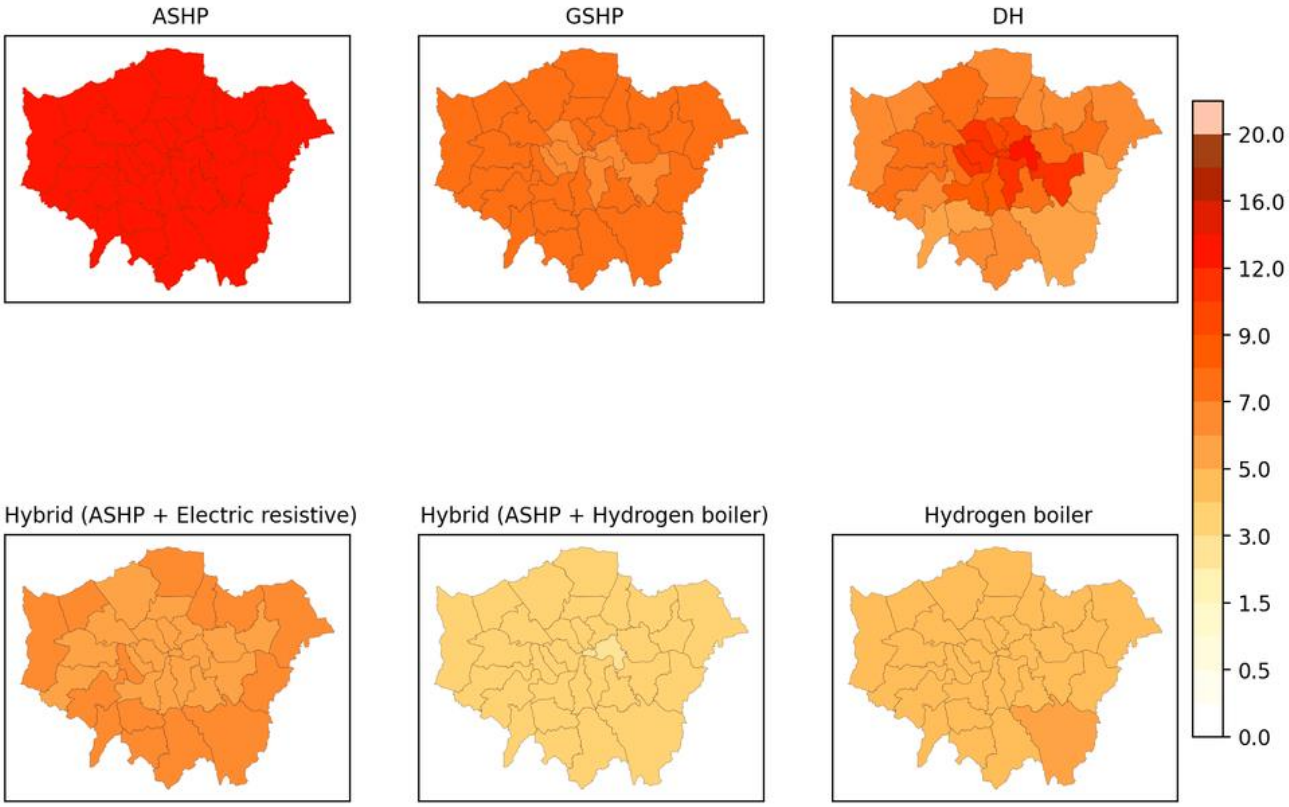

Figure 4 Technology comparison for the Greater London area in Consumer Transformation. DH – District Heating; GSHP - Ground Source Heat Pump; ASHP – Air Source Heat Pump

Figure 4 presents the technology comparison for the Greater London area. Taking a closer look shows the nature of housing stock and population density increases the prevalence of district heating within Central London. This also shows that the proportion of ground source heat pumps for individual properties reduces within Central London, as this technology would tend to be more common in less densely populated areas due to the amount of space that is required.

Proximity to infrastructure

Our analysis has shown that areas closer to the current natural gas grid are likely to have higher concentrations of hydrogen boilers in a hydrogen dominated scenario, such as our *System Transformation* scenario. In *System Transformation*, properties in all Local Authorities would eventually be allowed to connect to a hydrogen network if within a certain distance of the existing gas grid due to a re-purposing of the grid to accommodate higher levels of hydrogen. The modelling assumes that the building has to be within 23 meters of the gas grid for hydrogen network connections. From 2025 new build homes are assumed to include hydrogen-ready boilers and appliances in readiness for switching the natural gas network to hydrogen from 2030 under this scenario.

In our *Consumer Transformation* scenario we assumed that hydrogen production develops within a small number of industrial clusters. The uptake of hydrogen boilers would therefore be focused in those areas where there is proximity to production as the associated costs of network upgrades to transport the hydrogen from further away become prohibitive. These clusters are based on cost-optimisation. Understanding when and where hydrogen clusters will develop, following on from current pilot production projects, will become an increasingly important area of focus in our future modelling.

Figure 5 shows the differences in the regional uptake of hydrogen boilers by 2035 in our *Consumer Transformation* and *System Transformation* scenarios. The location of any potential industrial clusters will have a significant impact on the rollout of hydrogen boilers. The same is true of the impact of widespread conversion of the current natural gas network infrastructure to transport hydrogen. We assume that the conversion of the gas network to hydrogen is a key requirement for increasing hydrogen boiler uptake. The population density is an important factor here when supplying through a network, as this reduces the cost of hydrogen as a heating source compared with less dense off grid areas.

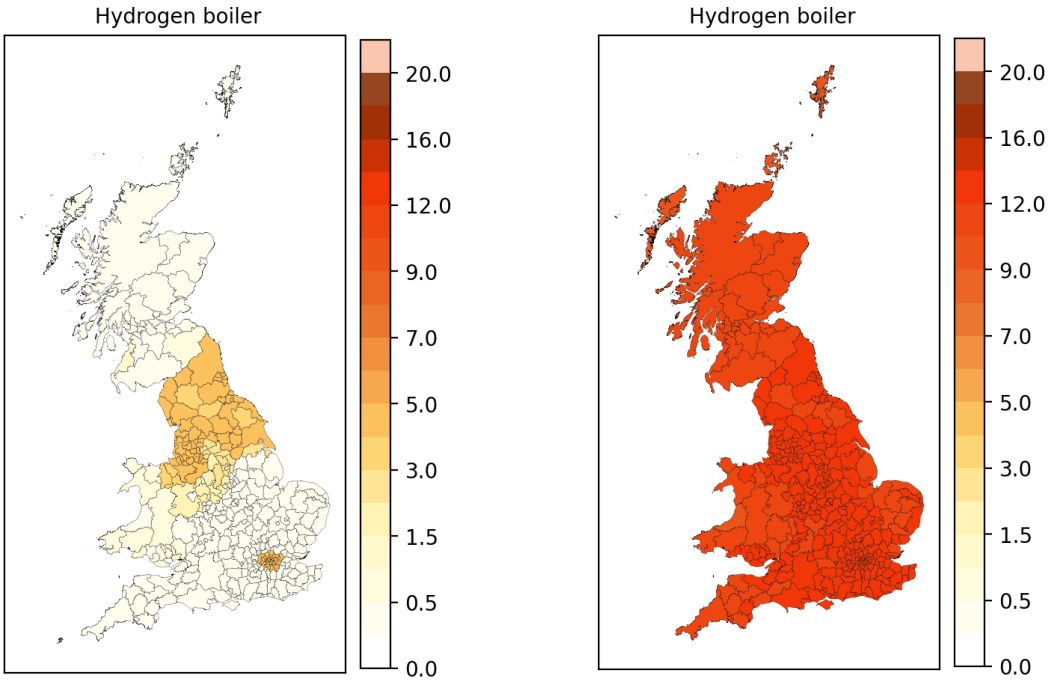

Figure 5: Proportion of housing stock with hydrogen boilers in 2035 in Consumer Transformation (left) and System Transformation (right)

Cost of alternatives

The new spatial heat model optimises the cost of technology uptake and thermal efficiency measures together. This optimisation is completed at building level and aims to get the best value for the consumer by considering their willingness to pay and the potential choices they will make in relation to their day-to-day usage of their heating systems.

The model begins this optimisation with a baseline understanding of future demand for heat and then models the full range of technologies that could meet that demand at minimum cost, considering availability of particular thermal efficiency measures and matching the technology to different insulation packages, be that wall, window, floor or loft insulation. Therefore, the spatial deployment of low carbon heating technologies is greatly influenced by the cost and availability of alternative technologies. We described this in our FES 2021 publication, looking at the deployment of heat pumps across GB.

The regional variation in the cost of alternatives is particularly evident in *Consumer Transformation* and *Leading the Way* as shown in Figure 6. In *Consumer Transformation* there is no hydrogen network prevalent in Scotland, which leads to a higher deployment of heat pumps to fill the gap as the most cost-effective technology. However, we have assumed a small number of Hydrogen clusters will develop elsewhere such as in Greater London. The *Consumer Transformation* scenario has the highest levels of electricification of all scenarios and we have assumed that all new-build homes will have heat pumps installed from 2025. We have also assumed that households that are currently not connected to the natural gas grid will either use heat pumps, biofuels or heat

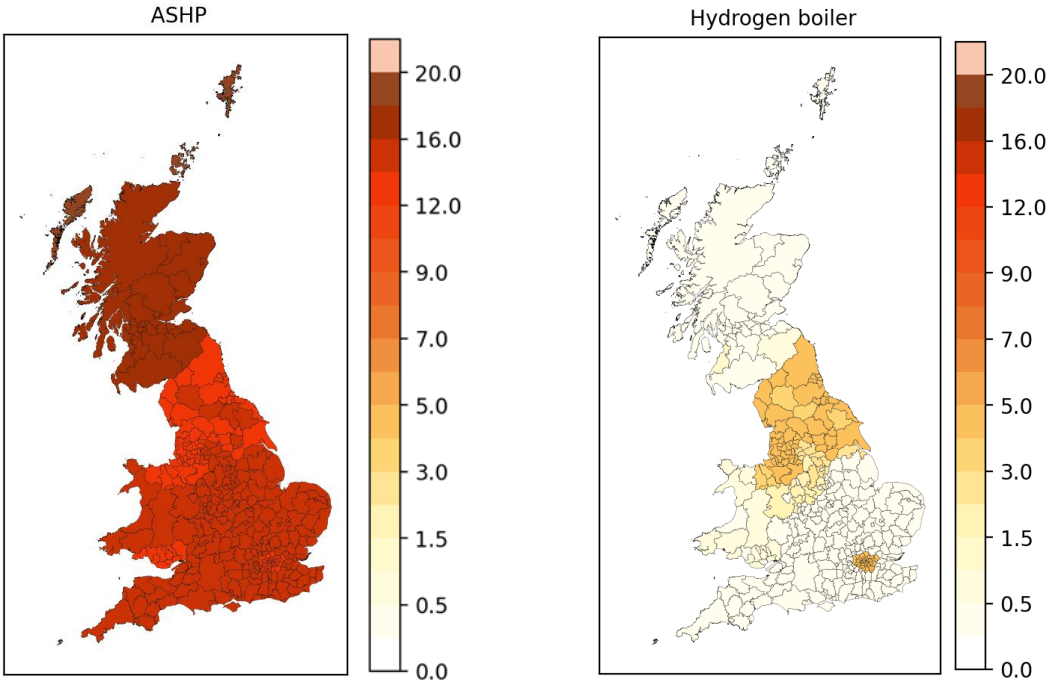

Figure 6: Proportion of housing stock with air source heat pumps (left) and Hydrogen boilers (right) in 2035 in Consumer Transformation

pump-biofuel hybrids.

In *Leading the Way* government policy will drive significant uptake of heat pumps across the whole of GB by reducing the costs of the heat pump to the consumer, but the development of local hydrogen networks would still be an important factor in decarbonisation. This is shown in Figure 7. In this scenario, hydrogen production facilities are located in Wales and in Scotland, with district heat available in London and heat pump deployment is lower in these regions when compared to the rest of GB.

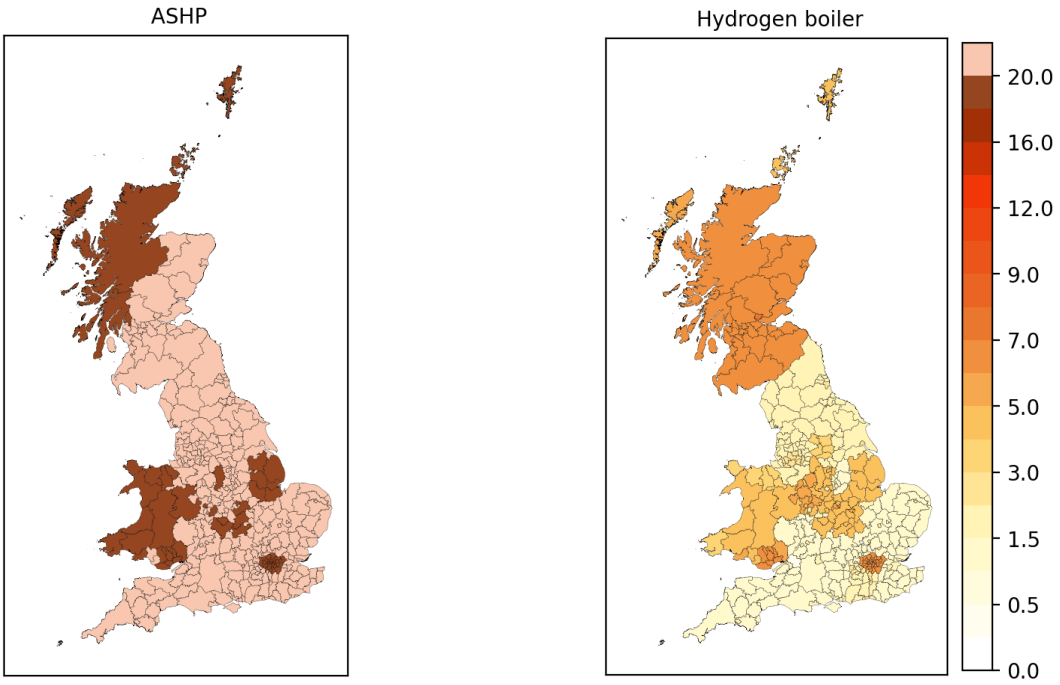

Figure 7: Proportion of housing stock with air source heat pumps (left) and Hydrogen boilers (right) in 2035 in Leading the Way. Please note the light pink shade denotes a higher concentration of heat pumps.

Next Steps

We have updated our spatial heat model in readiness for our FES 2022 analysis with specific improvements being made to the way that housing stock is processed regionally to enhance the quality of the outputs. We have also updated policies based on information from the Heat and Buildings strategy and other publications.

We intend to publish additional regional results alongside FES 2022 to increase the transparency of our outputs. We have published the supporting data for this thought piece which can be found on the ESO data portal here.

Get involved in the conversation

We will be building on our regional approach within FES 2022 and we would welcome your views on the future of heat decarbonisation. We are also interested to hear your views on what other areas of our modelling would benefit most from adopting a bottom-up regional approach. Get in touch with us at FES@nationalgrideso.com.