Assessing the value of competing carriers for domestic heat: analysis paralysis or spoiled for choice?

UKERC

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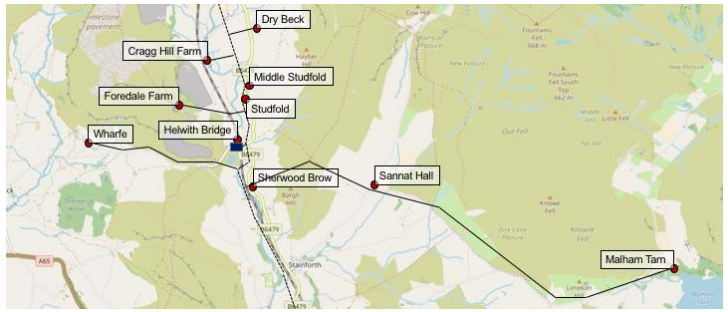
The UK Context

- Spatially heterogeneous population
  - 33% urban, 39% suburban, 28% rural by household
- Large volume of ageing housing stock
  - Limited progress in improving efficiency
- Ageing T&D network
  - Particularly constrained at local scales
- Plentiful renewable resources
  - Large volumes of curtailed energy
- High natural gas penetration
  - 79.8% of domestic heat demand in 2012

Rural

Disaggregate UK energy system into exemplar archetypes

Urban

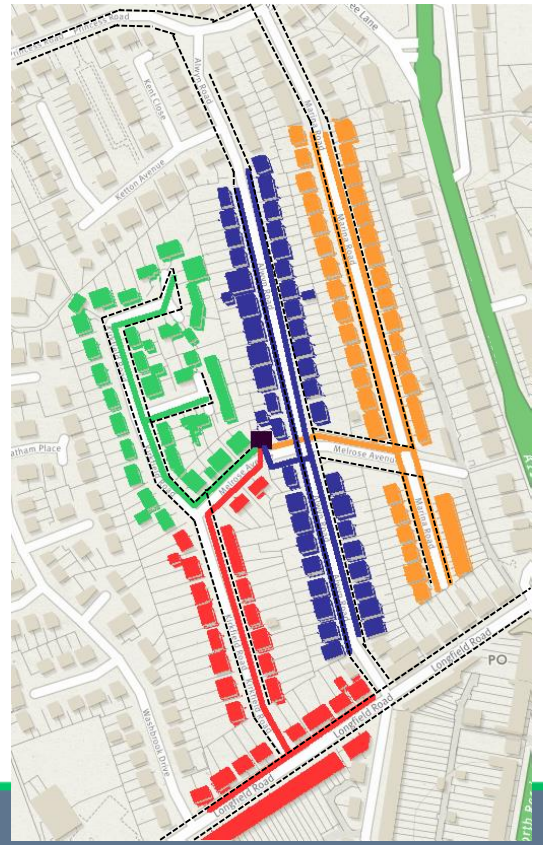


Highly spatially diverse system

Off gas grid, high fuel costs, high emissions intensity and low building efficiency

Strong potential to utilize curtailed wind energy

Suburban



Mixed semi-detached/ terraced, 1930s stock, low energy efficiency

Electricity network:

- 500kVA transformer
- 4 LV feeders

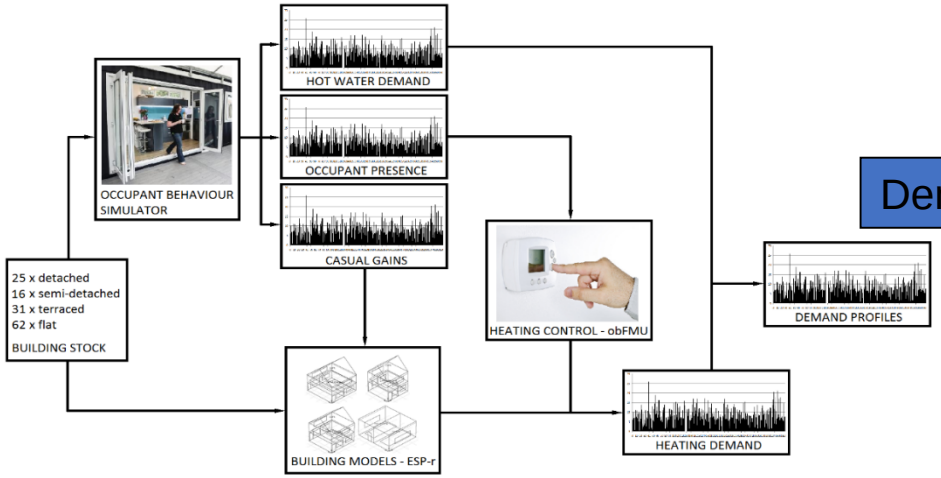
Mixture of ageing and renewed low pressure gas network

High density housing

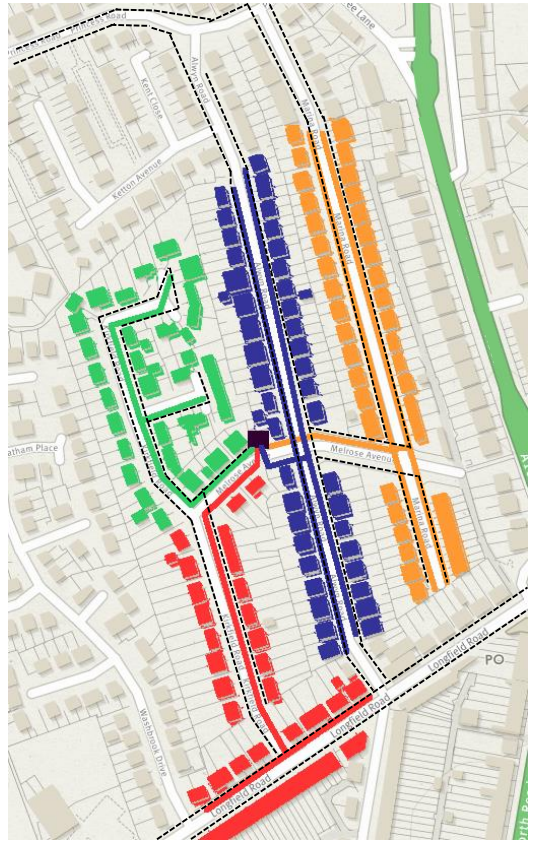
Gas supplied domestic boilers for space and hot water

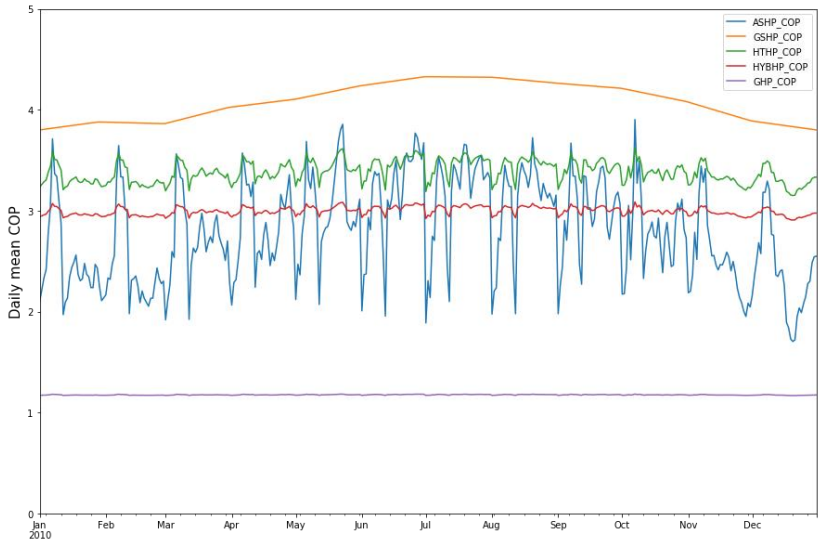
Opportunities for heat networks and high efficiency, but low availability of space

Demand and technology modelling



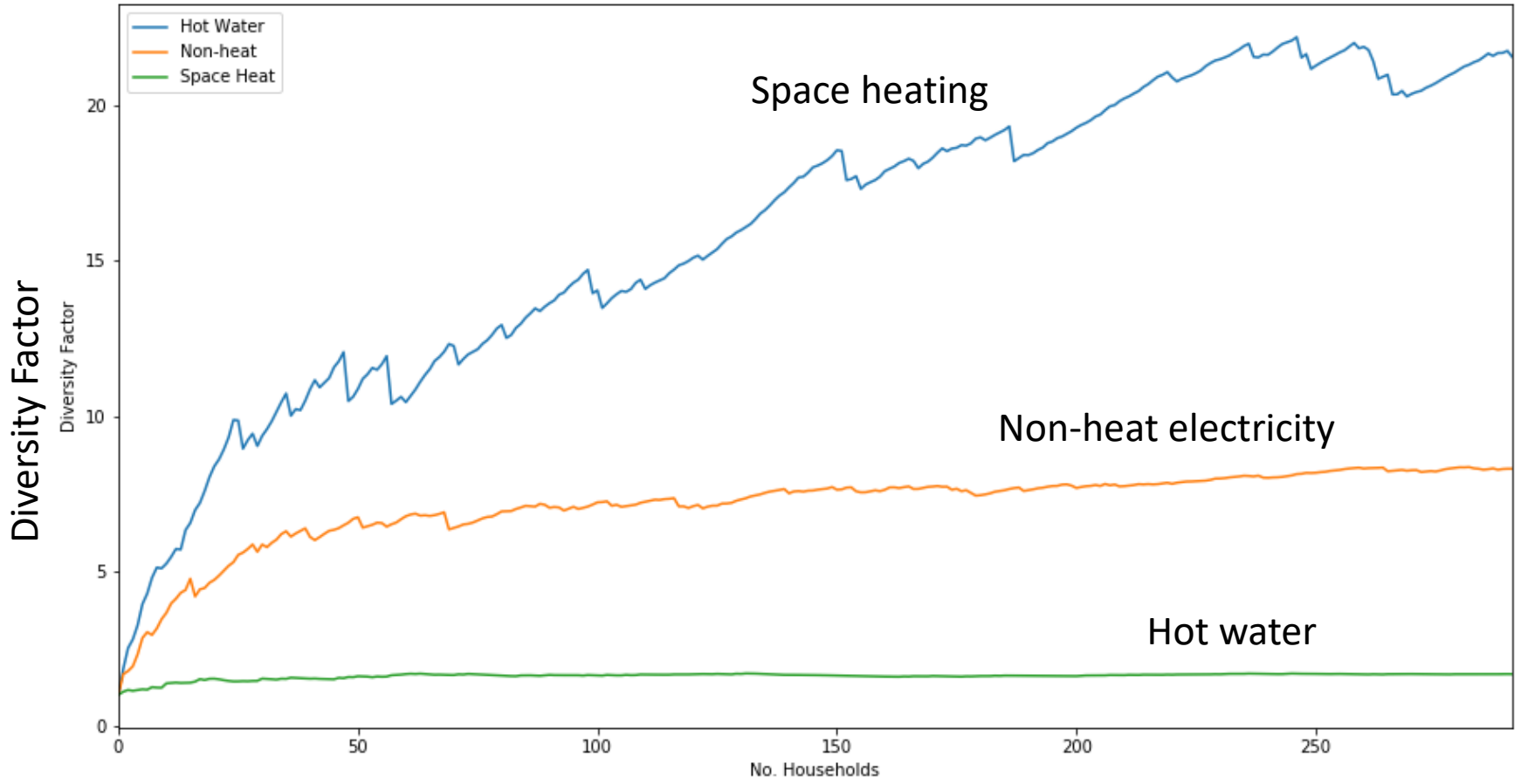
Demand





Supply

Heat load does not follow existing diversity patterns

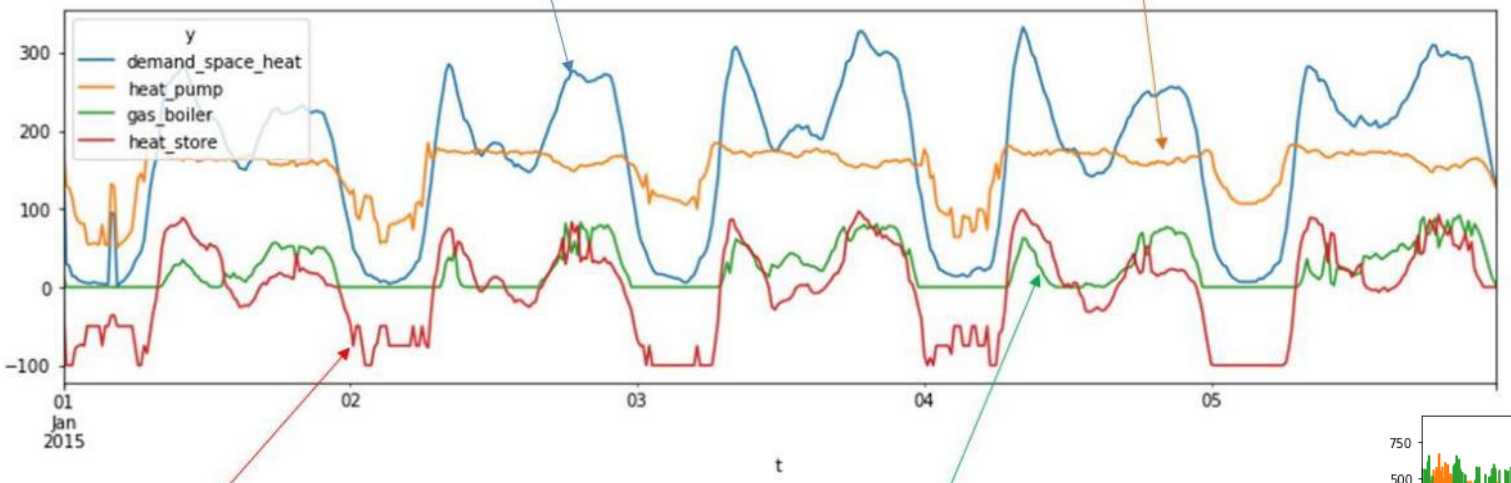


Increasing No. Households →

Dispatching thermal storage

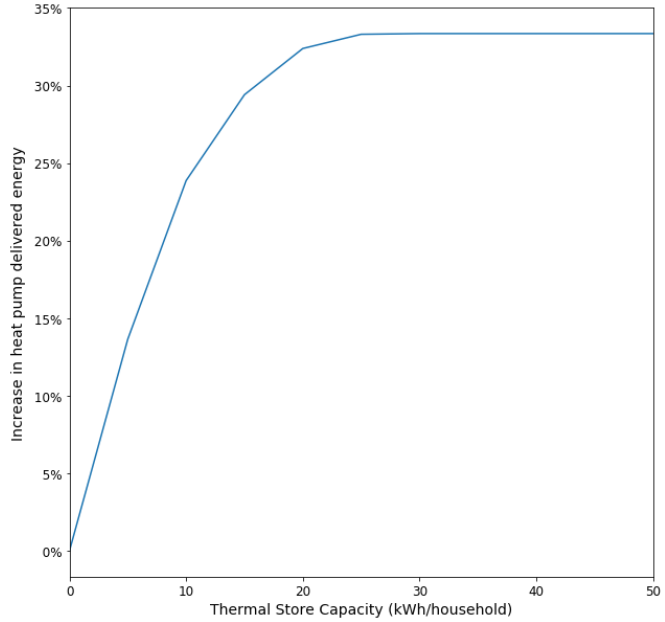
Net space heat demand: building efficiency reduces total energy and provides temporal buffering

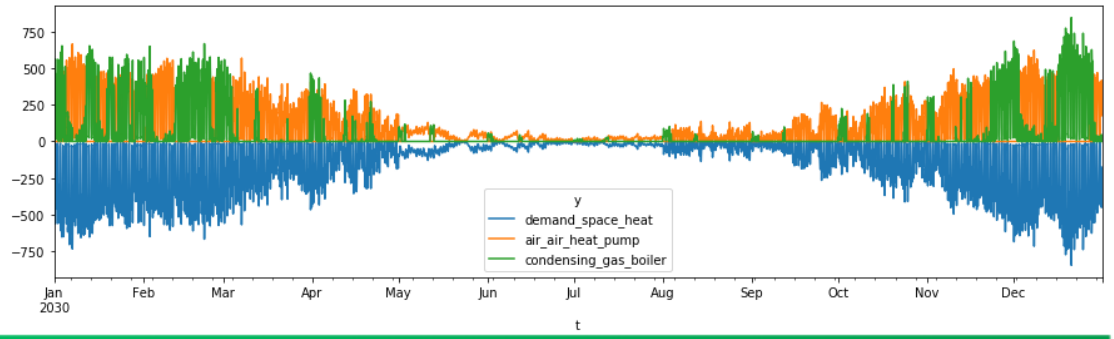
Heat pumps utilise decarbonised electricity (local and grid) to limit of network capacity (minus other electrical demand)



Heat storage increases utilization of heat pump capacity

Existing gas network and boilers provide remainder of space heating



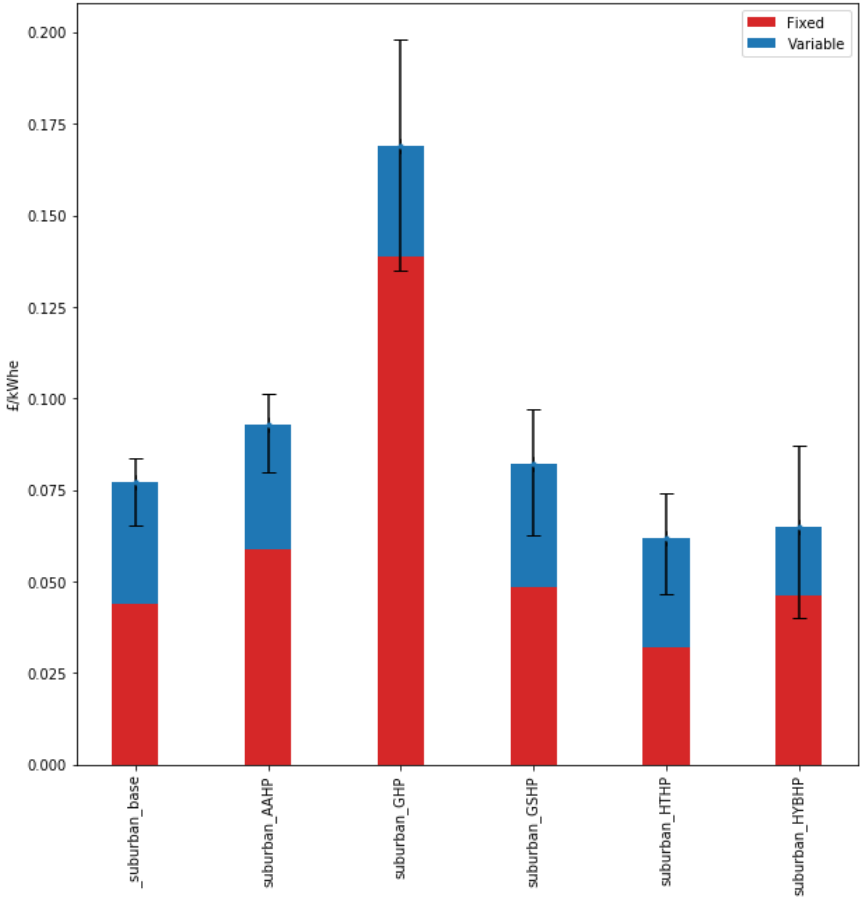


Where has all the hot water storage gone?

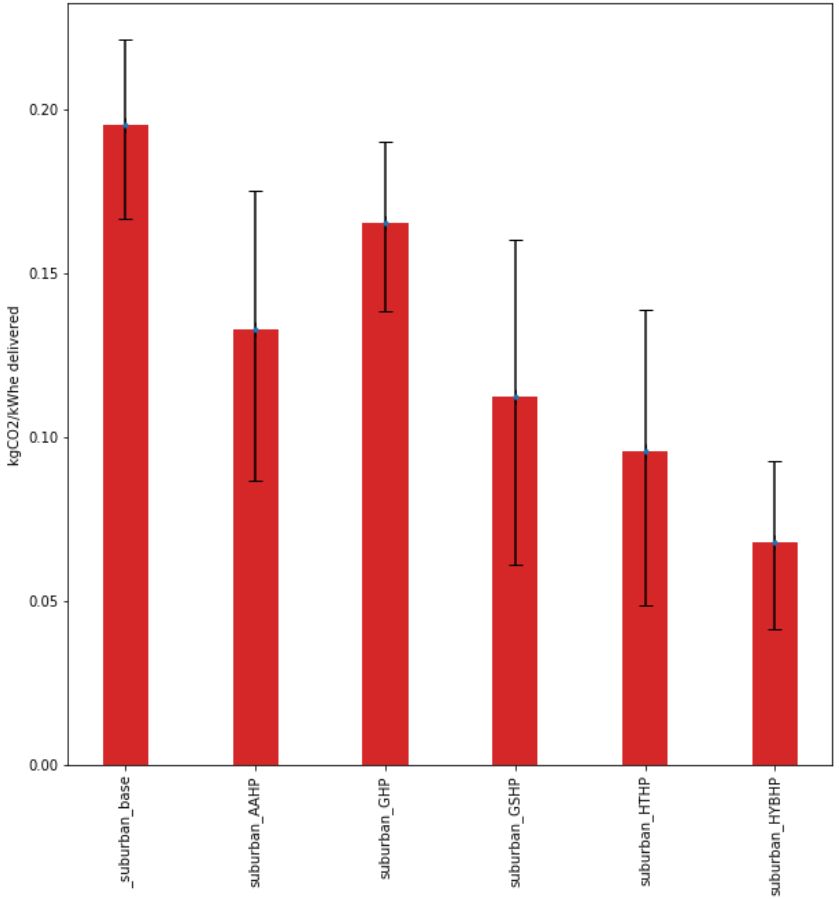
- UK domestic new-build properties are shrinking
- Combi boiler installations have ‘freed up’ additional space in many houses which is now being used as living space
- Many new-builds may not have sufficient supportive infrastructure (or space) to retrofit
- BEIS ‘Future Framework For Heat in Buildings’ call for evidence is considering futureproofing for storage in new build requirements

Suburban heat pump scenarios…

Total cost per unit energy delivered (CAPEX + OPEX)

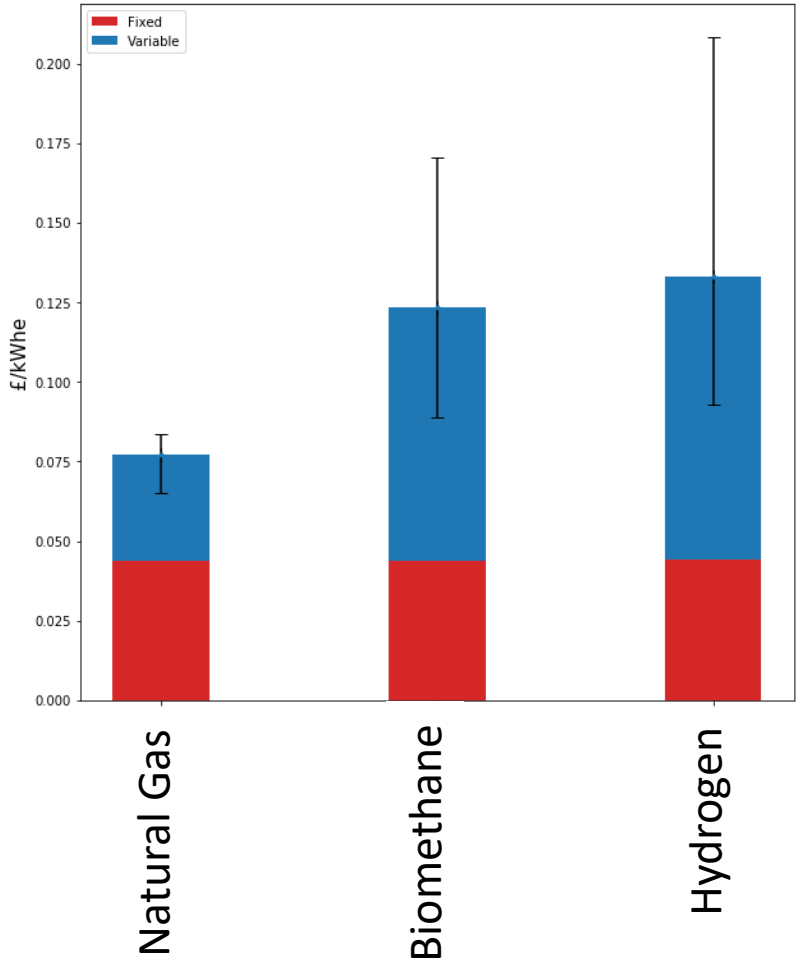


Average carbon emissions per unit energy

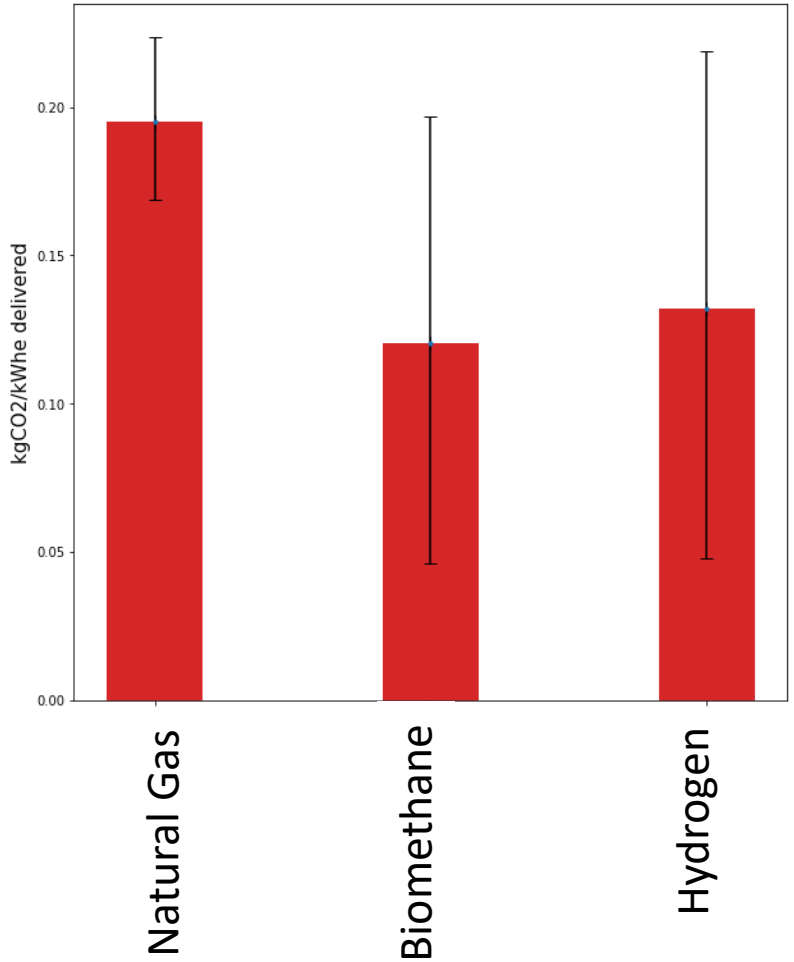


Uncertainties in costs and emissions

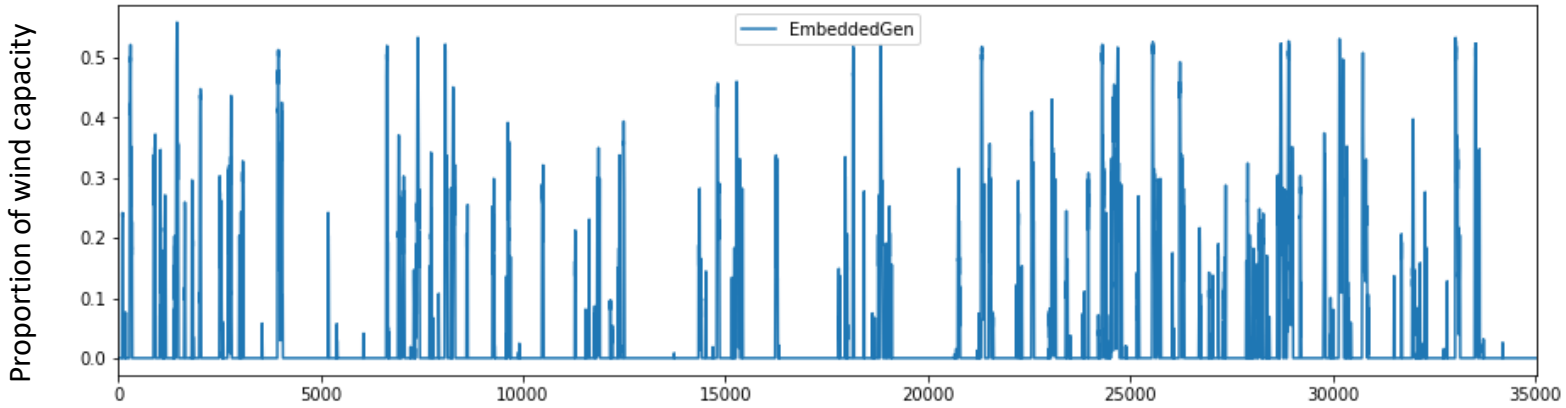
Total cost per unit energy delivered (CAPEX + OPEX)

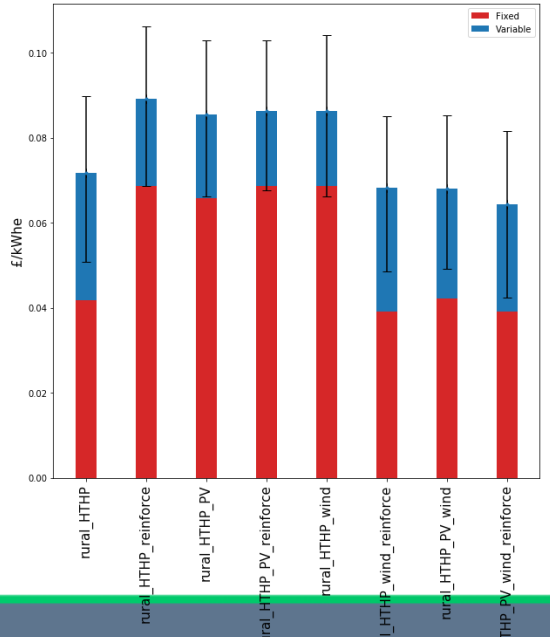


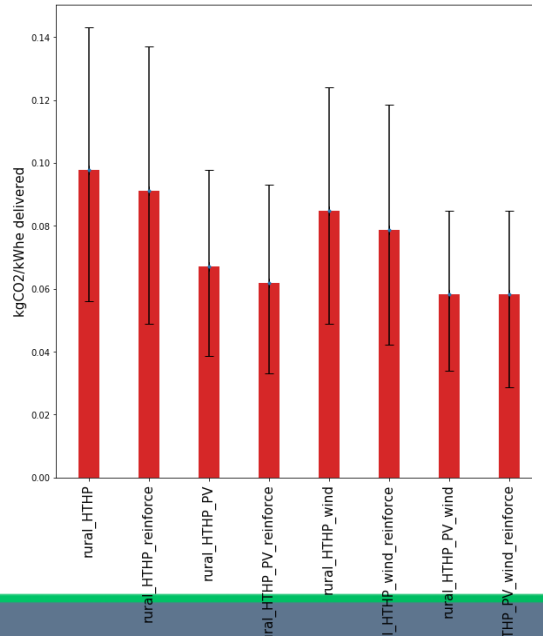
Average carbon emissions per unit energy



Opportunities from curtailed renewables



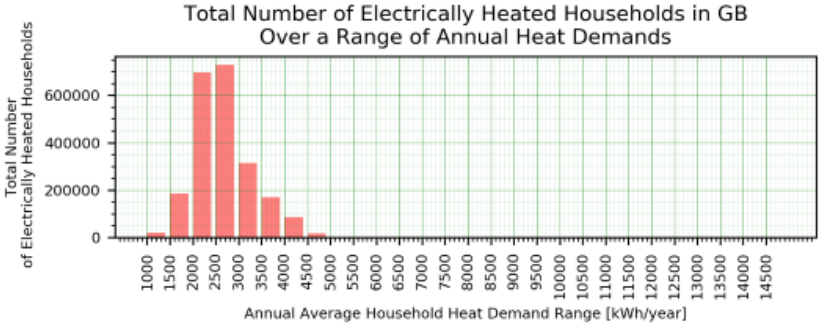


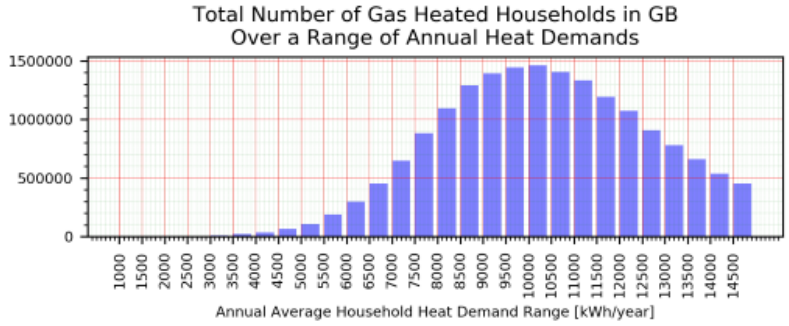


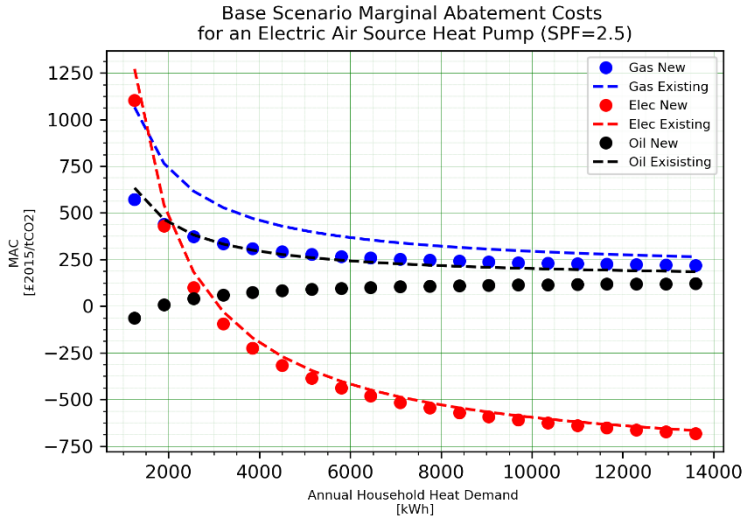
End Use Technology	Scenario PV	Wind	Reinforcement	Average Abatement Cost compared to Base Scenario (£/kgCO_2)
High Temperature Heat Pump	-	Yes	Yes	-0.203
High Temperature Heat Pump	-	-	Yes	-0.195
High Temperature Heat Pump	-	Yes	-	-0.190
High Temperature Heat Pump	-	-	-	-0.183
High Temperature Heat Pump	Yes	-	Yes	-0.091
High Temperature Heat Pump	Yes	Yes	-	-0.086
High Temperature Heat Pump	Yes	Yes	Yes	-0.086
High Temperature Heat Pump	Yes	-	-	-0.077
Ground-to-water Heat Pump	-	-	-	-0.052
Air-air Heat Pump	-	-	-	0.054

Abatement costs for high temperature heat pump scenarios compared to fuel oil condensing boilers, central assumptions

Targeting the right technologies at the right people







Sources: [1] England, Northern Ireland, Scotland and Wales 2011 Census: Office for National Statistics ; National Records of Scotland ; Northern Ireland Statistics and Research Agency (2017): 2011 Census aggregate data. UK Data Service (Edition: February 2017). DOI: http://dx.doi.org/10.5257/census/aggregate-2011-2; [2] UK GOV, Sub-national electricity and gas consumption data 2015

University of Strathclyde IPPI blog October 2018 - **Reducing emissions from heating our homes – does one size fit all?**
https://www.strath.ac.uk/research/internationalpublicpolicyinstitute/ourblog/october2018/reducingemissionsfromheatingourhomesdoesonesizefitall/

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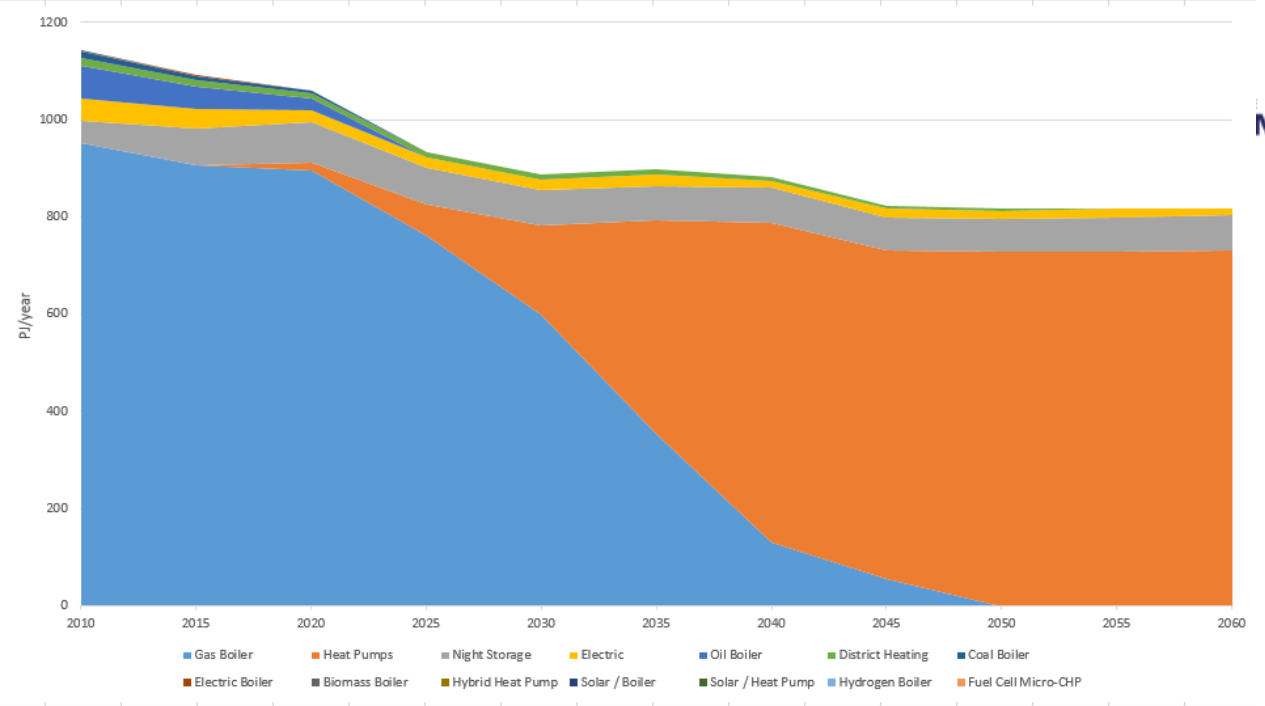
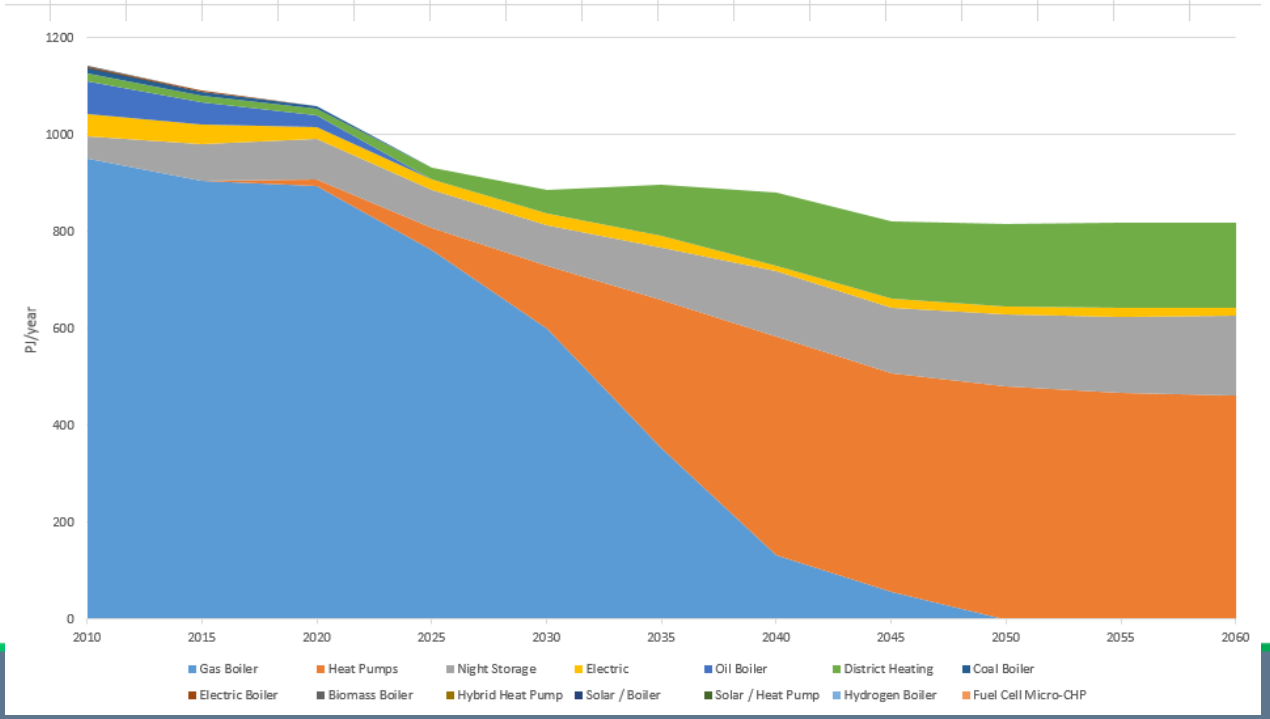
The Whole System View

Before spatial disaggregation



Heat pumps are the solution to all of our problems!

After spatial disaggregation



Economic heat network opportunities in densely populated urban areas

Increased value of heat storage in rural areas

Heat pumps remain as key technology displacing natural gas boilers over time

A False Dichotomy?

- The narrative is of total electrification vs decarbonisation of the gas grid
  - But the national energy system is a reflection of local designs
- An individualist approach to heat provision creates significant overcapacity
- There is a strong co-dependency between local renewable generation capacity and the value of decentralised heat storage / thermal buffering
- **The least-cost optimal solution is subject to high uncertainty due to the wide range of future technology cost estimates**