Regional modelling in FES

Discussion of the assumptions in our new Regional Heat Model

Key Messages

Our new spatial heat model optimises technology uptake and thermal efficiency measures together

- The model aims to get the best value for the consumer considering their willingness to pay and the potential choices they will make in relation to their day-to-day usage of their heating systems

We have transformed how we model building archetypes

- We are now able to model to a greater level of granularity than ever before moving from modelling 4 building archetypes to over 8000

We are now able to apply policy as a quantitative input in our modelling

- Our modelling allows us to specify how much incentivisation would be needed to drive a particular behaviour in end consumers

The new model allows the use of flexibility tools to manage within-day demand due to electricity price sensitivities

- We can use the model to investigate how to get best value for the consumer at times of high electricity prices

With regional assumptions we can understand how different parts of GB will decarbonise in different ways and at different rates

- We believe that there are aspects of decarbonising the whole energy system that are driven mainly by local factors and we are increasingly focusing on more granular regional outputs. This is both as part of our modelling and through the insights we provide to the industry

Introduction

We introduced the results from our new Regional Heat Model for the first time in FES 2021. The model and the results produced enable us to understand, to a greater level of detail than previously possible, the various pathways that exist for decarbonising heat. The model also introduces more granular regional modelling into the FES process which will increasingly become a focus area in future iterations of the FES.

Our new heat model was the result of a collaborative innovation project in partnership with National Grid Gas and developed by Element Energy, with both gas and electricity distribution companies on the Advisory Group. The model allows us to enhance our understanding of the potential heat decarbonisation routes, their likelihood, and their impact on networks and consumers. The model also provides results at a regional rather than national granularity.

This thought piece builds on our previous publications exploring our heat decarbonisation modelling and introducing our new regional heat model, as well as explaining in more depth the assumptions that were presented in our FES 2021 publication. We will outline the key differences in the assumptions compared to our former modelling framework to give context on the results presented through our main FES publication and associated data.

We want this to continue the conversation on our modelling and outputs and to get stakeholder input as we further develop our regional assumptions, modelling and outputs both in relation to heat but more broadly across the energy sector. We are specifically interested in your feedback on the assumptions presented here and your feedback will be used to inform our FES 2022 analysis.

What assumptions did we use previously and how do these compare to now?

We introduced the key assumptions for the new spatial heat model in our previous thought piece as well as exploring some of these assumptions in our Consumer View chapter in the FES 2021 publication. We describe these assumptions in more depth below as well as explaining how these compare to the assumptions used previously. We have also outlined how the detailed assumptions for each of the scenarios have changed later in the Appendix.

Our new spatial heat model analysis assumptions

The new spatial heat model optimises technology uptake and thermal efficiency measures together. The model considers all relevant heating costs. There are two different optimisation methods, one based on minimising the 'levelised cost of ownership' (considering capital and operation costs, selecting the configuration with the lowest combined levelised cost) and one that is consumer choice driven. Our heat decarbonisation analysis is completed using the second optimisation method, focussing on consumer choice (i.e. in line with our "level of societal change" axis). This means we can assess and produce a credible range of potential outcomes for heat decarbonisation in line with our scenario framework. This optimisation is completed at building level and aims to get the best value for the consumer 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 will meet that demand at minimum cost. This considers availability of particular thermal efficiency measures and matching the technology to different insulation packages which did not feature in our previous modelling method.

The optimisation balances the upfront cost of heating technology, storage system and insulation measures with how much the consumers are spending to meet their heating needs, trading-off between heat demand and fuel price. We have assumed different technology choices and insulation for each building archetype to get the optimal combination to represent the best overall cost to the end consumer. For example, if the building is already well insulated then a smaller heat pump might be the technology of choice in this instance.

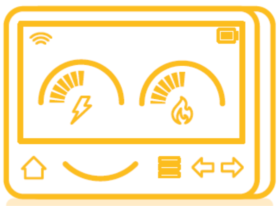
We have transformed how we model building archetypes. A key modelling difference between our previous modelling and now is the number of building archetypes considered. Our new modelling considers over 8000 different archetypes whilst our previous modelling only considered 4.

If consumers are engaged and taking proactive steps to reduce demand this can reduce the burden of requiring disruptive insulation measures in their properties. We have updated our assumptions to consider that consumers will take action if there is enough awareness and encouragement to change behaviour. We assume that this will have a positive impact on reducing the level of heat demand. This could play out in different ways, including consumers being proactive about the level of insulation that they have installed in their homes as well as changing how they heat their homes e.g. not heating certain rooms. Consumers could also turn their thermostat down and choose to turn the heat on less often which, when taken together, could result in a significant overall reduction in demand. We are also exploring how consumer

behaviour, both domestic and non-domestic, can be categorised and how to apply those categories or archetypes to our modelling.

One of our Key Messages in FES 2021 based on our modelling was that the thermal efficiency of buildings is as important for hydrogen boilers as it is for heat pumps. For hydrogen boilers increases in energy efficiency means reduced fuel costs and ongoing savings over the lifetime of the boiler. For heat pumps, the thermal efficiency requirements of the building will be linked to the initial sizing of the heat pump and up-front installation cost. In relation to this thermal efficiency, there is an interaction between consumer behaviour and building fabric changes - significant thermal insulation measures will still be needed across all scenarios, although changes in consumer behaviour can reduce how much is needed.

We are now able to better apply policy as a quantitative input in our modelling. This 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. This year we assumed direct financial incentives such as LCH (low carbon heating) with different technologies and direct financial disincentives for certain technologies (analogous to sales tax). The model also allows application of policies on a regional level, such as down to each local authority and at this stage we have chosen not to change policy on a per region basis. Therefore regional differences seen in our results are not due to policy but rather due to baseline variations in technology deployment as well as factors including housing density, housing stock parameters and infrastructure. Before we introduced the new spatial heat model into the FES process, we applied policy in relation to heat qualitatively and we were unable, for example, to specify how much incentivisation would be needed to drive a particular behaviour in end consumers.



The new model allows the use of flexibility tools to manage within-day demand due to electricity price sensitivities. We can use the model to investigate how to get best value for the consumer at times of high electricity prices. For instance, this could involve the use of thermal storage – either a simple hot water tank or more complex phase-change technology which can be filled at times of relatively low prices. In the case of a well-insulated building, it could include times of day when heating can be turned off or down. Hybrid systems can also be modelled, such as a heat pump paired with a hydrogen boiler that will allow consideration of electricity cost versus the cost for hydrogen or biofuel. This could be a good option for off-gas grid properties which are large and harder to insulate and could use a combination system to keep heat pumps to a reasonable size. Similarly, a heat pump could be paired with resistive heating which could reduce the size of heat pump that is needed, at the expense of an increase in peak demand.

In addition, we found that a 1°C (on average) decrease in home thermostat temperatures in our Leading the Way scenario compared to today's levels can lead to up to a 13% reduction in heat demand. Looking at this on a regional basis will add value due to the different weather patterns we see across GB.

Figure 1 shows how thermal storage can help manage household demand if thermal storage solutions are used alongside heat pumps for example. The appropriate price incentives will encourage consumers to store heat at times of low demand and high supply ready to be used when demand on the local or national electricity networks are high.

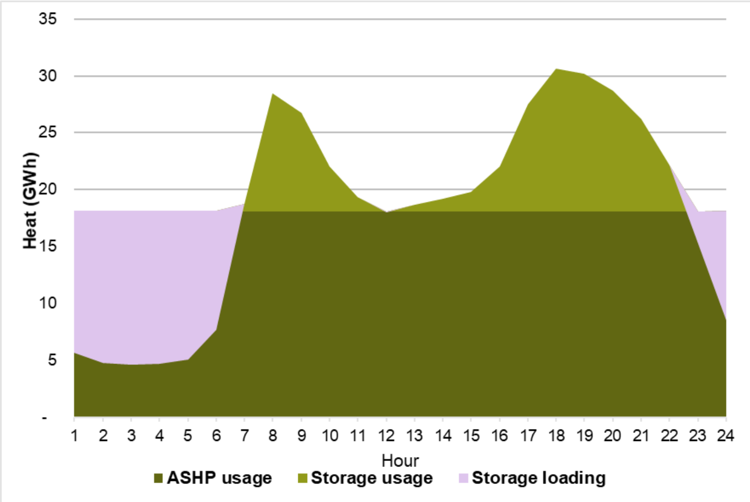


Figure 1: Thermal storage use on a peak day: hourly dispatch profiles for Air Source heat pump in Leading the Way

With regional assumptions we can understand how different parts of the country will decarbonise in different ways and at different rates. Our updated modelling allows us to complete calculations at higher granularity with District Heat and building level technologies down to lower layer super output areas (LSOA) levels and hydrogen down to Local Authority (LA) level. Once the calculations are complete, we then can aggregate the results to the appropriate network boundary, Grid Supply Points (GSPs) for the electricity system and offtakes for the gas system. We have assumed:

- Four temperature regions within GB: Scotland, northern England, southern England and Wales
- Once uptake of a technology increases within a particular LA, the model has an inbuilt feedback loop which leads to acceleration of the uptake for that technology. For example, the more hydrogen boilers installed will lead to a further increase in installations into the future
- Different housing densities which will impact the uptake of low carbon heating technologies across the country, such as District Heating systems
- Hydrogen infrastructure location is either based on existing distribution and transmission infrastructure or a new hydrogen network could be created, with clusters (hydrogen towns) growing and combining. Differences between regions would be small at the start and then propagate further into the future
- Hydrogen blending is a discrete option over having a dedicated hydrogen network and is only applied in Steady Progression in FES 2021
- Policy inputs are at GB level and therefore any regional variations in uptake of particular technology are not as a result regional differences in policies

Next steps and how you can get involved in the conversation

We have been doing further detailed analysis using the new spatial heat model to explore the regional impacts of different consumer choices and how technology uptake will vary across the country and according to the relevant scenario. We intend on presenting these new insights and additional regional data soon. Any feedback we receive will help shape the analysis for our next FES publication launching in July 2022. We would like to hear your feedback on the assumptions presented here and we have outlined these in the next section. Figure 2 shows some of the outputs from the regional analysis we introduced in our FES 2021 publication.

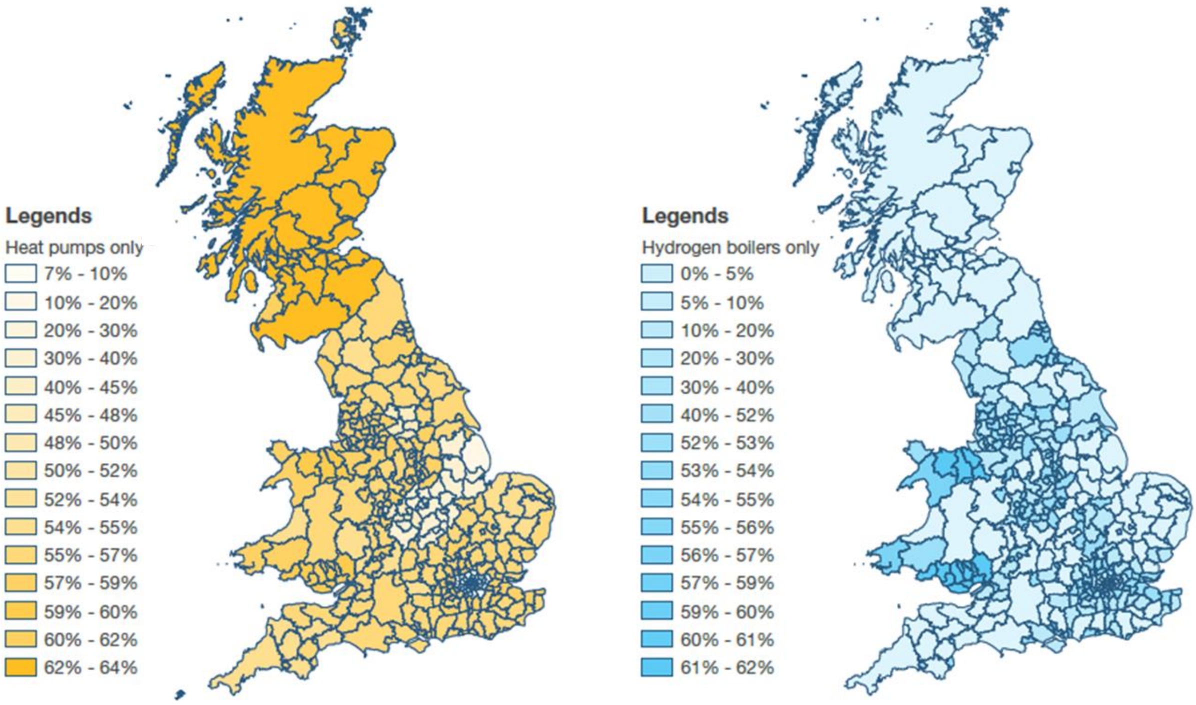


Figure 2: Proportion of homes in 2050 with heat pumps in Consumer Transformation (left) and proportion of homes in 2050 with hydrogen boilers in System Transformation (right)

Can we have your feedback?

We are keen to understand your thoughts on our modelling and the assumptions below

- **Will consumer heating behaviour affect annual and peak demands in the same way?**

  Our Leading the Way (LW) and Consumer Transformation (CT) scenarios assumed reduction in indoor temperatures by up to 1ºC and 0.5ºC respectively driven by changes in consumer behaviour. The way we modelled this assumed annual and peak demands would be affected in similar ways and we are interested in your views on this. Will consumers be prepared to turn down their thermostats on cold days?

- **What sort of timeframes are reasonable for our consumer behaviour assumptions?**

  We assume the behaviour that drives reduction in indoor temperatures in CT and LW happens immediately on the basis that no technological change is required. Is this a reasonable approximation in our higher “societal change” scenarios or is a more continuous change important?

- **Will thermal storage represent the largest share of peak shaving potential for heat and how much is credible?**

  In our analysis we have found that amongst the technologies we considered to enable the use of flexibility tools to manage within-day heat demand due to electricity price sensitivities, use of thermal storage technologies was the most effective when combined with low carbon heating technologies. Do you agree and what level of peak shaving potential do you think is credible in relation to heat-related demand?

- **What is the likelihood that regional differences in policy will be enduring?**

  We haven’t applied regional differences to policies in our model and we assumed that any regional differences wouldn’t be enduring. There would be much greater regional difference in technology uptakes if we did include this in our modelling and are interested in your views. We would need to have access to detailed information on local policies in order to model their impact accurately.

- **Our modelling places hydrogen clusters where it is cost optimal to do so. Is this a reasonable assumption?**

  The model doesn't consider the specific location of current pilot hydrogen production projects in its calculations and placement of future hydrogen clusters, but rather bases the results on cost optimisation and consideration of where clusters are likely to develop from an economic perspective. We are interested in your views on this.

- **Should we be modelling more temperature regions within GB?**

  We currently model four temperature Scotland, northern England, southern England and Wales. Do you think we should be increasing the granularity to capture more regional differences?

- **Do you have access to regional data that would improve our modelling?**

  Through our recent stakeholder engagement we have started to collect more regional data that we can use as an input into the model but we are always after more. Regarding heat, we are particularly interested in any information related to consumer behaviour and we are also interested in specific data related to the technologies we have modelled. This includes coefficients of performance or seasonal performance factors and the potential cost assumptions of different technologies into the future.

We have created a Form so you can provide your feedback directly to us. We'd also love to hear your general thoughts on the future of heat decarbonisation and more broadly on how we incorporate regionalisation in other areas of our modelling. Get in touch with us at FES@nationalgrideso.com

Appendix

Comparison of the Model Assumptions

Sitting underneath our scenario framework are the detailed assumptions that feed into forming each of the scenarios we have considered. These assumptions allow us to set the detailed granular inputs into our models and are set generally at high, medium or low for each of the four scenarios. These HML settings represent the relative differences between the scenarios for each of the assumptions rather than an absolute position. The table below summarises the assumptions that are relevant to our heat modelling and how they have changed upon introduction of the new model.

Type	Assumption	FES 2020	FES 2021 & 2022
Retained assumptions	Heat pump adoption rates	**Low (Steady Progression)** **Medium (System Transformation)** **High (Consumer Transformation)** **High (Leading the Way)**	
	Heat: comfort level	**High** **Medium** **Low** **Low**	
	Home thermal efficiency levels	**Low** **Medium** **High** **High**	
Amended assumptions	Residential Thermal Storage	**Low** **Medium** **High** **High**	**Low** **Low** **High** **Medium**
	Uptake of gas-electric hybrid heating system units	**Low** **Medium** **Low** **High**	**Low** **Low** **Medium** **High**
Legacy FES 2020 assumptions	District Heat	**Low** **Medium** **High** **High**	
	Boiler population efficiency	**Low** **Medium** **High** **High**	
	Proportion of the year gas-electric hybrid heat system use electricity	**Low** **Medium** **High** **High**	
FES 2021 onwards assumptions	Heating appliance efficiency		**Low** **Medium** **High** **High**
	Hydrogen boiler adoption rate		**Low** **High** **Low** **Medium**

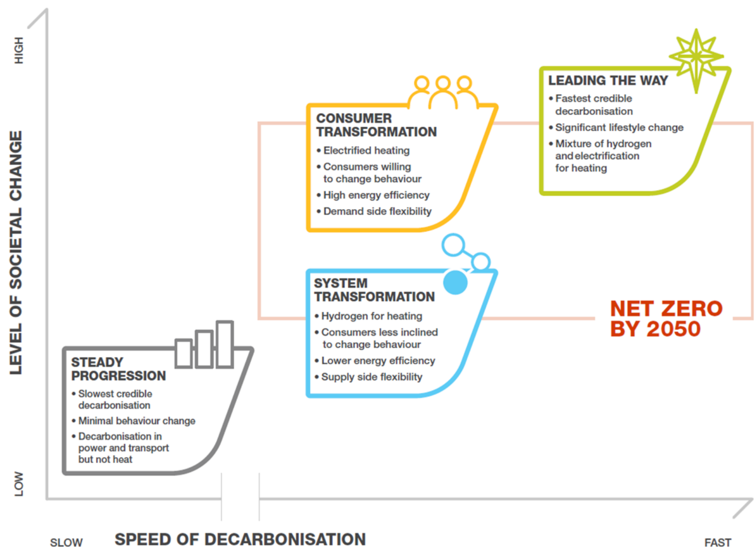
Our heat adoption rates, heat comfort level and home thermal efficiency assumptions remain consistent between our previous and new heat decarbonisation analysis across all scenarios. We have removed the District Heating assumptions as the new spatial heat model allows us to model a broader range of technologies to a more granular regional level and incorporates the level of district heating schemes deployed as well as considering which areas of the country differ in the technologies adopted to decarbonise heating.

We have removed the Boiler Population efficiency assumption which represented the rate of change of high efficiency boiler uptake. This has been replaced with heating appliance efficiency assumptions which has allowed us to take a broader look at the rate at which new technological innovations and best practices are adopted to improve the fuel efficiency of building heating appliances.

Our assumptions have changed regarding the level of thermal storage usage across the scenarios – particularly we now assume moderate levels of thermal storage in our Leading the way analysis because of high levels of technology hybridization in that scenario.

We have removed our assumptions regarding the fuel split in hybrid heat systems due to the granularity and technologies the spatial heat model allows us to analyse. Similarly, we have expanded our assumption regarding the uptake of hybrid system units to account for a broader range of technologies e.g. Air source heat pumps paired with BioLPG or with electric resistive heaters.

Our Future Energy Scenarios Framework



Consumer Transformation

- Electrified heating
- Consumers willing to change behaviour
- Higher energy efficiency
- Demand side flexibility

System Transformation

- Hydrogen for heating
- Consumers less inclined to change behaviour
- Lower energy efficiency
- Supply side flexibility

Leading the Way

- Fastest credible decarbonisation
- Significant lifestyle change
- Mixture of hydrogen and electrification for heating

Steady Progression

- Slowest credible decarbonisation
- Minimal behaviour change
- Decarbonisation in power and transport but not heat