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# Impacts of Heat Decarbonisation Pathways on the GB Electricity and Gas Demand

Ali Ehsan, Robin Preece

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THE CONVERSATION

# Heat pumps: UK to install 600,000 a year by 2028 but electrical grid will need massive investment to cope

Published: September 30, 2021 4.47pm BST

Power cuts could happen more regularly if the grid is not updated. Riccev/Shutterstock

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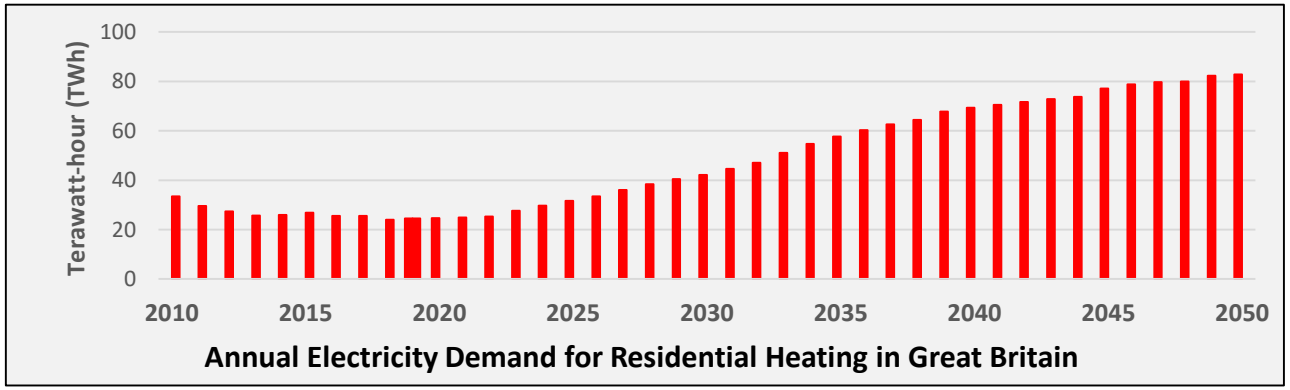
In its bid to massively reduce household use of greenhouse gases to net zero by 2050, the UK government aims to encourage the installation of 600,000 heat pumps a year by 2028.



Annual Electricity Demand for Residential Heating in Great Britain

Without additional investments in electricity networks and additional innovations, such power cuts will be more likely. There are ways to reduce this risk but these mean major investment, financial incentives and public acceptance. The government has acknowledged the need to upgrade the grid.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**Disclosure statement**

Robin Preece works for The University of Manchester. He receives funding from EPSRC.

Ali Ehsan works for The University of Manchester. He receives funding from EPSRC through the Supergen Energy Networks Hub.

**Partners**

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# Quantifying the impacts of heat decarbonisation pathways on the future electricity and gas demand

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*Department of Electrical and Electronic Engineering, The University of Manchester, Manchester, United Kingdom*

## Research Questions

1. What is the breakdown of annual electricity and gas demand by end-use in 2050?
2. How volatile is the electricity and gas demand in 2050?
3. How sensitive is the 2050 electricity demand to coefficient of performance of heat pumps and building energy efficiency upgrades?
4. How effective is demand-side flexibility at reducing the electricity demand volatility**?**

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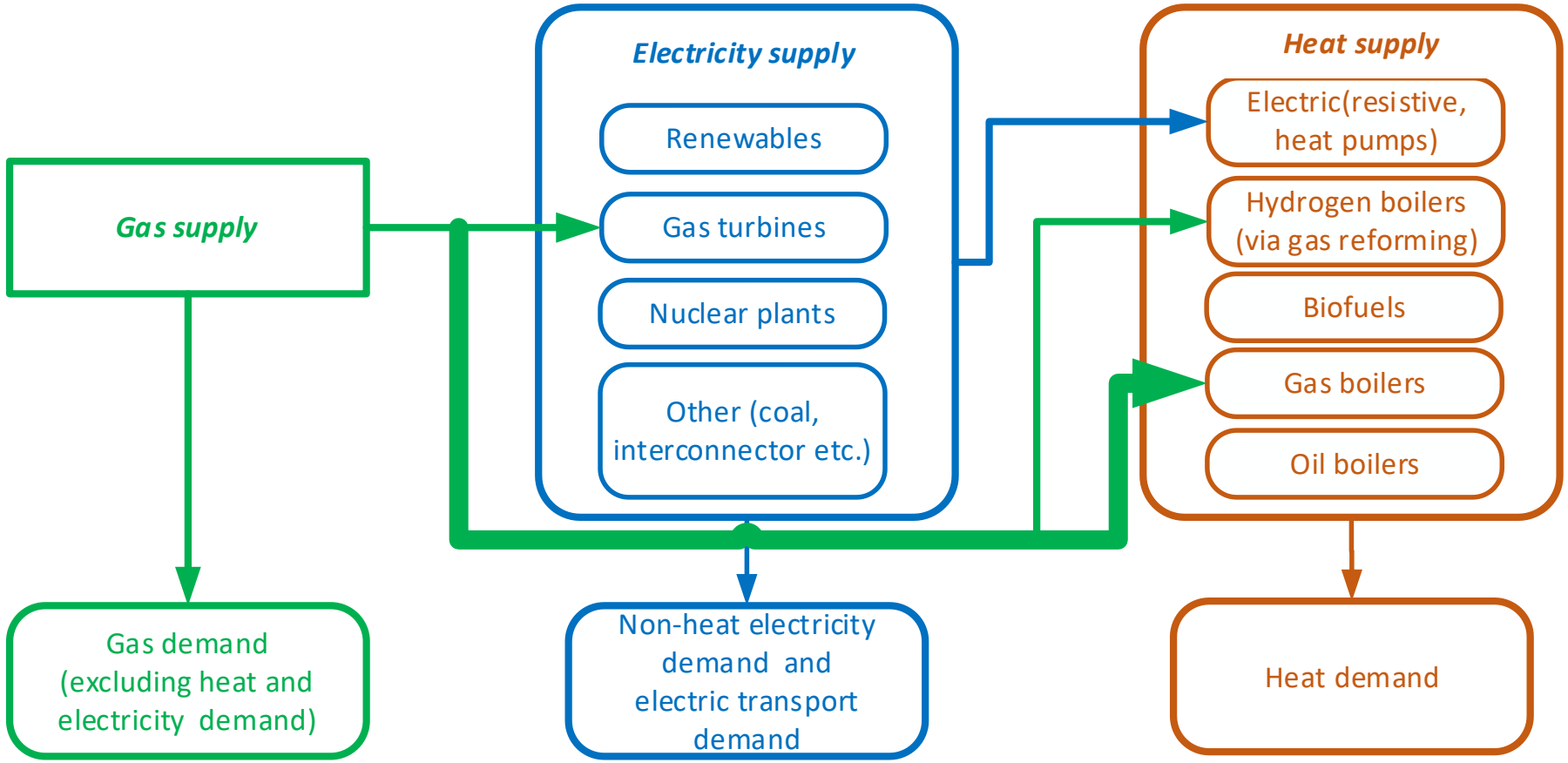
# Interdependence of the energy supply systems in Great Britain

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Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

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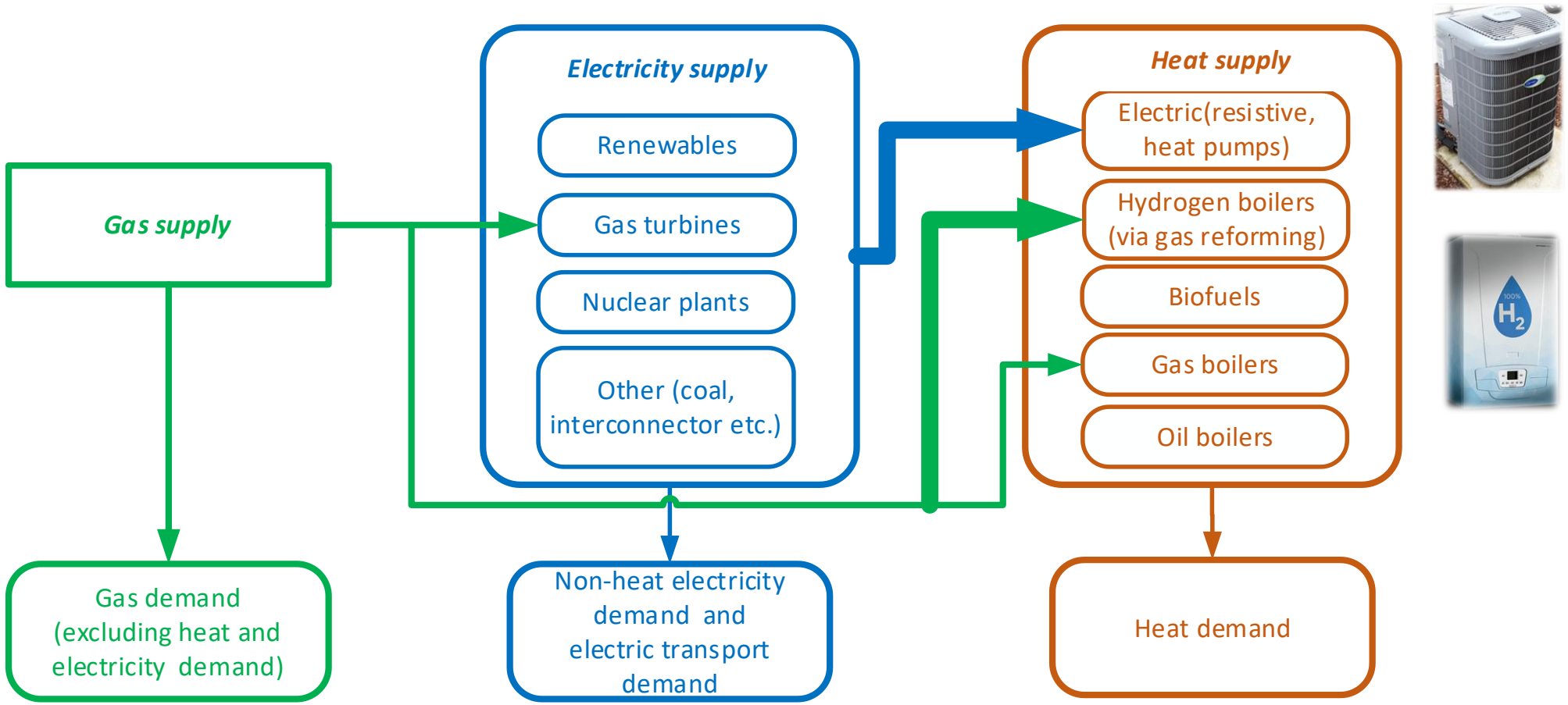
# Interdependence of the energy supply systems in Great Britain









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Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

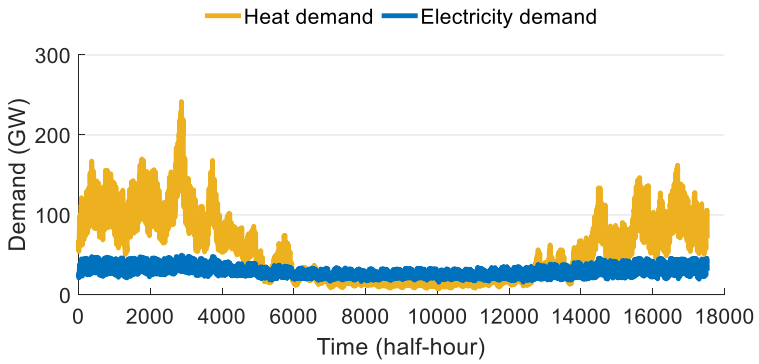
# Optimisation framework of the integrated gas, electricity and heat supply model

| | Electricity | Gas | Heat |
|---|---|---|---|
| **Inputs** | • Historic electricity demand profiles of heating, non-heat and road transport<br>• Historic wind and photovoltaic generation<br>• Installed capacity of power generation units | Historic gas demand profiles of daily-metered customers, industry and cooking | • Historic heat demand profile<br>• Share of heating technologies in heat supply |

| | |
|---|---|
| **Objective** | Minimise the costs of electricity generation, gas supply and the associated emissions |

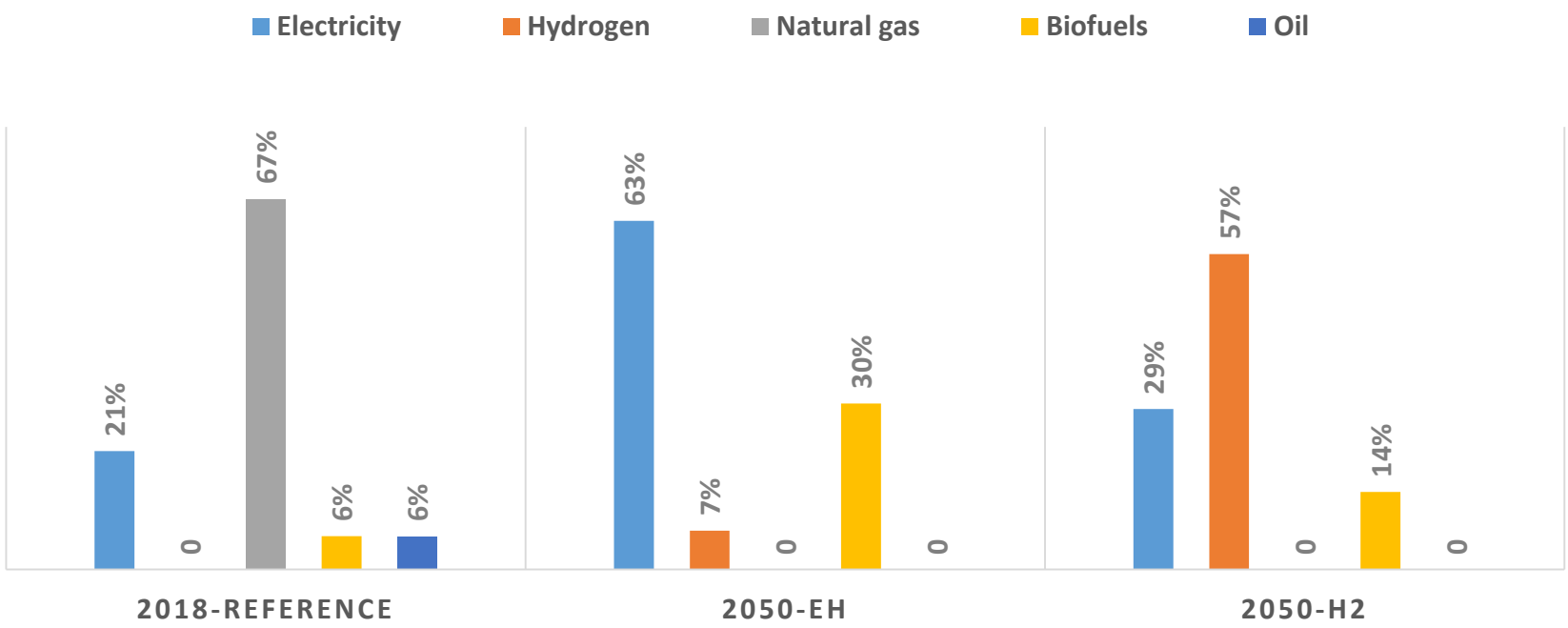
| | | |
|---|---|---|
| **Constraints** | • Electricity supply and demand balance<br>• Generation capacity limits<br>• Ramp rate limits of thermal power plants | • Heat supply and demand balance<br>• Gas supply and demand balance<br>• Coupling components |

| | |
|---|---|
| **Outputs** | • Annual and peak electricity demand<br>• Annual and peak gas demand |




Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

# Composition of scenarios w.r.t. heat supply




Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

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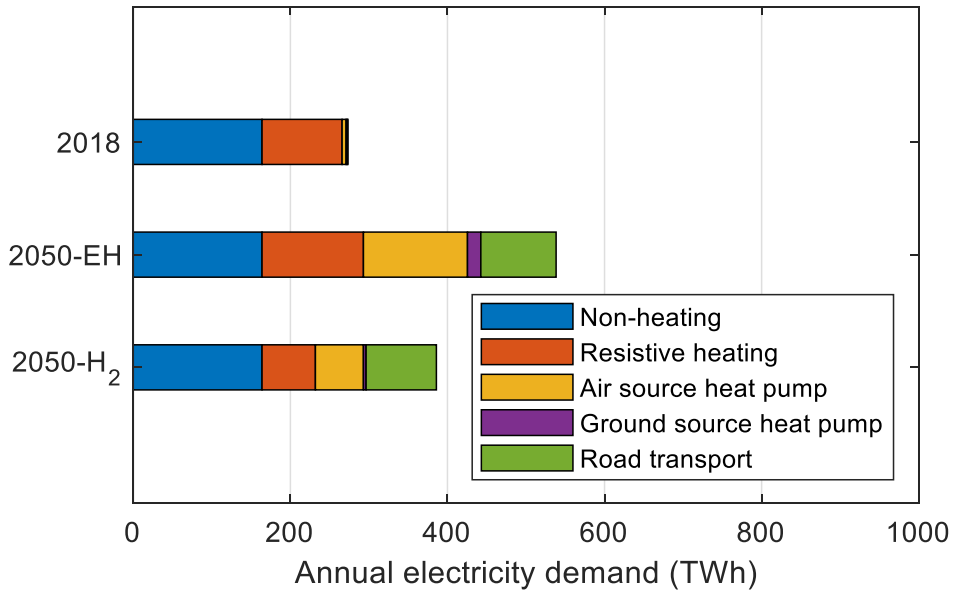
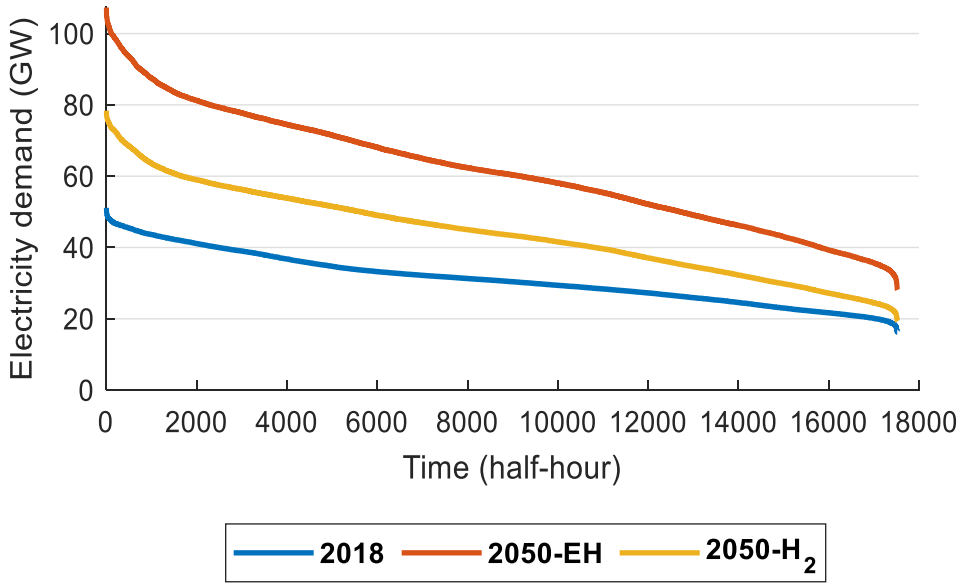
## What is the breakdown of annual electricity demand by end-use in 2050?




## How volatile is the electricity demand in 2050?

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Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

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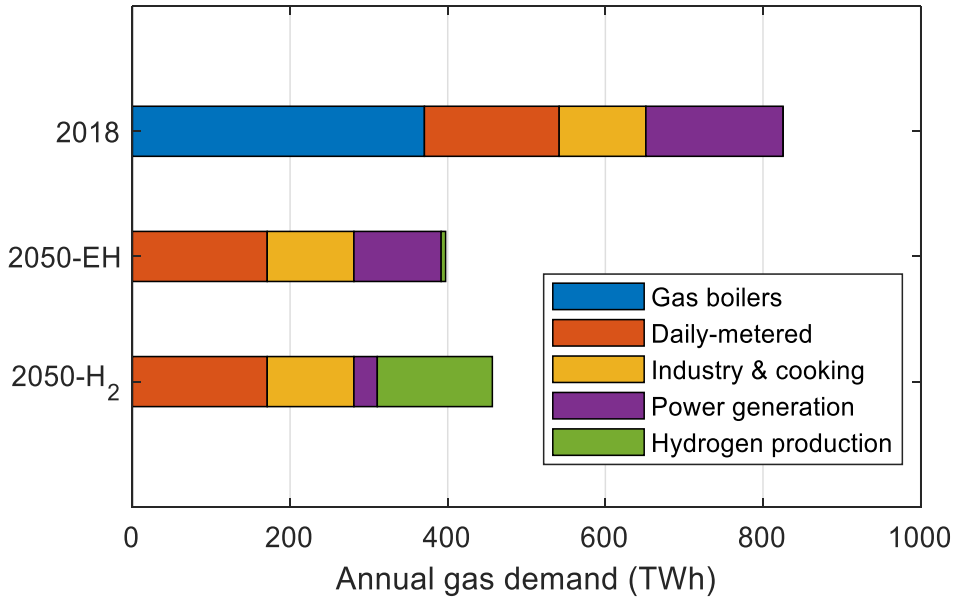
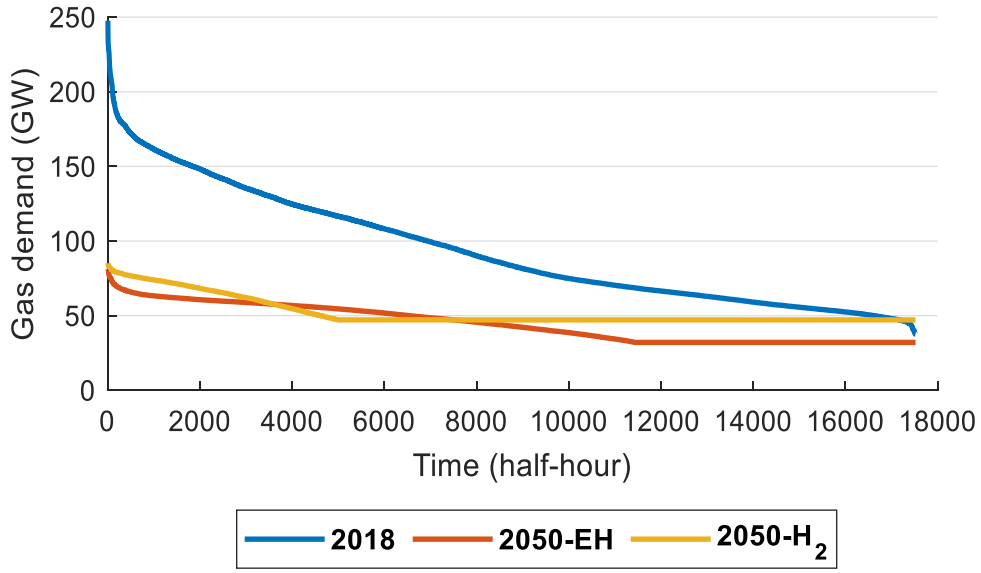
## What is the breakdown of annual gas demand by end-use in 2050?




## How volatile is the gas demand in 2050?

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Source: Ehsan A, Preece R. Quantifying the Impacts of Heat Decarbonisation Pathways on the Future Electricity and Gas Demand, *Energy*, vol. 254, 2022

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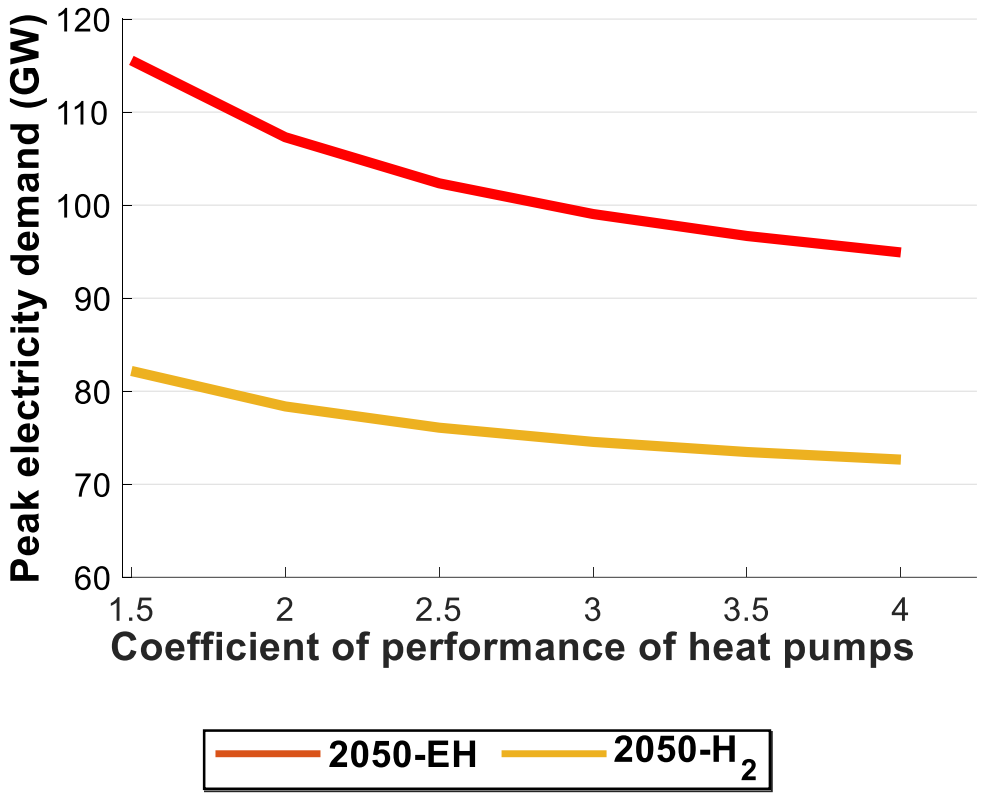
# How sensitive is the 2050 electricity demand to COP of heat pumps?

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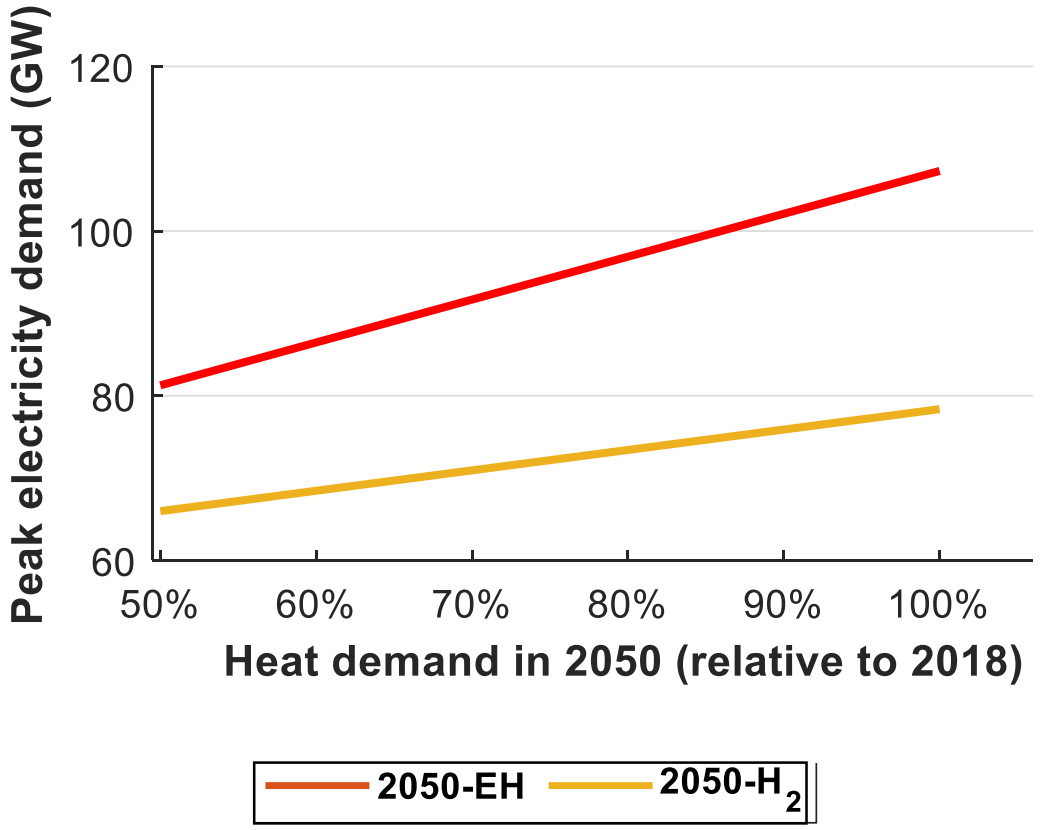
## How sensitive is the 2050 electricity demand to building energy efficiency upgrades?

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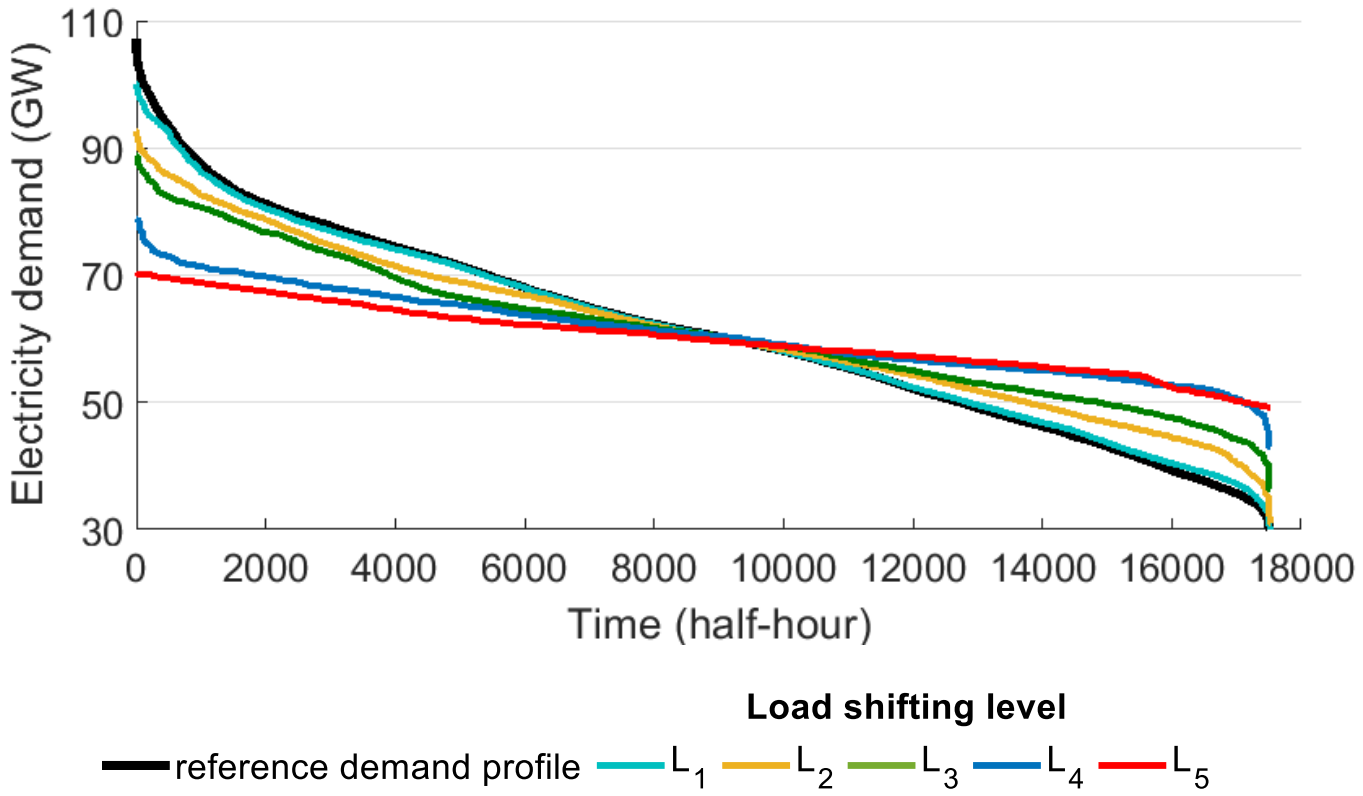
# How effective is demand-side flexibility at reducing the electricity demand volatility?

## Scenario 2050-EH

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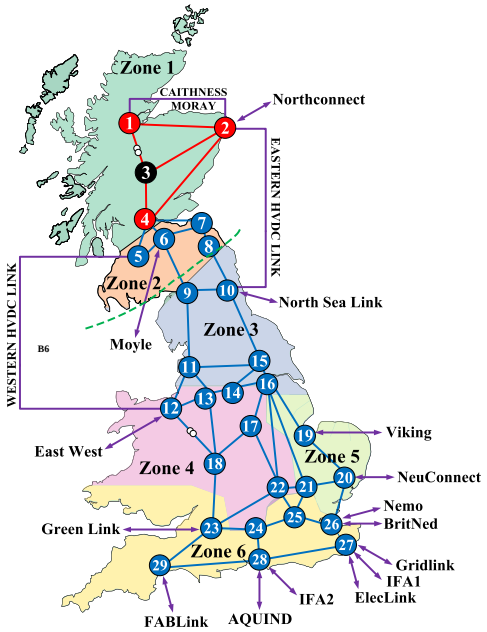
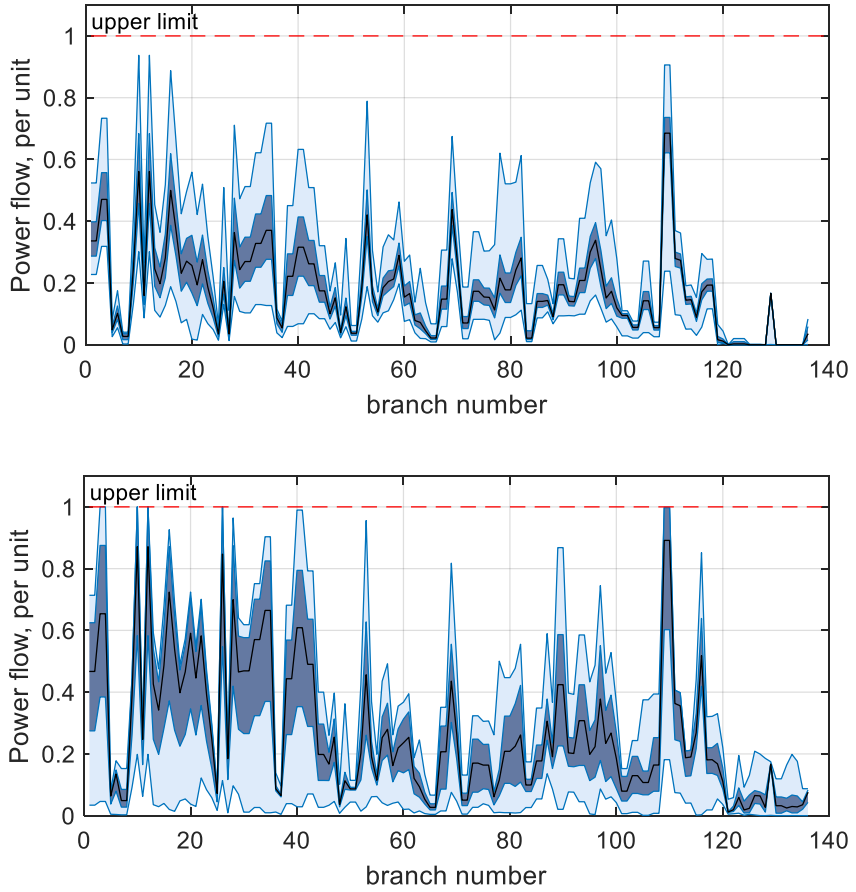
# Conclusion and Future work

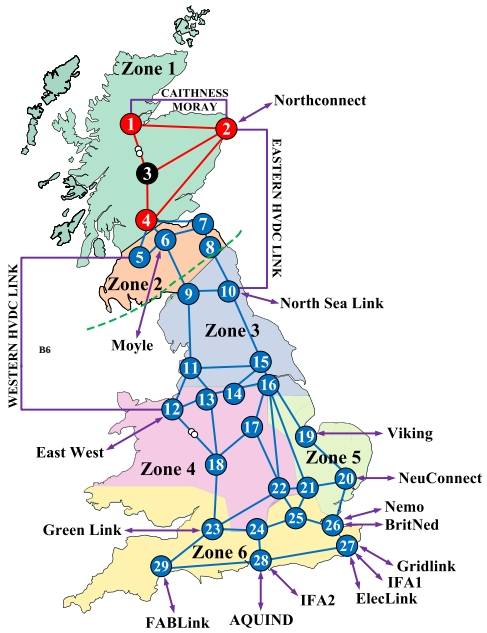



**The GB electricity and gas network**

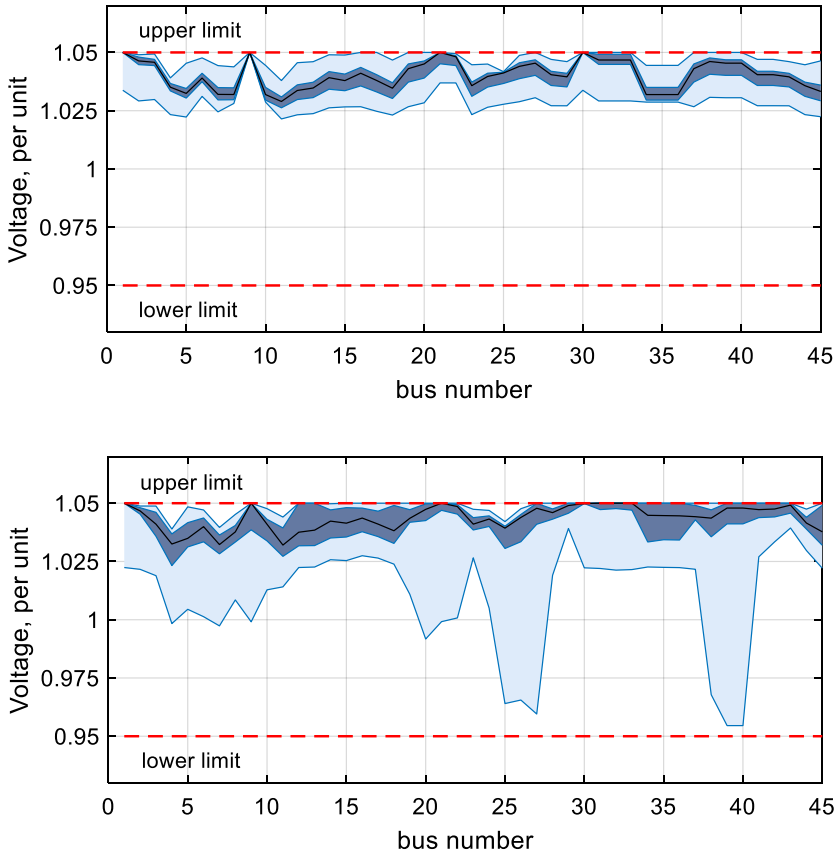



The interquartile range (0, 25th, 75th and 100th percentiles) and median **power flows,** represented as blue line and black lines, respectively, for (a) Case I 2019; (b) Case II 2030

# Conclusion and Future work

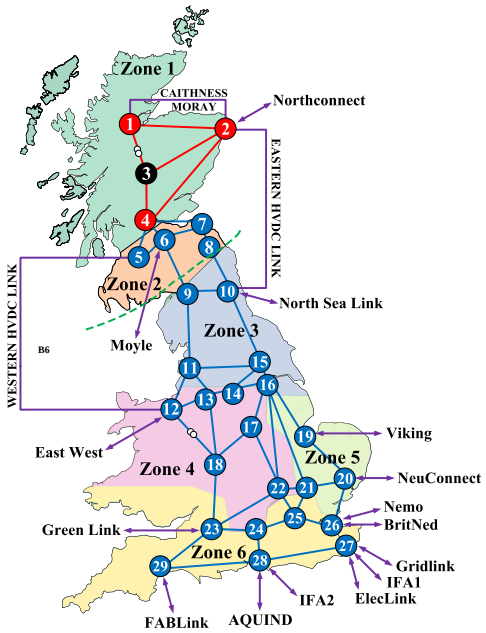



**The GB electricity and gas network**

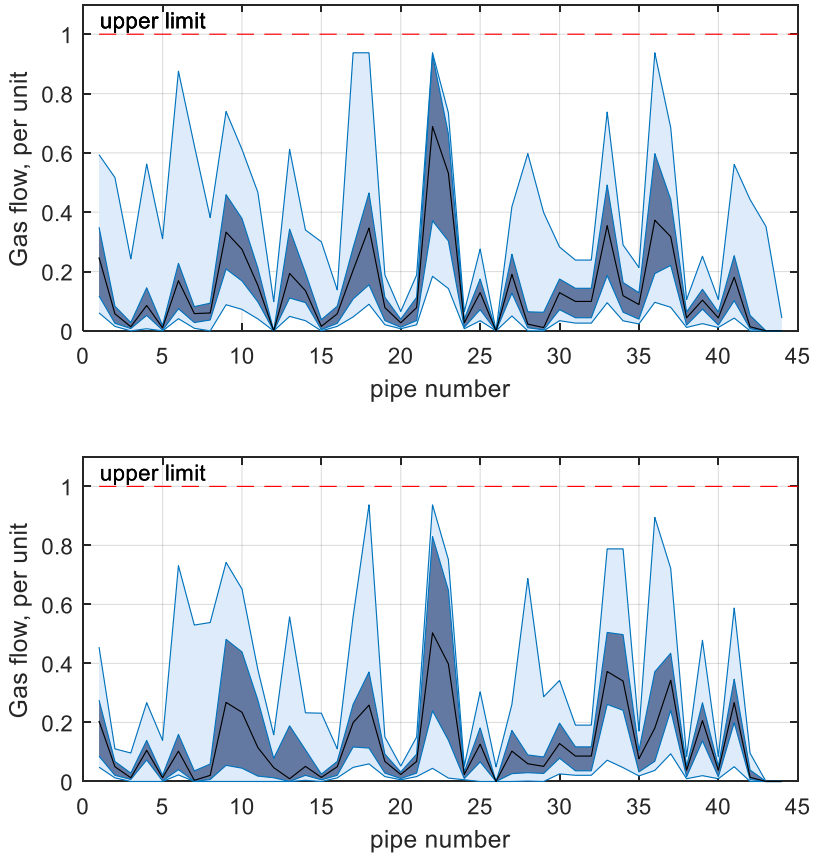



The interquartile range (0, 25th, 75th and 100th percentiles) and median **bus voltages**, represented as blue line and black lines, respectively, for (a) Case I 2019; (b) Case II 2030

# Conclusion and Future work




**The GB electricity and gas network**




The interquartile range (0, 25th, 75th and 100th percentiles) and median **gas flows**, represented as blue line and black lines, respectively, for each of the pipelines in the gas network for (a) Case I 2019; (b) Case II 2030

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# Thanks for your Attention

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