5 problems and 5 solutions in decarbonising domestic heat… and what it means for networks
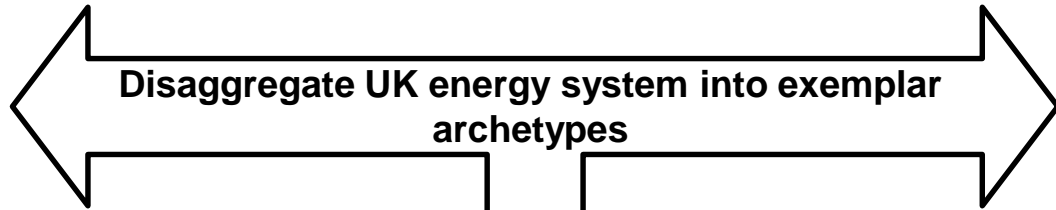
LCNI 2018 Conference – Views from Academia

Dr Graeme Hawker
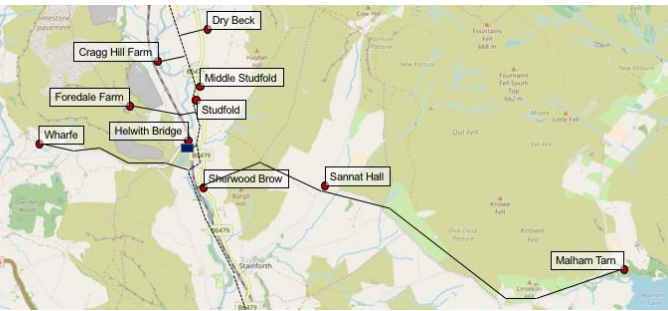
Institute for Energy and Environment, Department of Electronic and Electrical Engineering, University of Strathclyde
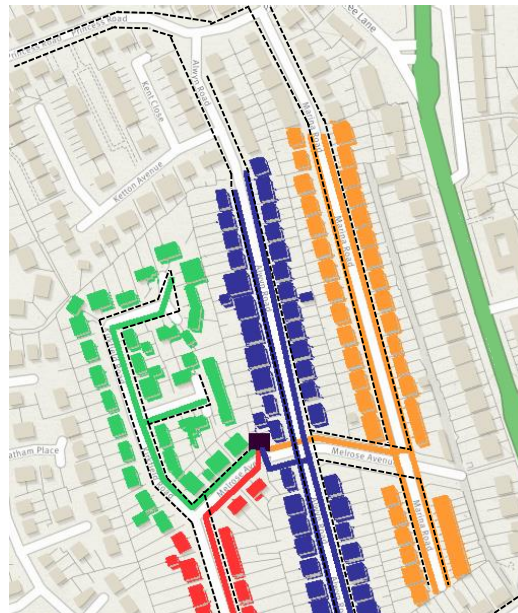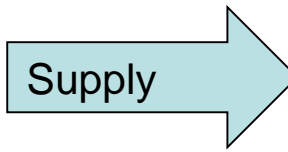
Local Network Modelling

Rural ← Disaggregate UK energy system into exemplar archetypes → **Urban**
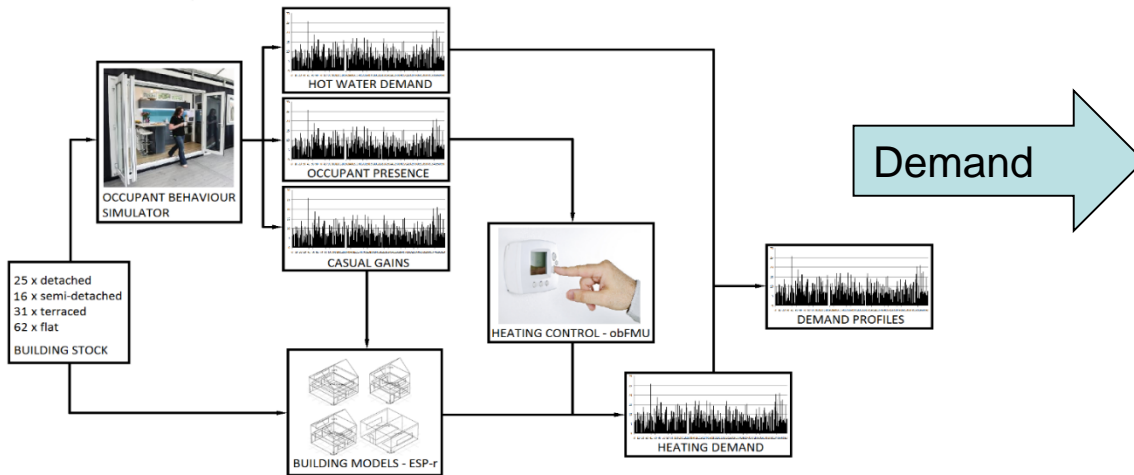
Suburban

Demand and technology modelling

Demand

Supply

Problem 1: Peak heat demand pick-up

On 1st March 2018 at 6pm:
- hourly local gas demand: 214GW
- electrical supply: 53GW
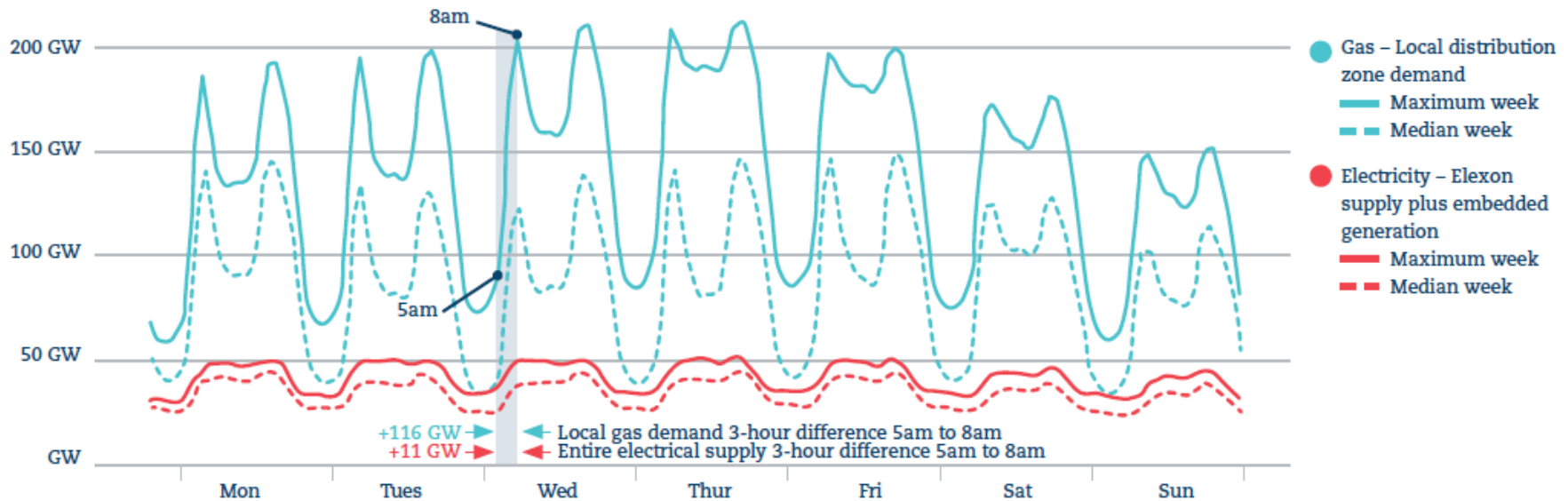
Grant Wilson, University of Birmingham
http://www.ukerc.ac.uk/publications/local-gas-demand-vs-electricity-supply.html

Problem 2: Heat load does not follow existing diversity patterns

Hawker G. (2018) Spatial and temporal disaggregation of whole system energy models through exemplar local multi-carrier networks
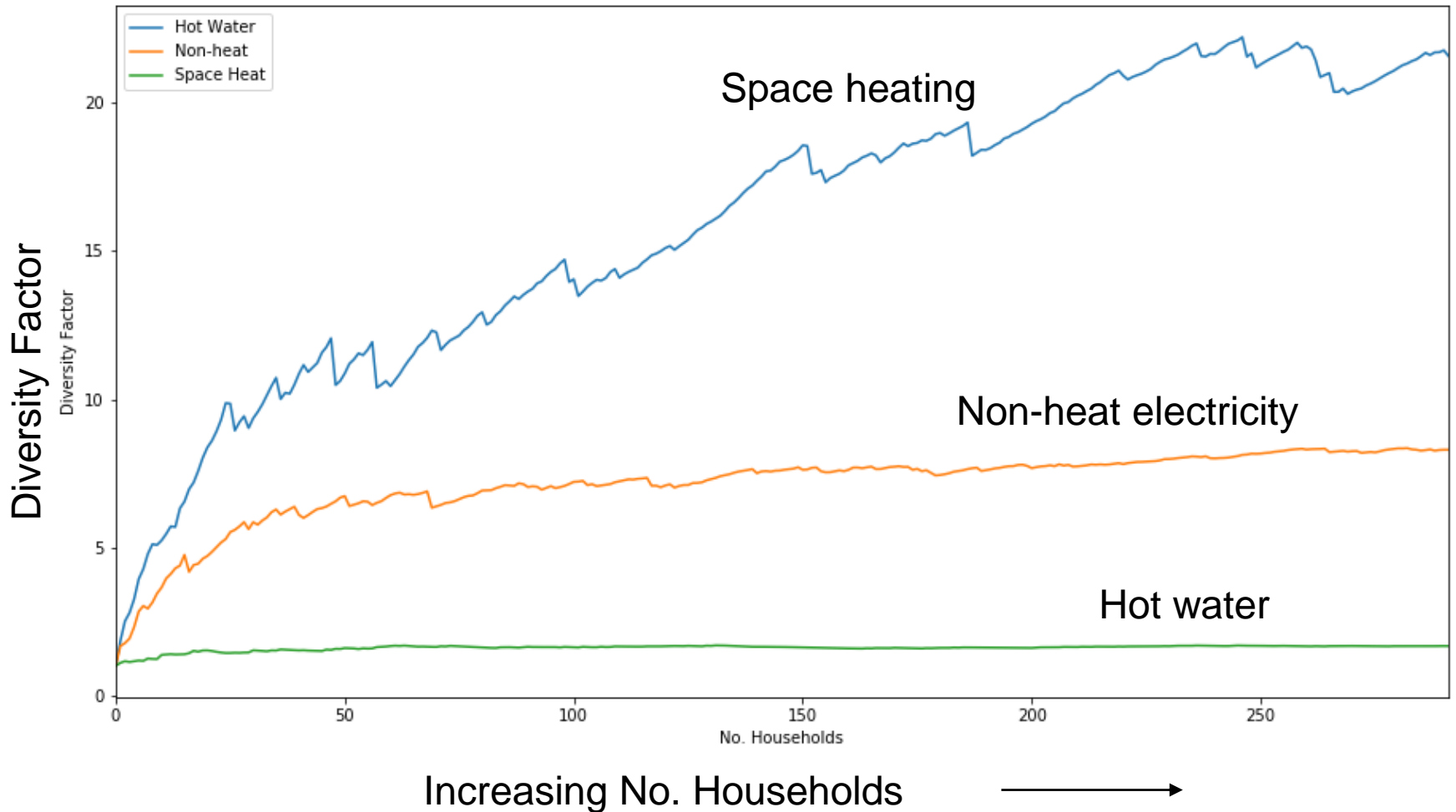
# Problem 3: Where has all the hot water storage gone?

- 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
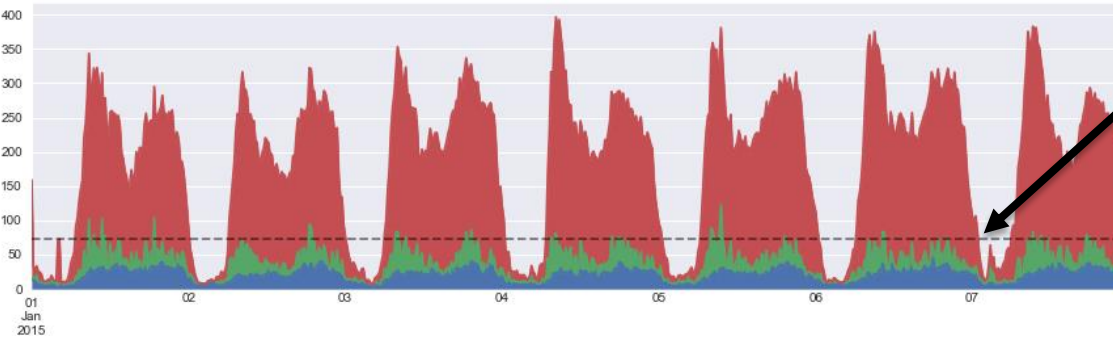
Problem 4: Working with the system we have
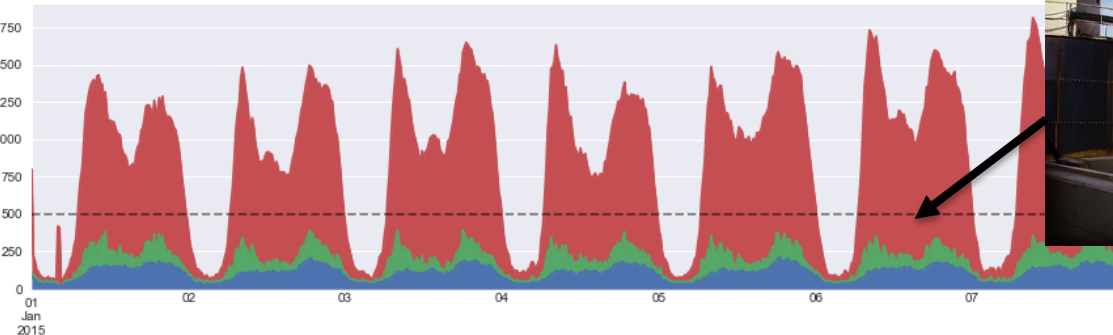

University of
Strathclyde
Engineering
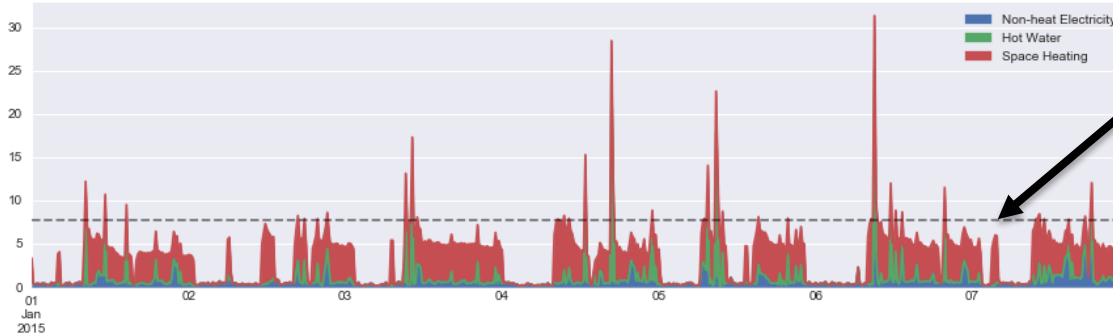
1 house
3 occupants
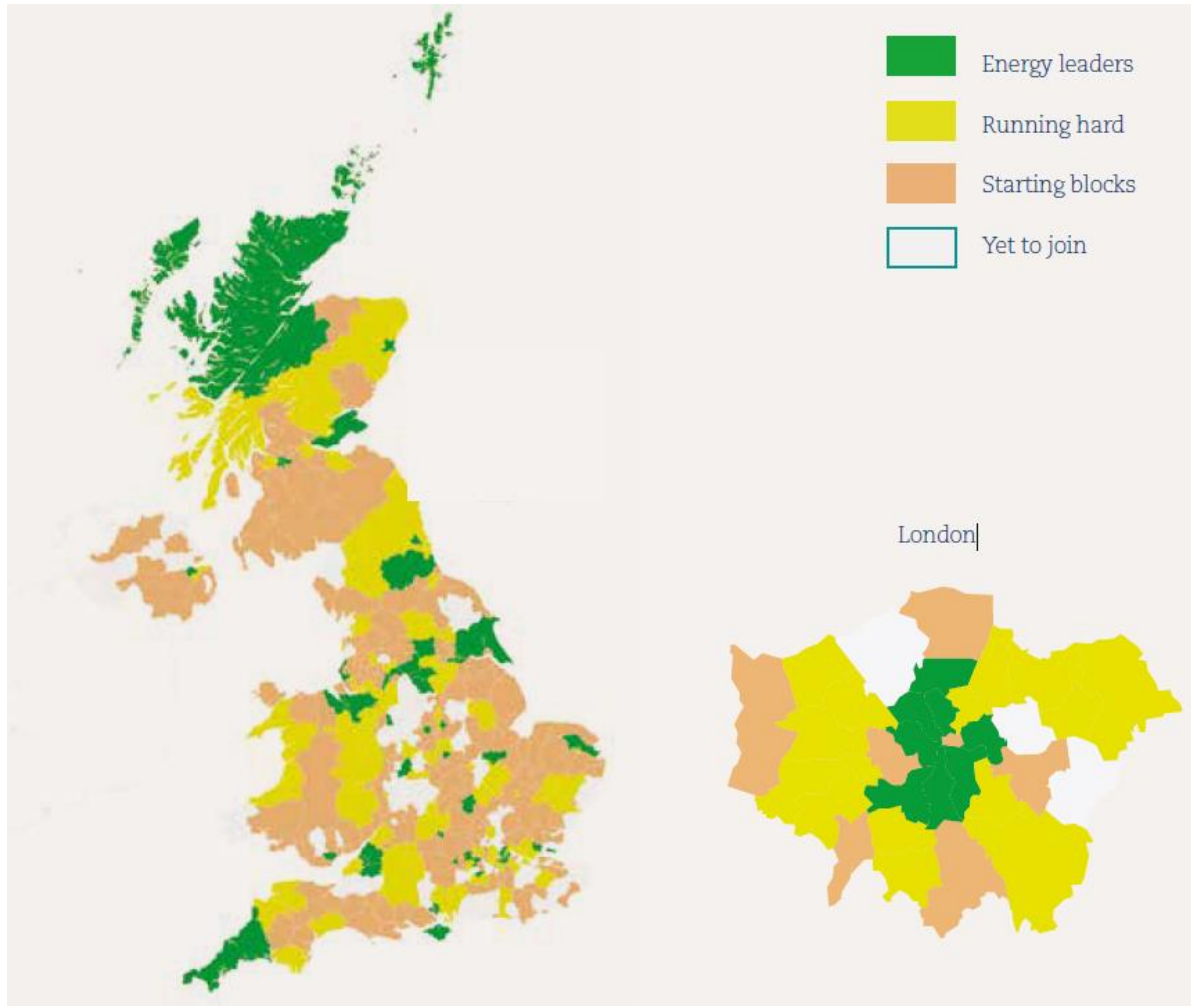
1 LV Feeder
59 houses
162 occupants

1 LV Xformer
292 houses
697 occupants

Problem 5: Coordination is complex

Legend:
- Energy leaders
- Running hard
- Starting blocks
- Yet to join

London

Webb, Tingey and Hawkey (2017), What we know about local authority engagement in UK energy systems, UKERC and ETI

Solution 1: Recognising spatial heterogeneity

The Whole System View

Before spatial disaggregation

After spatial disaggregation
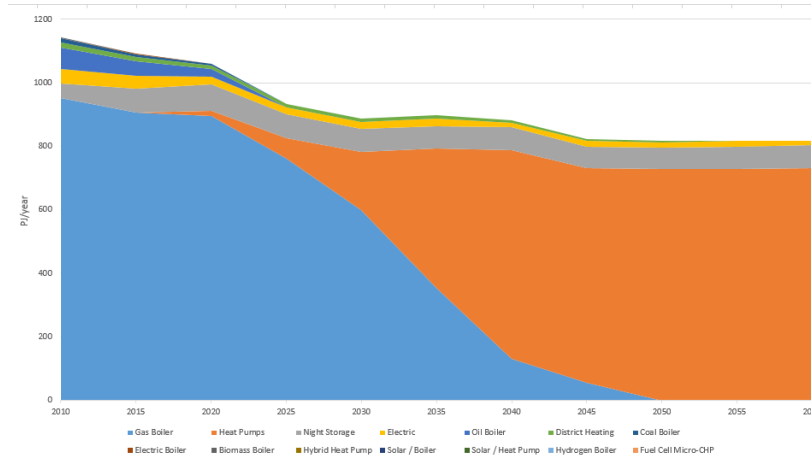
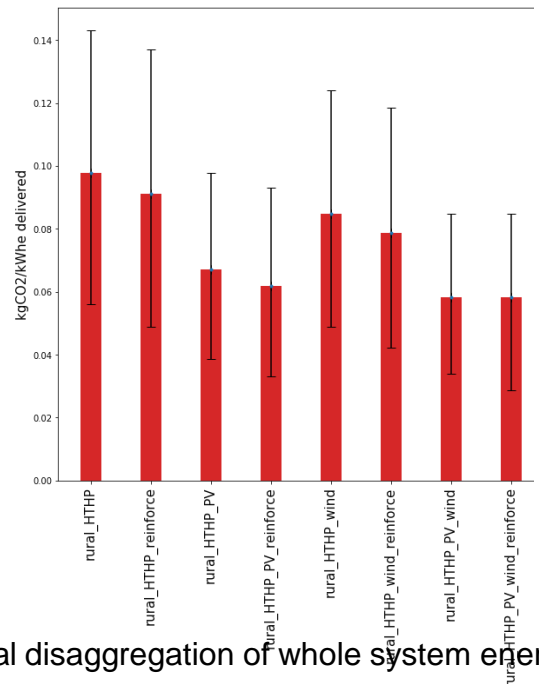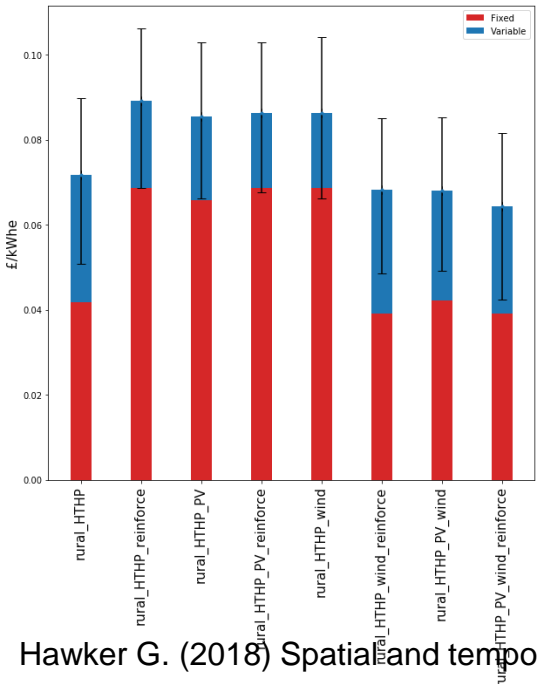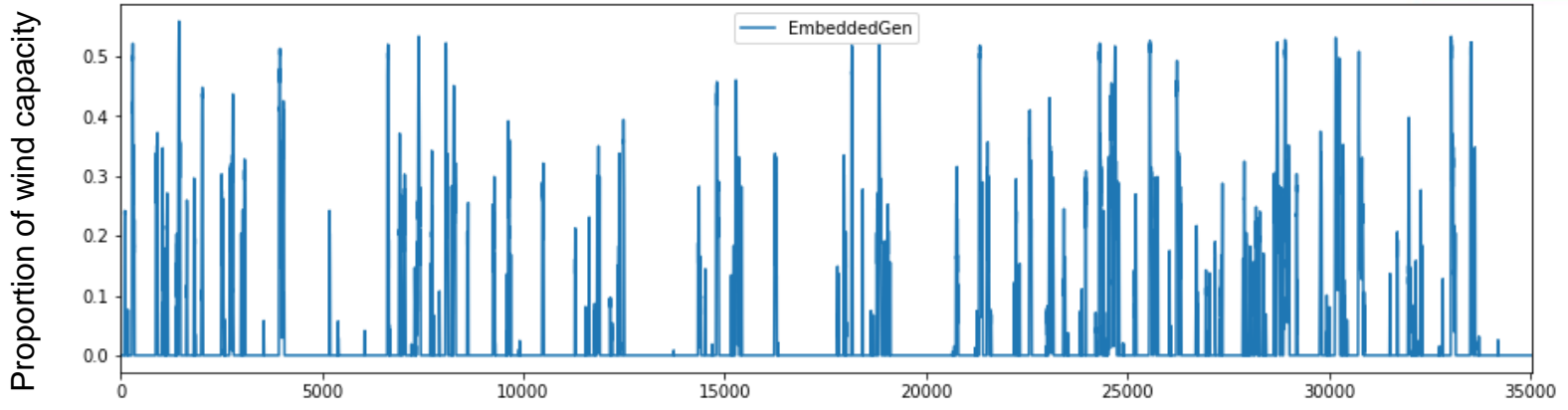Heat pumps are the solution to all of our problems!
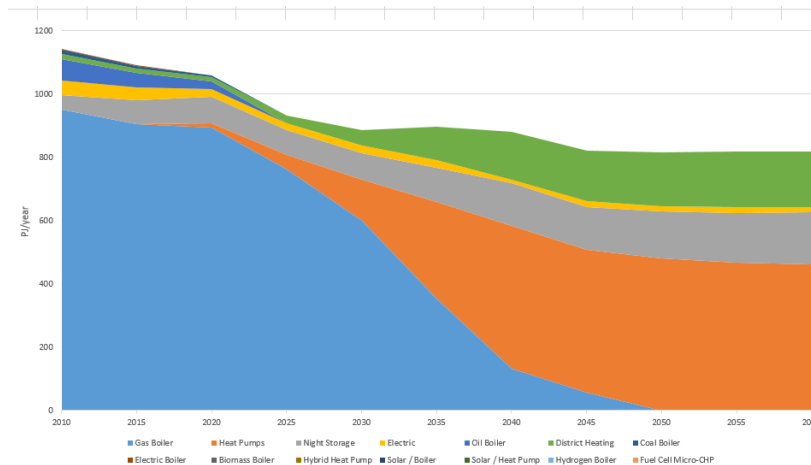
Economic heat network opportunities in densely populated urban areas

Increased value of heat storage in rural areas

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

Hawker G. (2018) Spatial and temporal disaggregation of whole system energy models through exemplar local multi-carrier networks

Solution 2: Opportunities from curtailed renewables

	Scenario			Average Abatement Cost compared to Base Scenario (£/kgCO₂)
End Use Technology	**PV**	**Wind**	**Reinforcement**	
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, rural model, central assumptions

Hawker G. (2018) Spatial and temporal disaggregation of whole system energy models through exemplar local multi-carrier networks

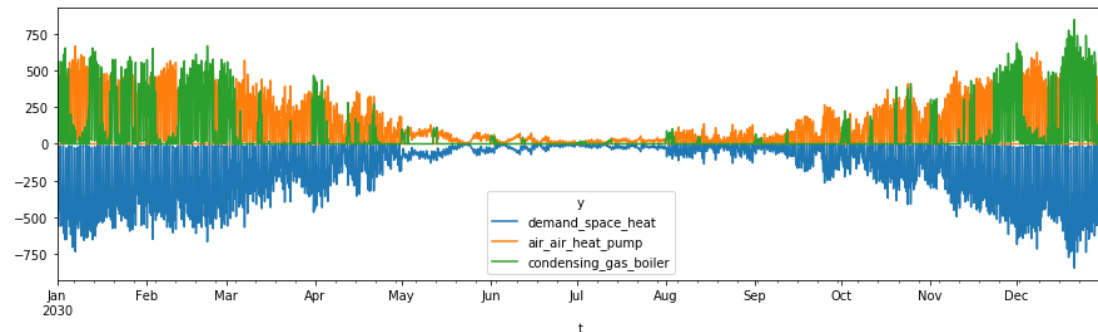# Solution 3: Heat buffering and thermal storage

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)
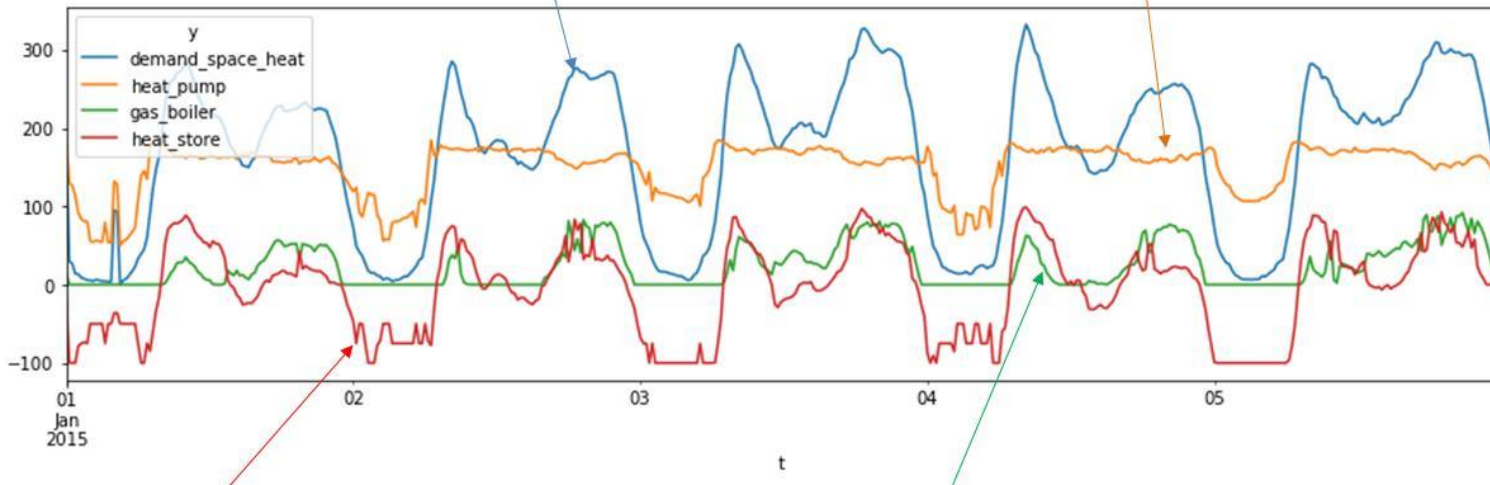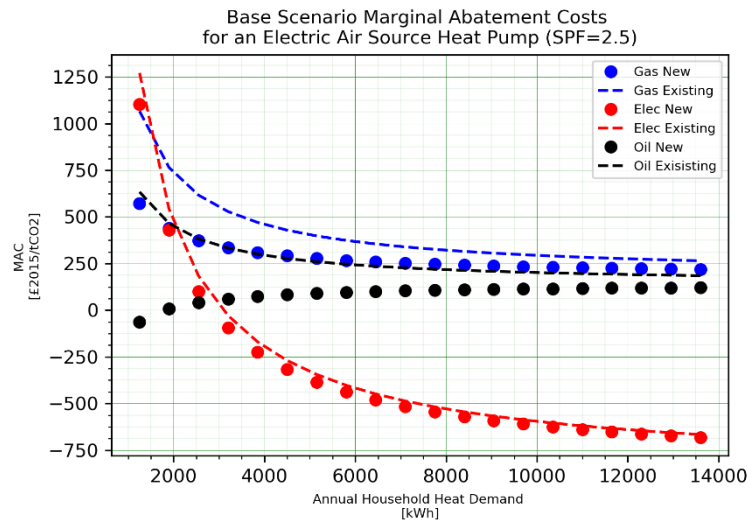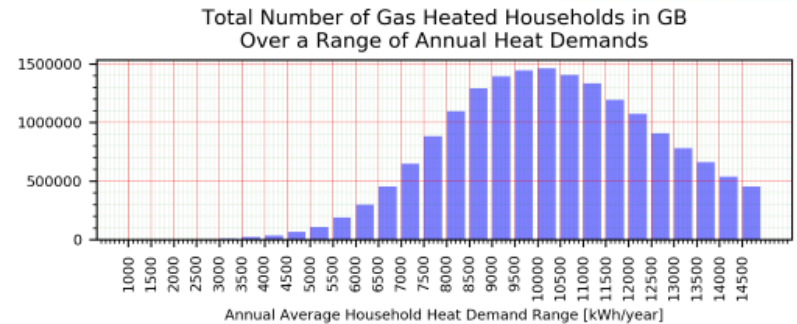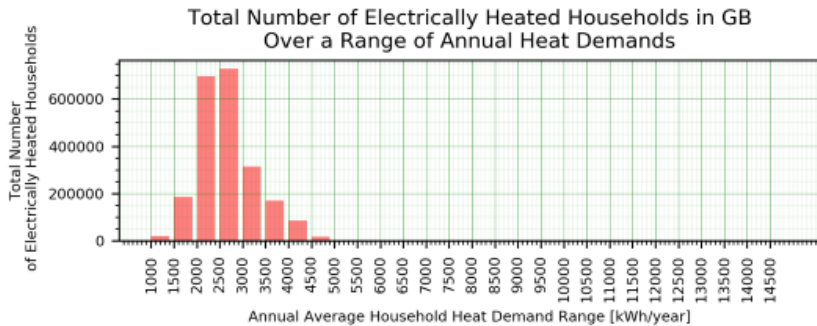

Heat storage increases utilization of heat pump capacity

Existing gas network and boilers provide remainder of space heating

# Solution 4: Targeting the right technologies at the right people

Total Number of Electrically Heated Households in GB Over a Range of Annual Heat Demands

Total Number of Gas Heated Households in GB Over a Range of Annual Heat Demands

Base Scenario Marginal Abatement Costs for an Electric Air Source Heat Pump (SPF=2.5)

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/
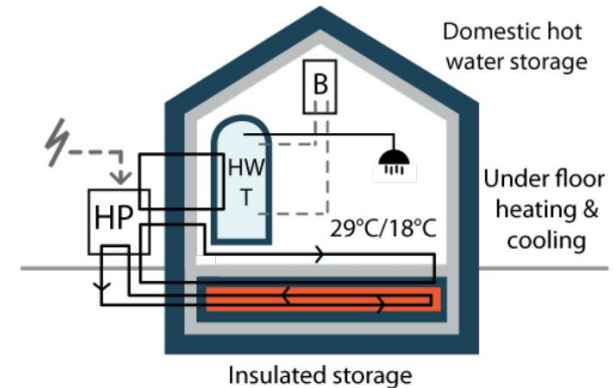
Solution 5: Recognising the link between buildings and networks

Semi-decoupled ventilated wall storage
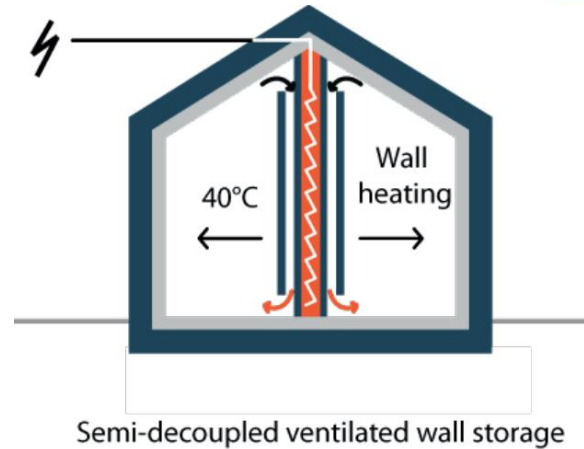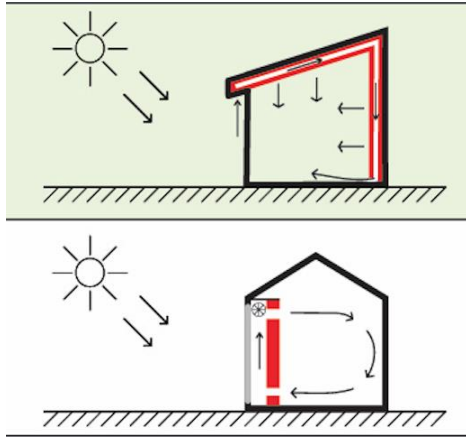
Solid Storage heated and cooled with heat pump
Solid storage with water as the heat distribution fluid

Other locations:
Exterior walls and under staircases

Insulated storage

Insulated storage

Marinho de Castro, M.M. et al., (2018). A Taxonomy of Fabric Integrated Thermal Energy Storage: A review of storage types and building locations. Future Cities and Environment. 4(1), p.5. DOI: http://doi.org/10.5334/fce.6
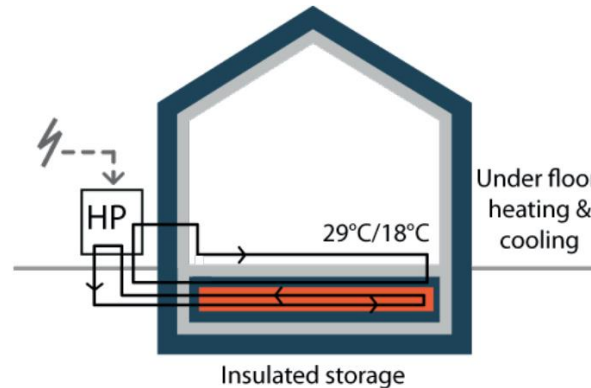
So what?

- Building standards and efficiency have direct and significant impacts on network requirements, not only in terms of aggregate demand

- An individualist approach to heat provision creates significant overcapacity

- Heat solutions which do not entirely displace incumbent technologies may imply overcapacity of both end-use technologies and network

- The UK is a highly spatially heterogeneous system with a broad variety of extant technologies and use cases, and great care should be taken in extrapolating from case studies

- The least-cost and least-emissions pathways (both for the system and consumer) are subject to high uncertainty due to the wide range of future technology cost estimates and fuel carbon intensities