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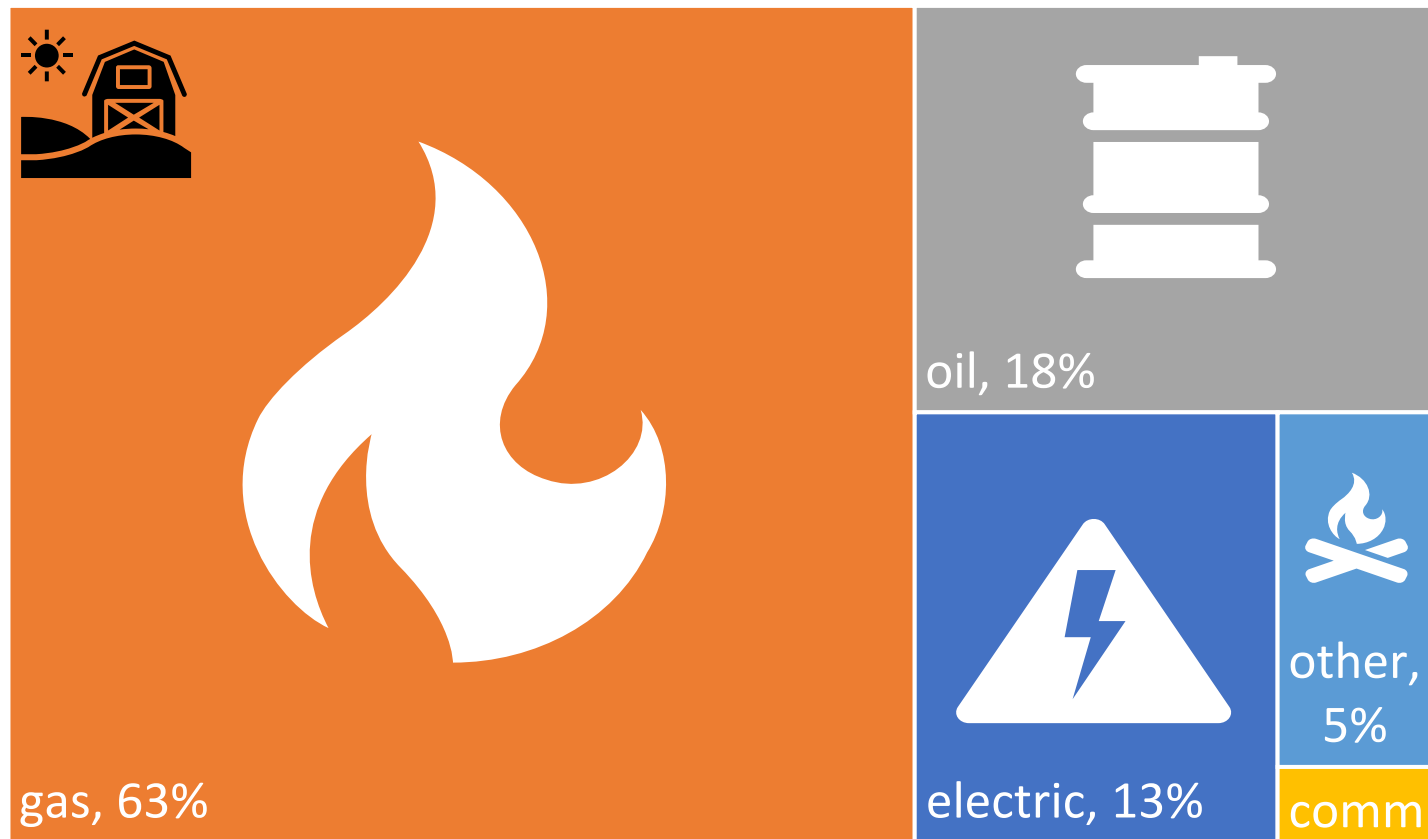
Domestic heating fuels across the UK

18% of the UK population live in **rural areas**, encompassing **91% of UK land area**.

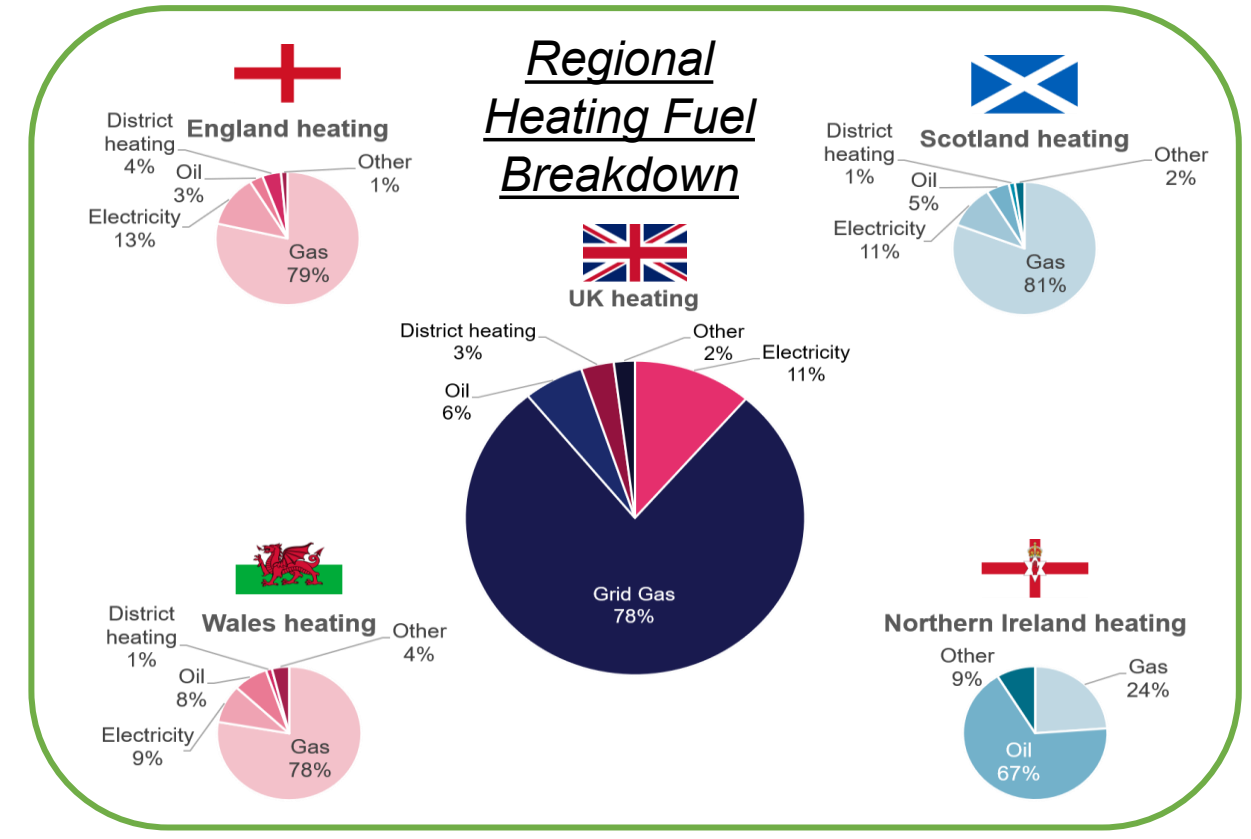
A rural resident will produce **5% more emissions** and **pay 10% more** for the same unit of energy used compared to an urban counterpart

- In West Oxfordshire District 37.5% of homes are non-gas heated properties, primarily oil heated

UK Rural heating fuels



UK Urban heating fuels



Domestic heating in rural communities have different compounding challenges than urban:

- Access to energy – Use **bulk fuels** for heating such as Oil, LPG, Wood and Coal, with onsite storage tanks.
- Cost of energy – Bulk fuels have **no price caps** and are much more **expensive** and **exposed to global markets**
- Building fabric quality – Insulation quality and EPC ratings are typically **worse (older)** than urban buildings

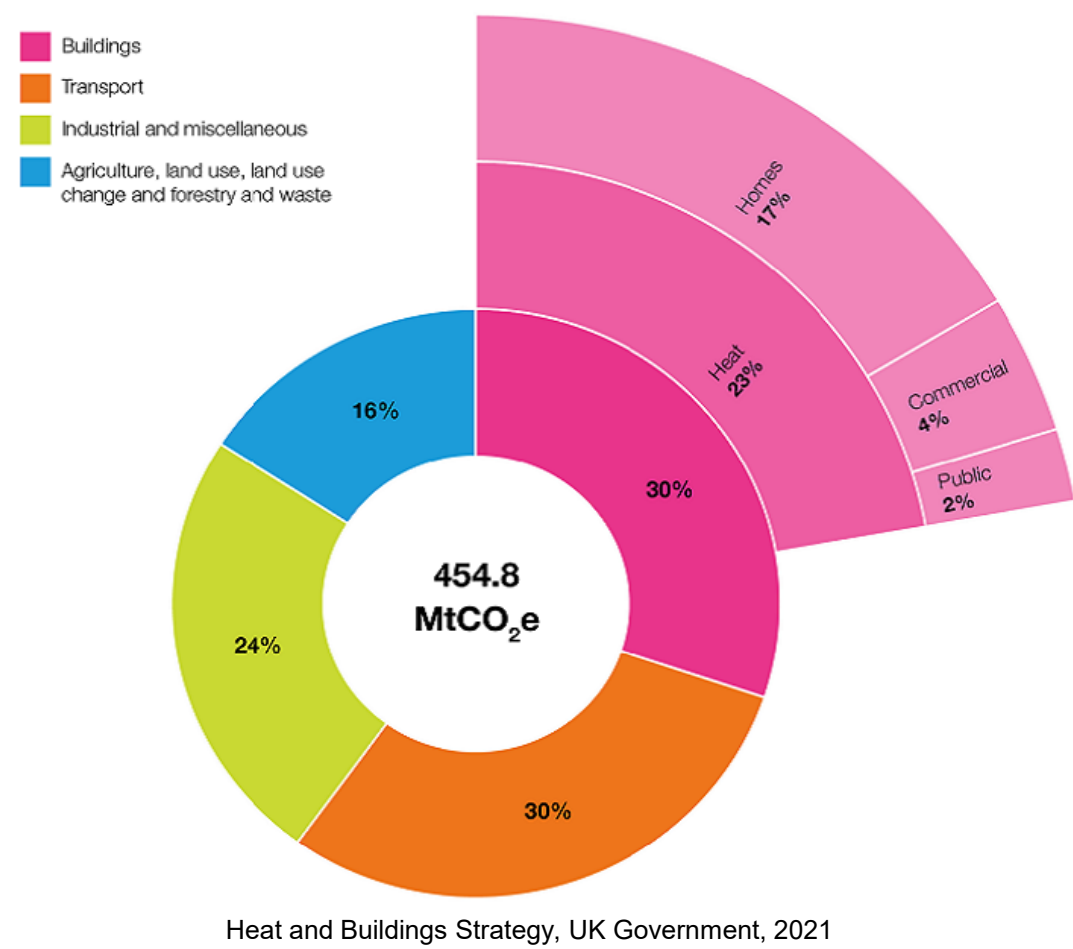
Therefore, decarbonising rural domestic heating is greater technical and economic challenge.

Techno-economic modelling is an important first step to compare the effectiveness of rural heating fuels for archetypal rural buildings.

UK heat policy

By law, the UK must reach net zero (compared to 1990) greenhouse gas emissions by 2050.

Residential heating emissions accounted for 17% of all UK emissions in 2019



UK government **currently** plans to encourage the mass adoption of heat pumps, while funding research for other solutions such as green hydrogen gas grids, through the **banning of new fossil fuel boiler installations in building retrofit** (ban reversed in Scotland in 2025 and UK in 2026)



Changing policy and messaging of rural off gas grid heating decarbonisation policy does not provide certainty or confidence for the adoption of heat pumps or other low carbon heating technology alternatives. Policy should first improve building fabric before energy system change.

Techno-economic modelling and comparison of UK rural heating systems



Download the smart meter data used here

A. Comparing different heating fuels currently used

11 fuels – modelled and compared

- Grid Gas
- Heating Oil
- House Coal (w/ hot water tank)
- Dry Wood Logs (w/ hot water tank)
- Electric boiler
- LPG bottle
- Electric immersion heater in tank
- Heat pump (w/ hot water tank)
- Electric storage heater
- Grey hydrogen Bottled
- Blue hydrogen Bottled

SMR with CCS (90% capture)



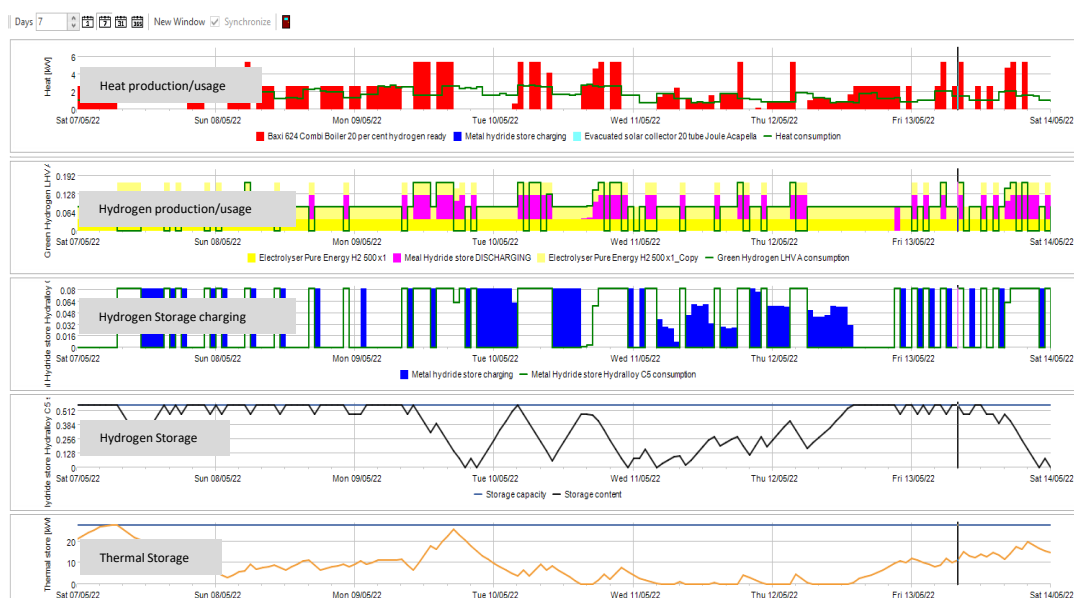
*Both groups of models have an electric grid connection

B. Comparing low carbon heating fuels/technologies

9 fuels/technologies – modelled and compared

+ Solar PV, Solar Thermal, Wind Turbine for all

- Grid Gas
- Biomass (Dry Wood Logs) (w/ hot water tank)
- Electrolysed green Hydrogen (w/ boiler)
- Electrolysed green Hydrogen (w/ fuel cell)
- Electric immersion heater in hot water tank
- Heat pump (w/ hot water tank)
- Hybrid heat pump and electrolysed green hydrogen boiler (w/ hot water tank)
- Hybrid heat pump and blue hydrogen bottle boiler (w/ hot water tank)
- Electrolysed green Hydrogen (w/ boiler + hot water tank) and metal hydride hydrogen storage tank.



energyPro simulation output of model 20.

Post processing to produce a relative scoring and ranking using min-max normalisation

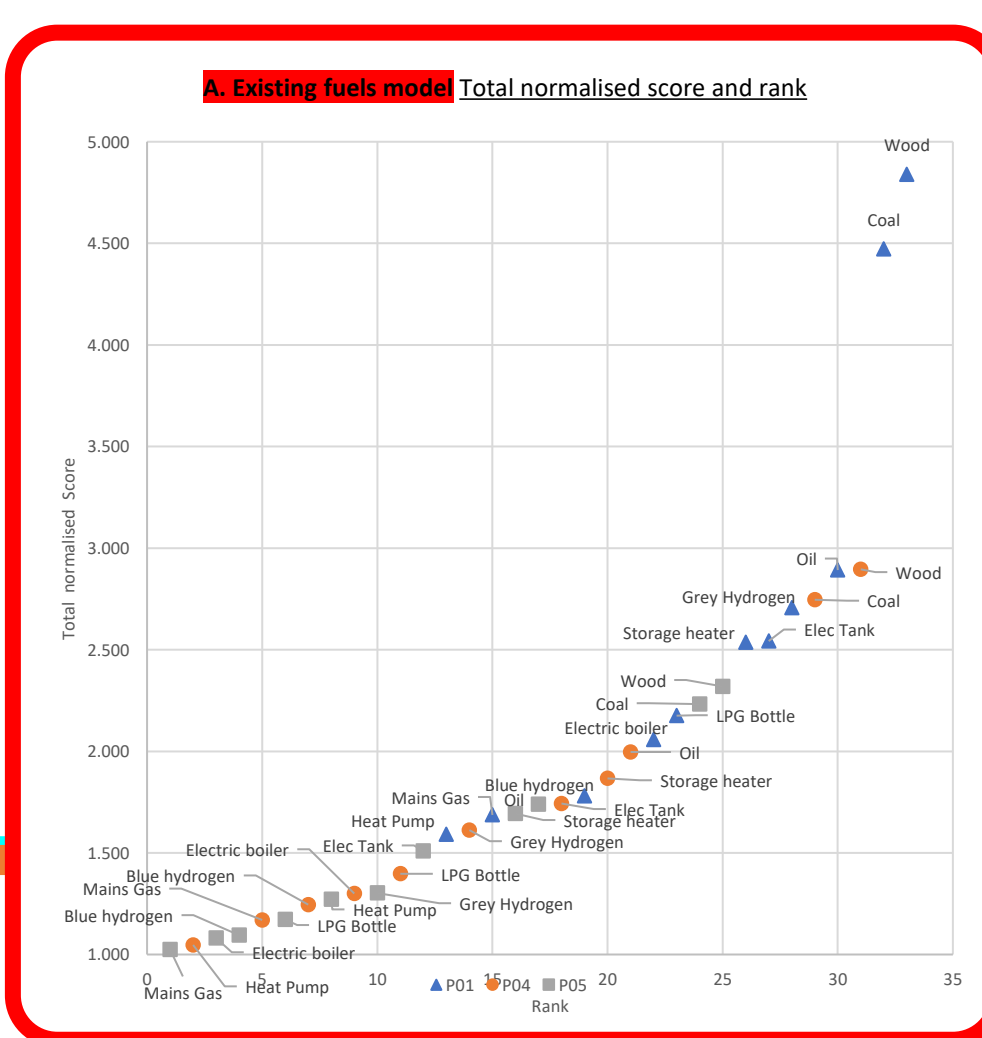
$$x' = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Output - Normalised scores for each category below:

- Annual emissions
- Annual operating cost (OPEX)
- Capital cost (CAPEX)
- System effectiveness
- Proportion of self sufficiency

Comparing normalised scores

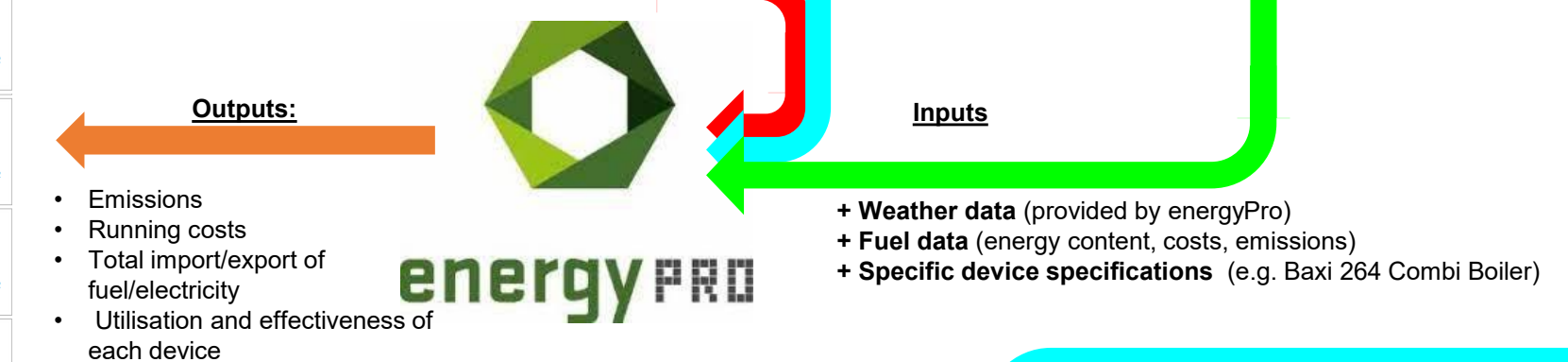
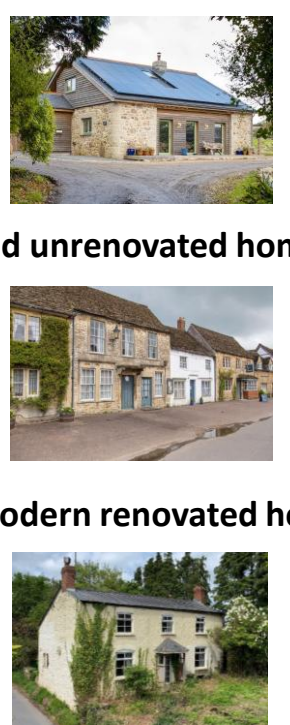
Summing all normalised scores together



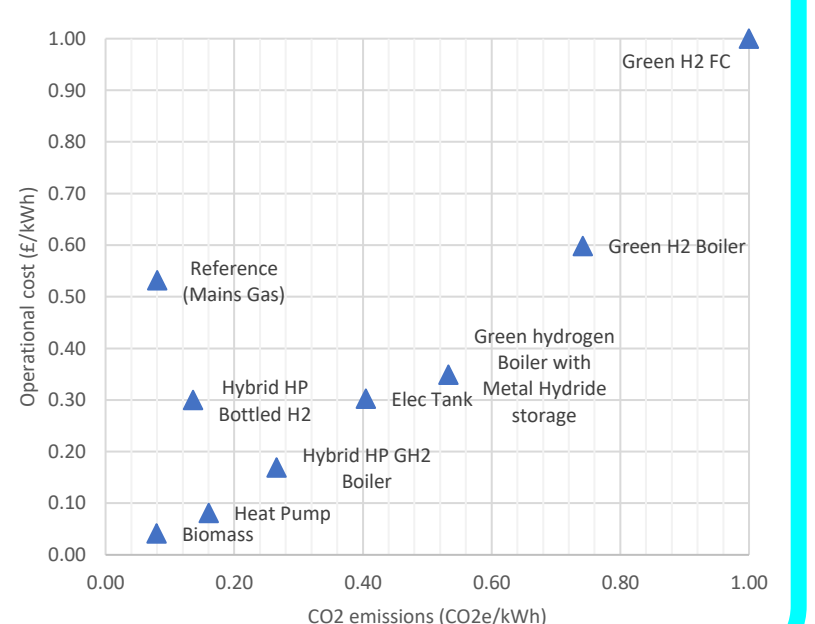
C. 3 Archetypal energy demand profiles (electricity and heat)

Generated using smart meter data from SERL and unique survey data

- On gas grid village home (P01)
- Old unrenovated home (P04)
- Modern renovated home (P05)



B. Renewable model results comparing normalised OPEX and annual emissions



Conclusion

Common rural heating fuels are **techno-economically worse** than modern energy fuels/systems. **Heat pump, hybrid heat pump and hydrogen systems are more effective** methods of rural heating than existing systems.

In future in depth research on building fabric and social challenges for effective rural heat decarbonisation is necessary.

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Further information on this research here:



Across all simulations computed there are over 57 models, 136 modules, 78 time series, 294 files in total.