T-ERA & SIRACH Networking and Dissemination Event

Systems Level Integration and future integrated thermal systems

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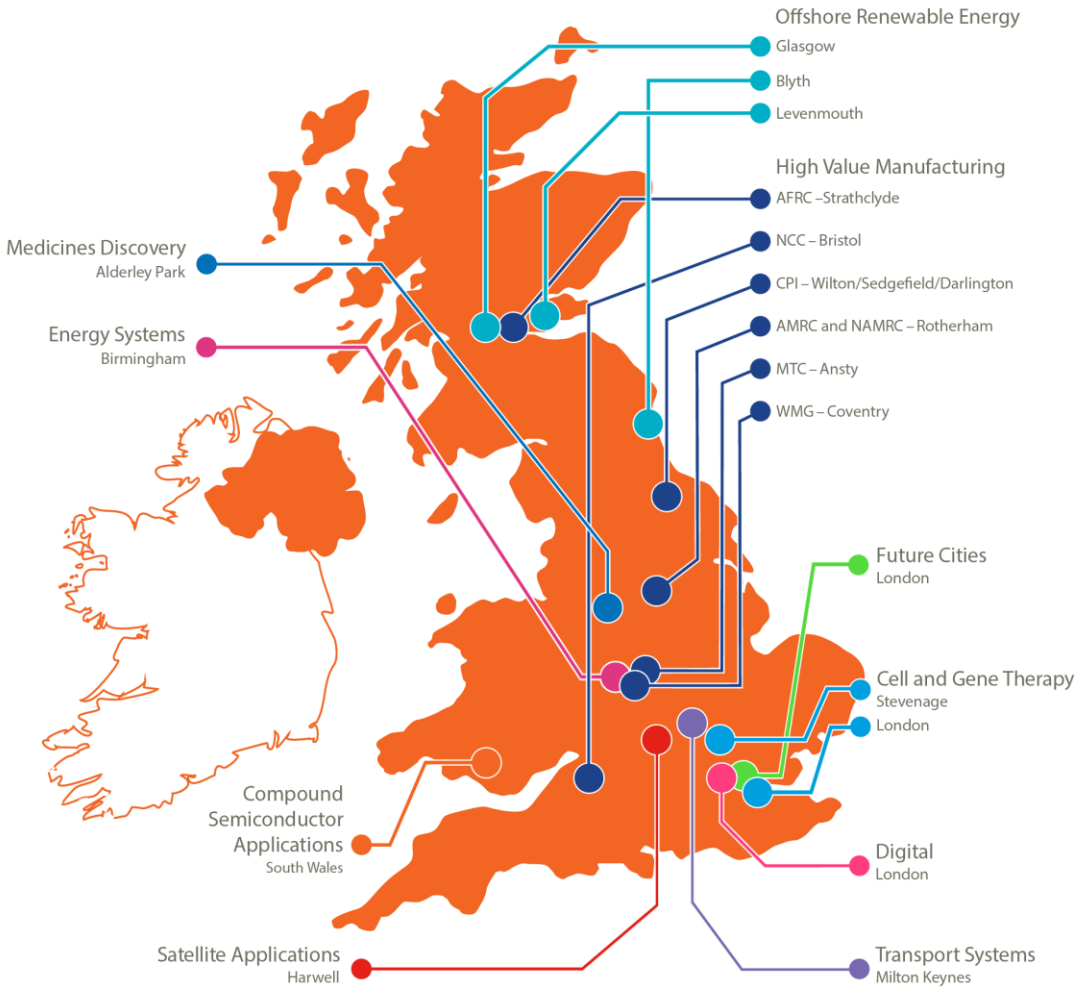
@EnergySysCat LinkedIn

What is a Catapult?

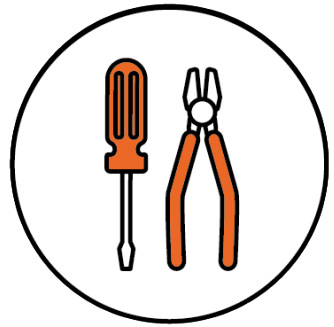
CATAPULT
Energy Systems



We work with Innovate UK

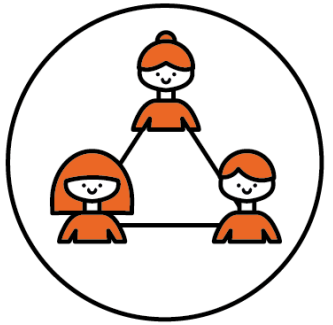
Established and overseen by Innovate UK

10 catapults



Technical capabilities, equipment, and other resources

Solve key problems and develop new products and services

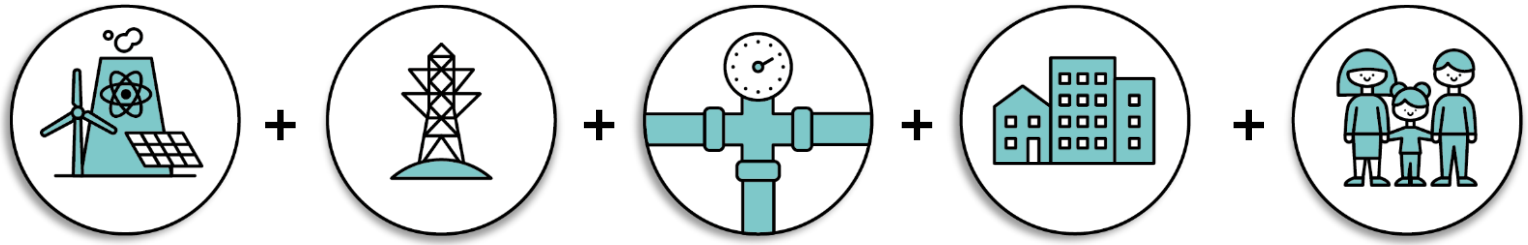


Bridge the gap between stakeholders in the sector

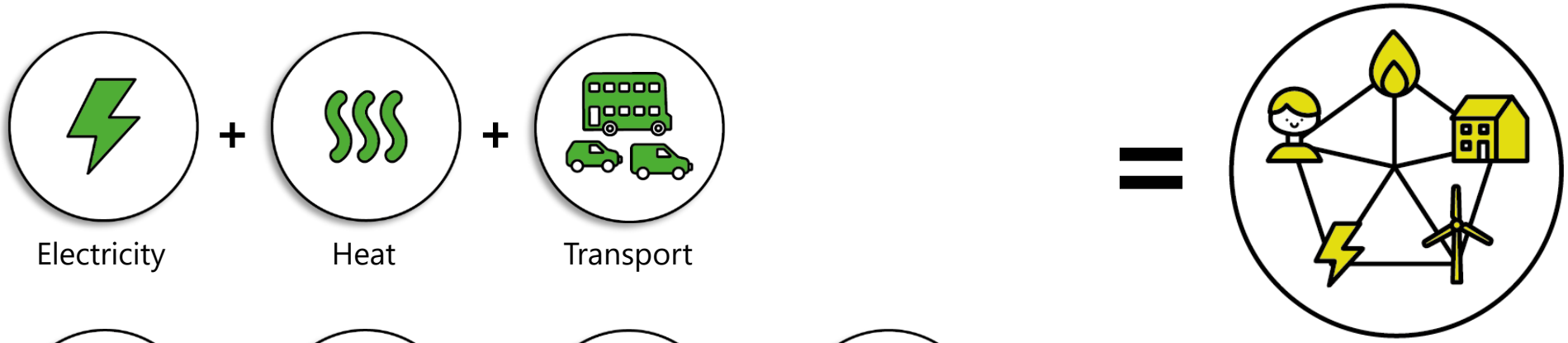
Open up opportunities for innovators, in the UK and globally

What is whole systems thinking?

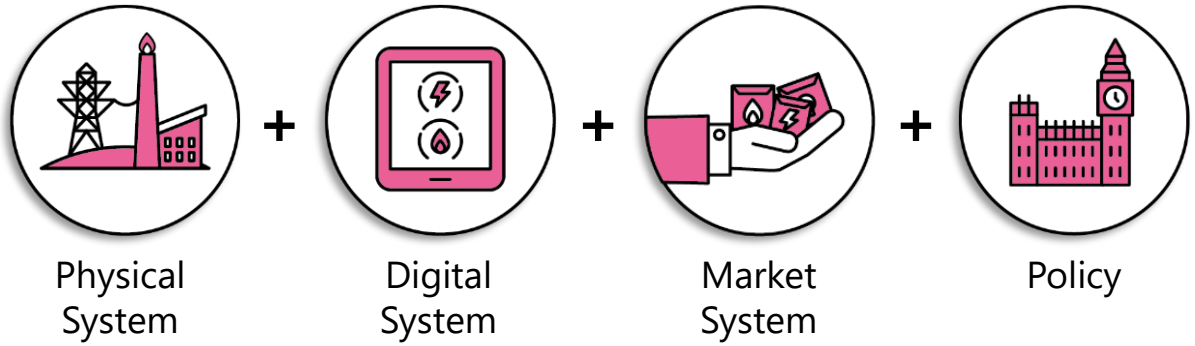
Joining up the system from sources of energy to the consumer



Breaking down silos between energy vectors



Joining up physical requirements of the system, with policy, market and digital arrangements



The Energy System

- The energy system can be balanced using a combination of three tools:
  - Modifying supply
  - Modifying demand
  - Decoupling the two through energy storage

- The key challenge of the future energy system is that the mechanisms by which these are achieved are becoming more diverse and more complex, and frequently going “behind the meter”

An extremely simplified Functional View

Extract Energy

Mining.org

Transmit Energy

lea-coal.org

Store Energy

worldcoal.org

Convert Energy

Pinterest.com

Transmit Energy

Use Energy

Extract Energy

Convert Energy

Transmit Energy

Store Energy

Transmit Energy

Use Energy

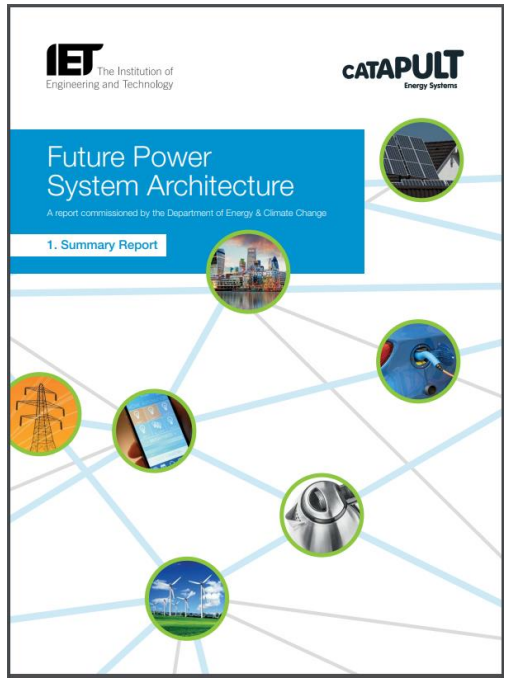
Future Power Systems Architecture (FPSA)

- The FPSA Project was commissioned by the Dept of Energy & Climate Change and lead by the ESC and ETI

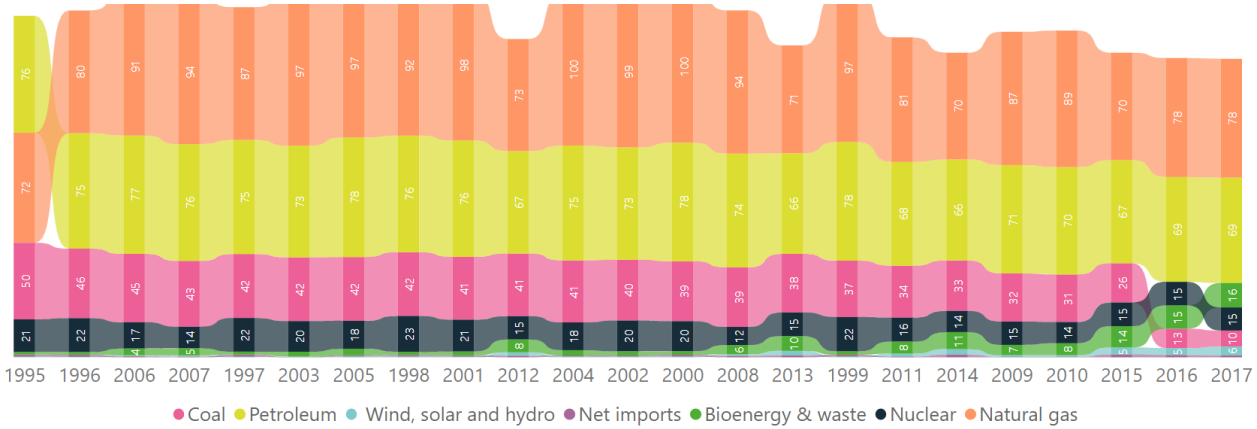
- The project identified 35 new/significantly modified functions for the future energy system grouped by 7 higher level drivers, including:

  - **The flexibility to meet changing but uncertain requirements** recognising that the form, magnitude, timing and tipping points of future power system developments are not all predictable far in advance. Changes include uptake of new technologies (e.g. domestic generation and storage, electric vehicles, heat pumps) or active consumer participation (e.g. smart tariffs, home energy automation).

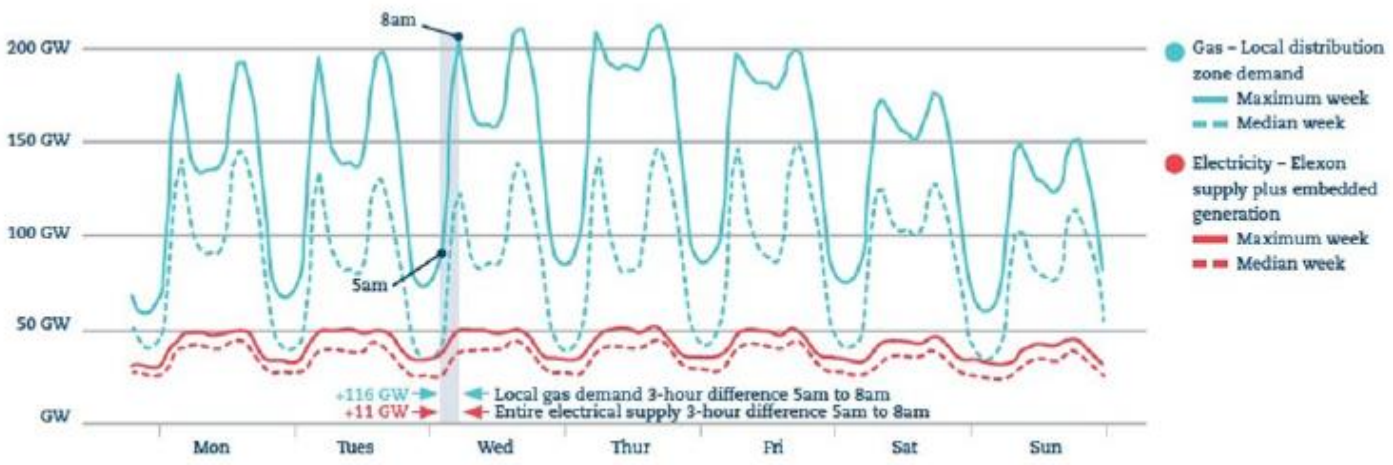
  - **The active management of networks, generation, storage and demand** will facilitate growth of intermittent and distributed generation and new loads such as heat pumps and electric vehicles, without unnecessary network constraints or costly upgrades.



Why storage and where is it today



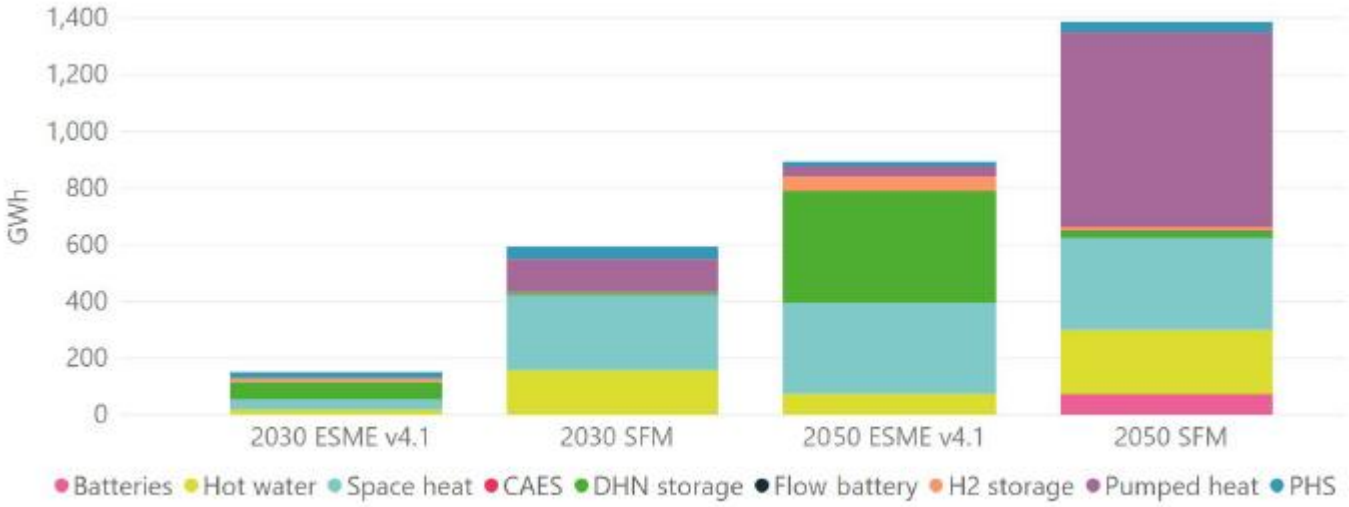
Annual Inland Energy Consumption by Primary Fuel in the UK [Million tonnes of oil equivalent] (DUKES, 2018)



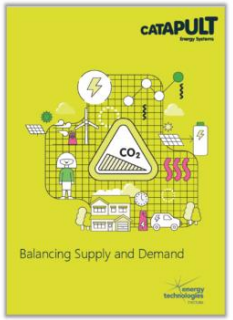
- Storage capacity is essential in the energy system
- The vast majority of today's storage is in the form of the fossil fuels themselves
- Storage not only supports overall changes in demand, but also is key to managing the rate of change

Where might things be heading?
Storage & Flexibility Modelling example output

- There is likely to be a significantly increased role for energy storage by 2050
- Particularly **building level heat storage**, used to smooth electrified heat production and avoid coupling the electricity sector from high intra-day heat demand variation



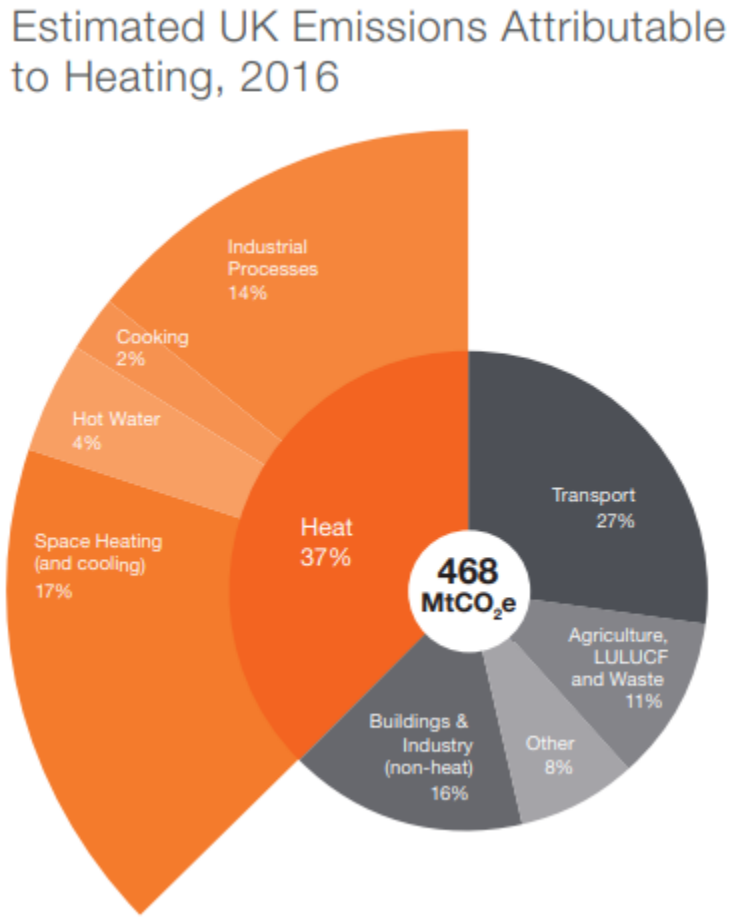
- High volumes of electrical storage (longer duration, cost effective) to be used for peak load reduction and to balance increasing reserve requirements
- Flexibility can be provided by multi-vector integration, which is key to how technologies are operated
- **Heat storage flexibility** may be used run Heat Pumps in fully utilised baseload operation – reducing system cost and smoothing the demand on the electricity system



https://es.catapult.org.uk/news/energy-storage-model-to-offer-clearest-view-of-its-future-role/

The Heating Problem

- Space heating and hot water account for 21% of UK carbon emissions – decarbonising heat therefore essential to meet carbon reduction targets
- As we decarbonise our economy and transition to net zero, large scale electrification of heating will significantly increase load on the electricity network.
- **Thermal storage technologies provide a possible route to mitigating some of this impact and finding new opportunities through:**
  - Time-shifting and peak shaving.
  - Electricity system balancing and provision of ancillary services.
  - Supporting network investment deferral and avoiding renewable curtailment



"Clean Growth – Transforming Heating, Overview of Current Evidence", BEIS, 2018

An extremely simplified Functional View (domestic level space heating)

Extract Energy | Transmit Energy | Convert Energy | Transmit Energy | Use Energy | Store Energy

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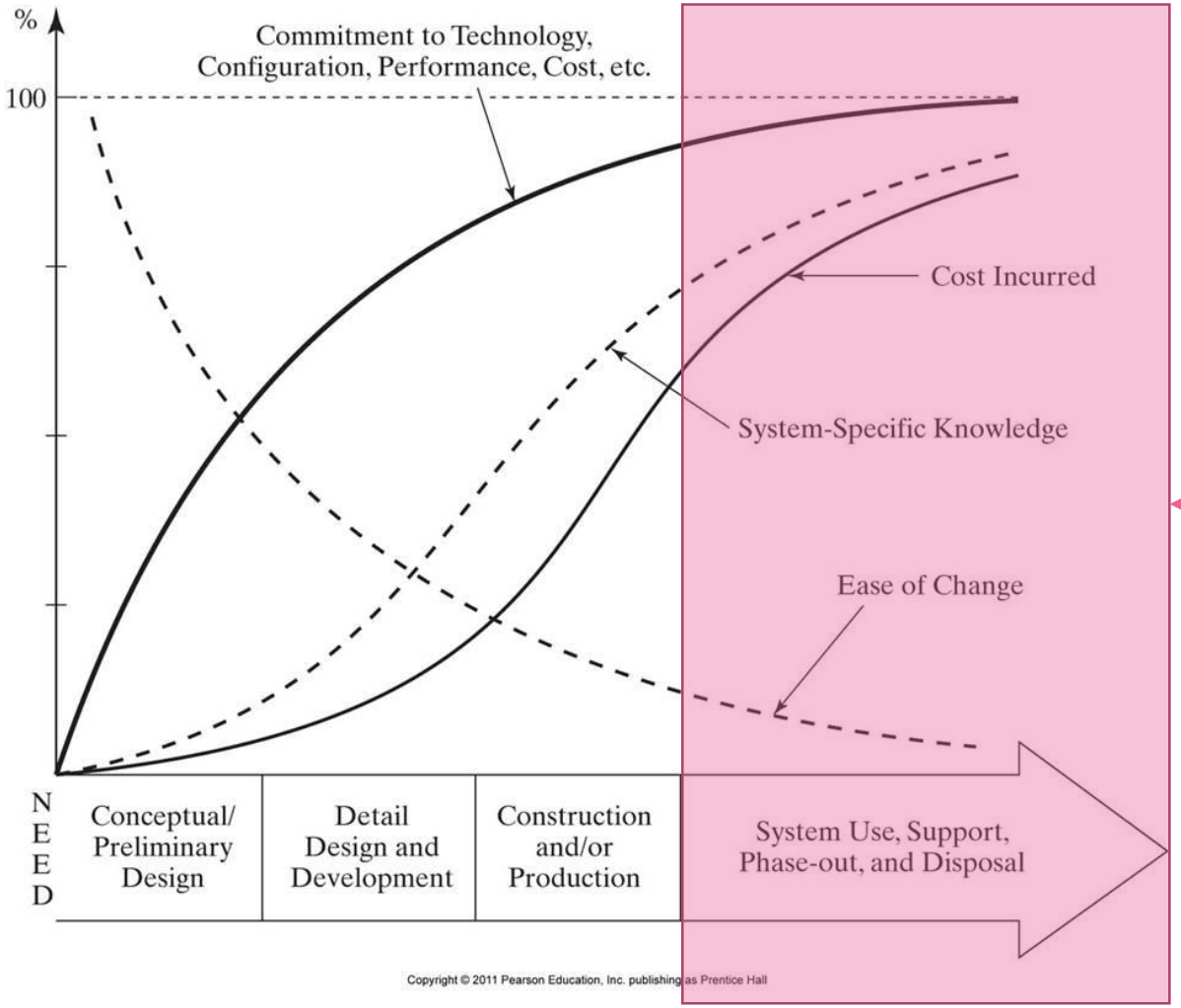
Domestic Thermal Storage

Obligatory Systems Engineering vs Cost Graph!



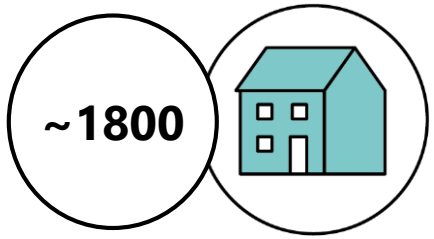
All of our buildings are here!

Changing the type of heating system is hard, costly and disruptive

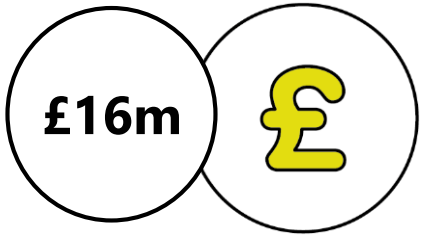
Where would you put a thermal store in your home if you don't already have one?

BEIS Electrification of Heat Project

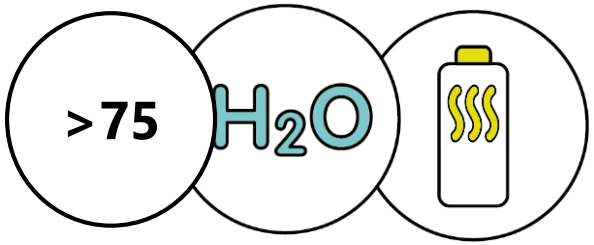
- The Electrification of Heat Demonstration Project aims to demonstrate the feasibility of a large-scale rollout of heat pumps by installing systems in a representative range of housing archetypes, alongside new products and services designed to overcome barriers to deployment.



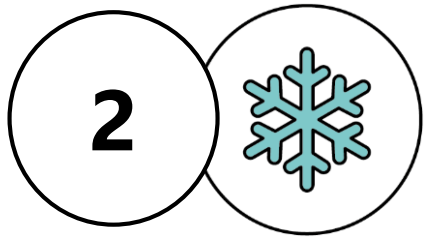
Home Suitability Surveys – range of housing archetypes and social groups



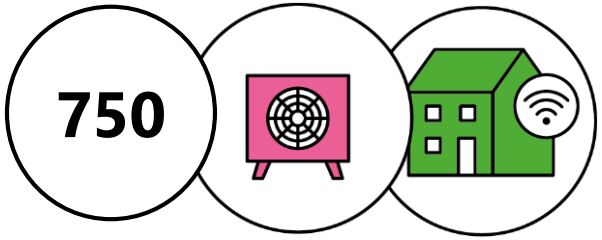
Total Project budget



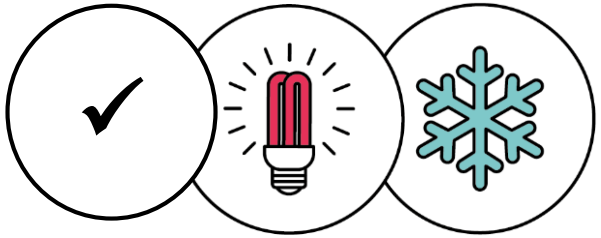
Innovative space-saving thermal storage solutions



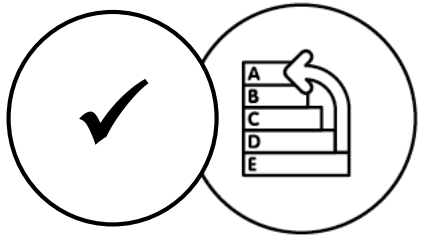
Winters worth of monitoring data



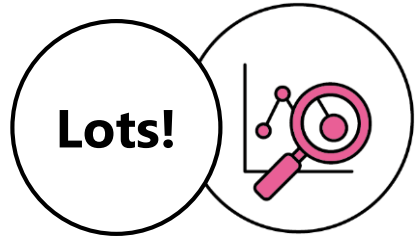
Heat Pump and monitoring system installations (ASHP, GSHP & Hybrids)



Trials of Noise reduction technology, cooling & other improvements



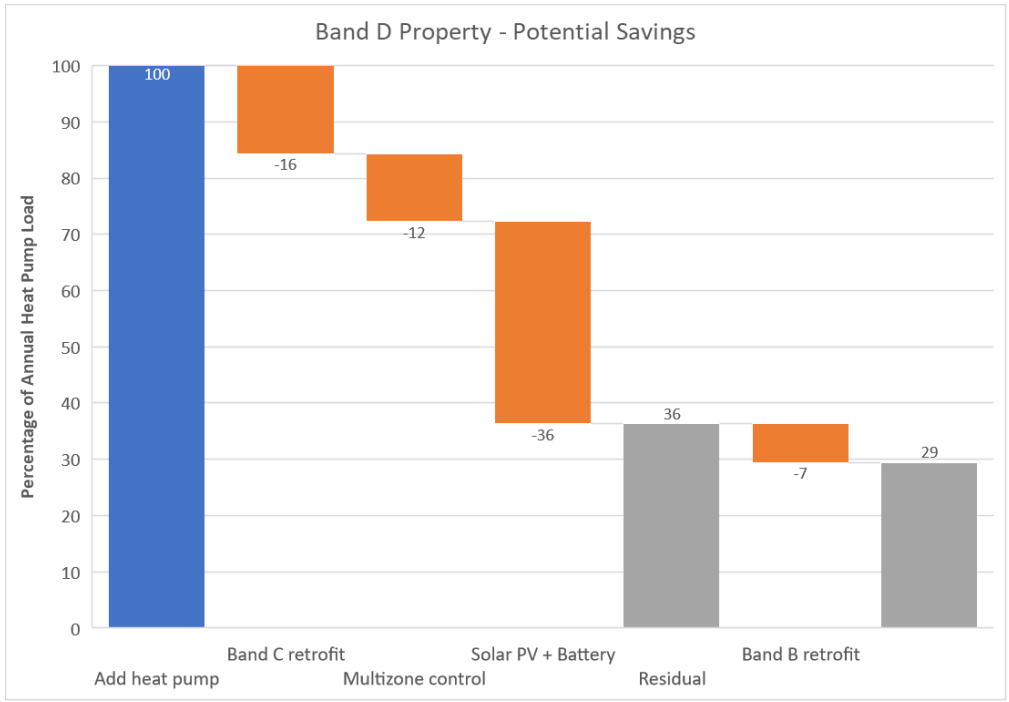
Fabric retrofit



Analysis and investigation

Future Domestic Heating Systems

- Future heating systems will be provided through a range of means – Electric Heating (heat pumps, resistive), Communal and/or District Heating, Hydrogen – will all have a role to play



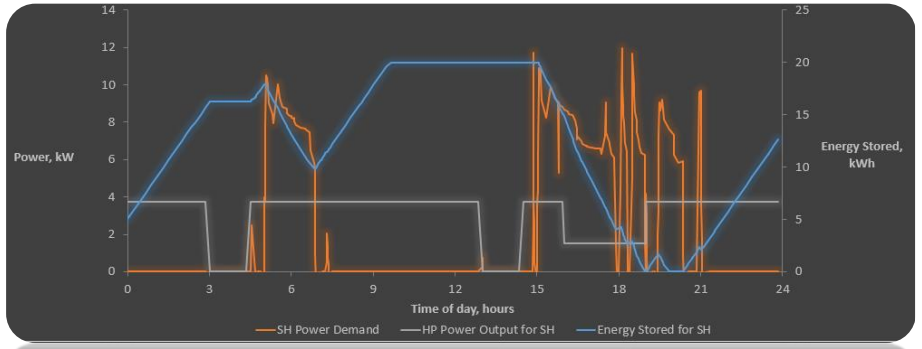
- However the system impact of electric heating systems will be significant and requires mitigation
- Building energy efficiency measures (e.g. retrofit) will be essential, as will advanced controls.
- Thermal storage offers a route to further managing this risk, but it requires whole energy system integration

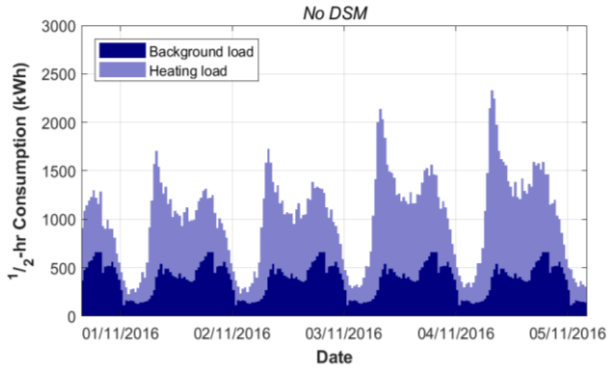
The next stage – Thermal store and Network integration

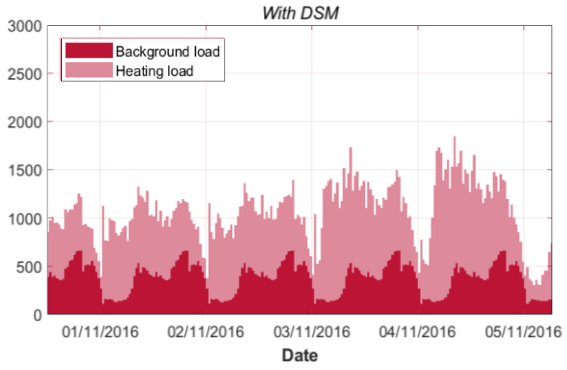
- Reduce energy requirements (+ add PV)

House	Wall Insulation	Floor insulation	Roof/loft insulation	New windows	New doors
A	9.7%	2.0%	1.2%	5.1%	4.3%
B	24.0%	5.6%	1.6%	4.3%	1.6%
C	17.9%	n/a	1.7%	n/a	n/a
D	12.0%	2.4%	1.6%	6.4%	0.4%
E	n/a	1.4%	0.8%	4.8%	0.5%

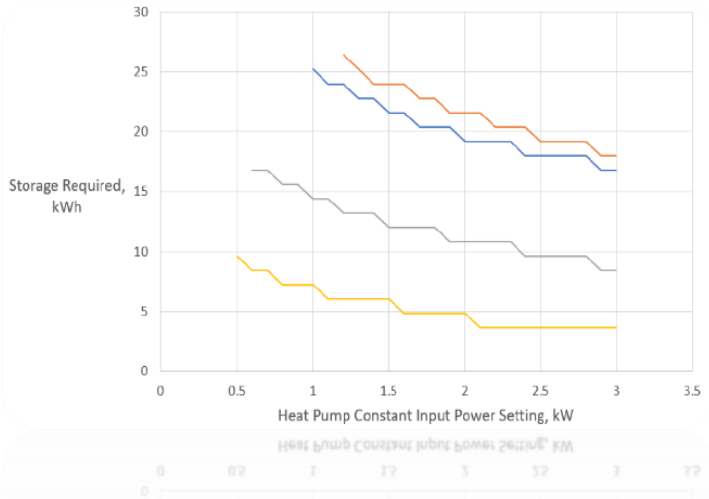
- PCM thermal store to shift and smooth demand





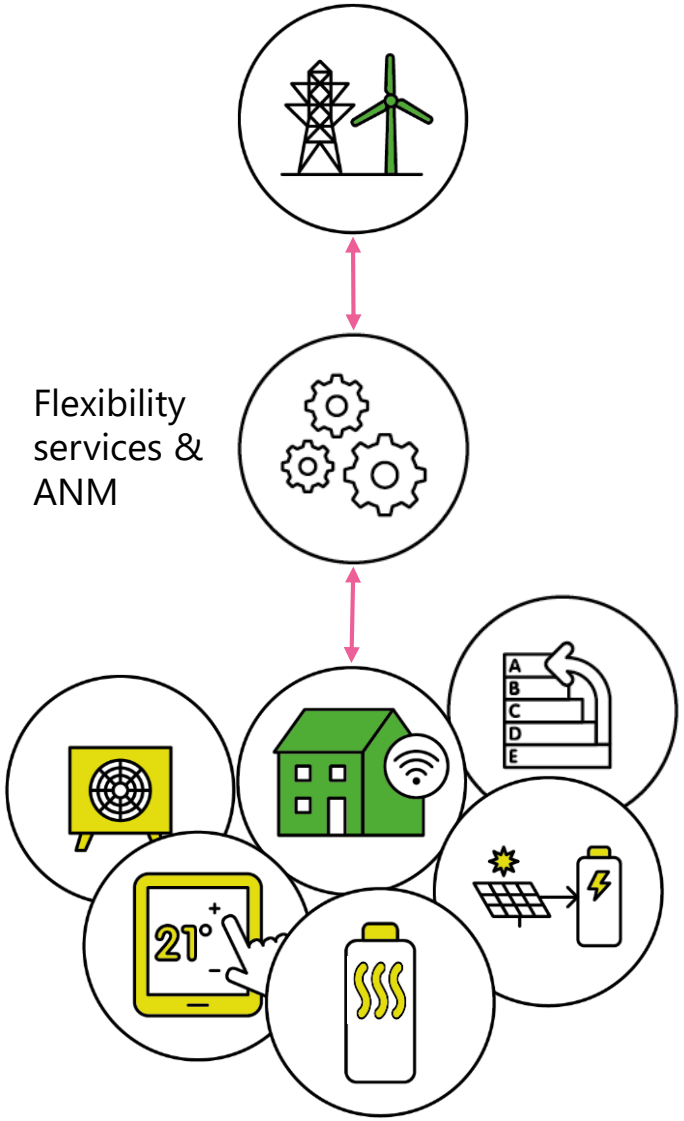


- Network influence / control of heat pumps to adjust demand

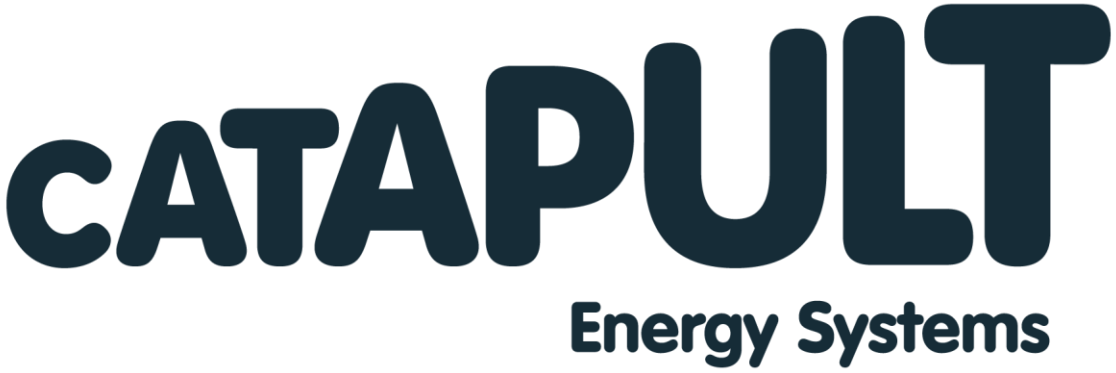


- Increase storage to reduce demand further

Proposed Project (~500 homes and offshore generation)



- **Reducing Heating system capacity and load**
  - Reducing energy needs first, while supplementing with domestic generation (solar PV and battery)
  - Investigate defining the **Thermal store as the primary heat provider**, potentially allowing heat pump size to be reduced
- **New Technology = New Opportunities for flexibility**
  - Design and install a system deliberately with the objective of smoothing (rather than just shifting) load
  - Develop network and domestic level control systems, inc Active Network Management, to manage demand across a large number of homes
- **Understand failure modes**
  - Many thermal stores include a resistive heating element - can be used if heat pump fails or is insufficient.
  - May make system an attractive consumer proposition (i.e. still stay warm if heat pump breaks down) – but what are the consequences to the grid?
- **Consumer Focus and Business Models**
  - Is it attractive or compelling? How could consumers be encouraged or incentivised to adopt it?
  - What new business models could be developed to encourage consumers to allow access to the flexibility in the system?



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