ITRC mistral

multi-scale infrastructure systems analytics

# Energy Supply System Modelling

**Energy Supply**
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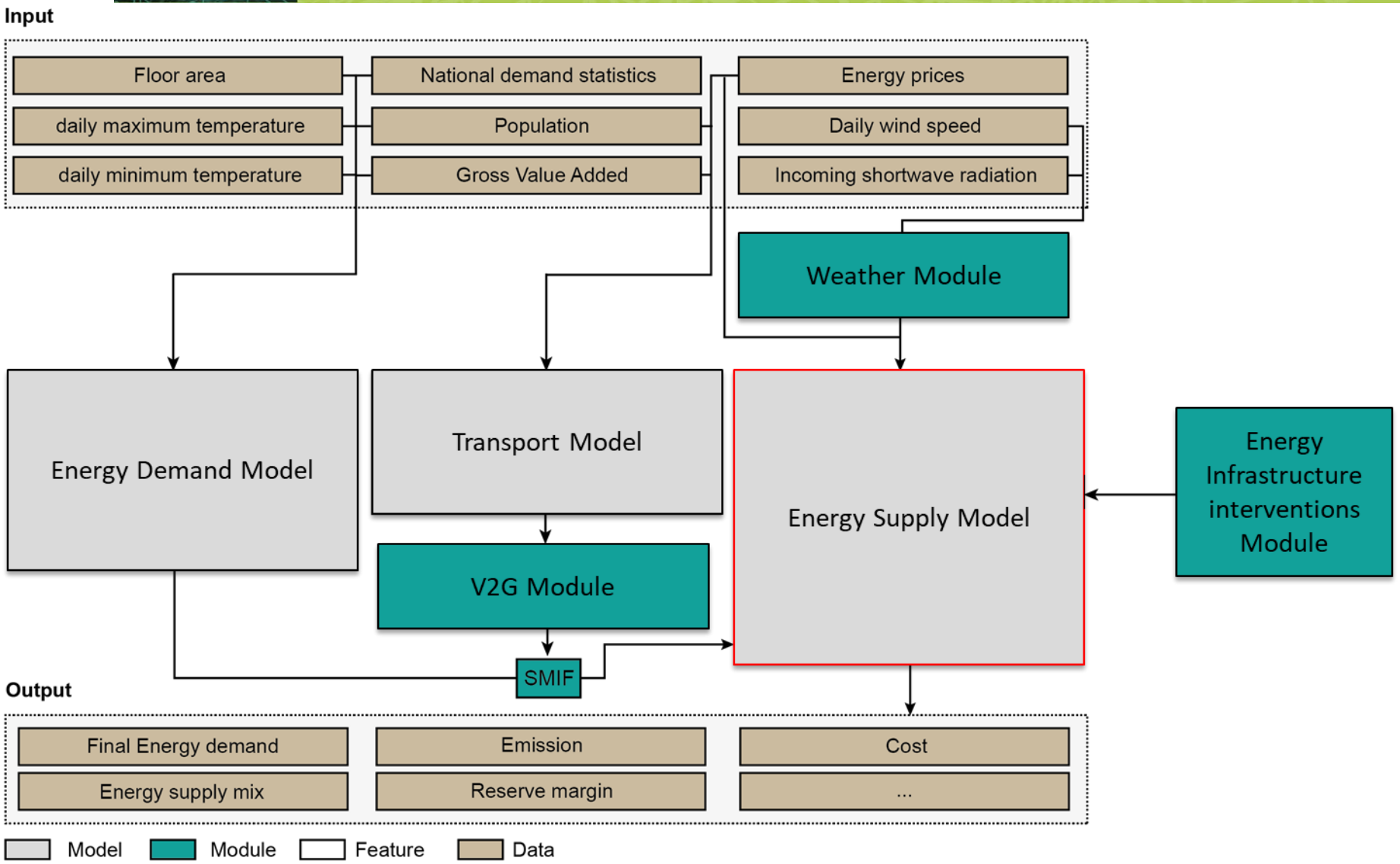
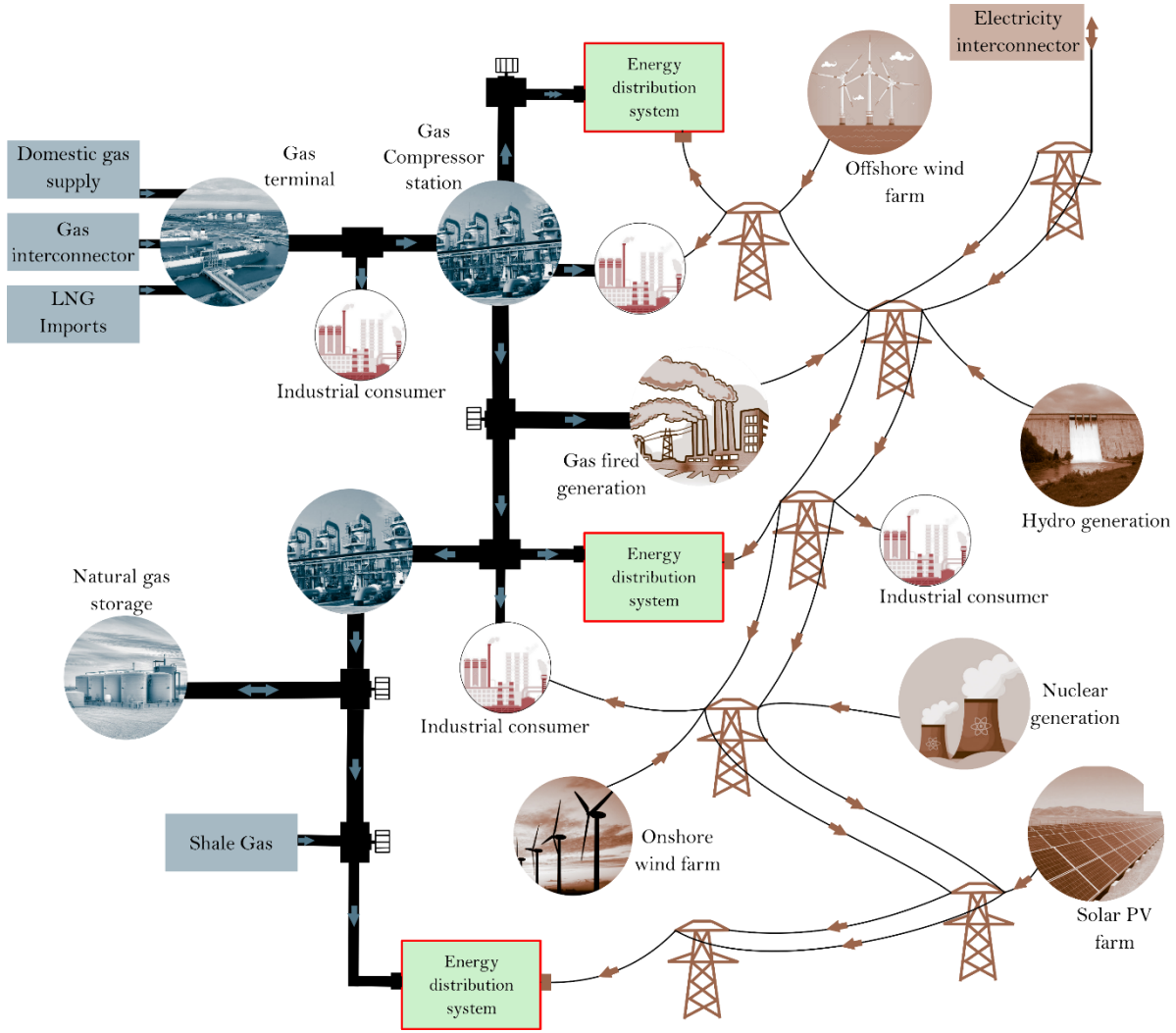
EPSRC
Engineering and Physical Sciences Research Council

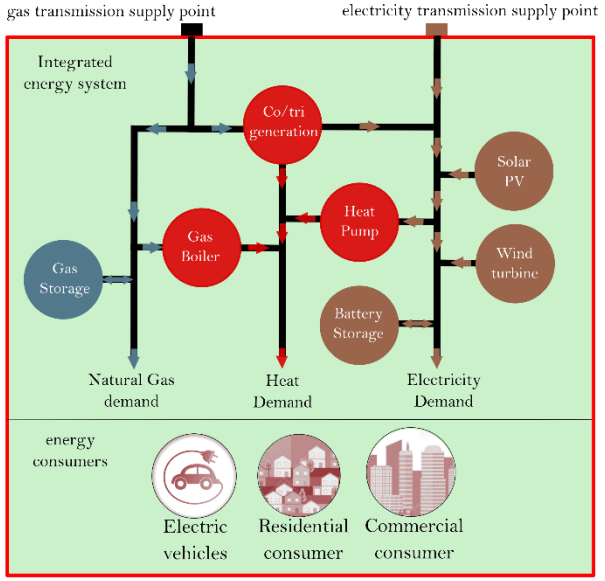
# Integrated Energy System model:
## System of Systems Setup




SMIF* – Systems Model Integration Framework

# Energy Supply -
# Energy System representation




Energy distribution systems represented by **Energy Hub's**

Resources Supply ➡ Transmission ➡ Distribution ➡ End Use

# Energy Supply - Model capabilities

- Integrated modelling of interdependent energy vectors - ***Electricity, Gas, Heat and Hydrogen (Multi Vector Energy Systems)*** across multiple spatial scales.

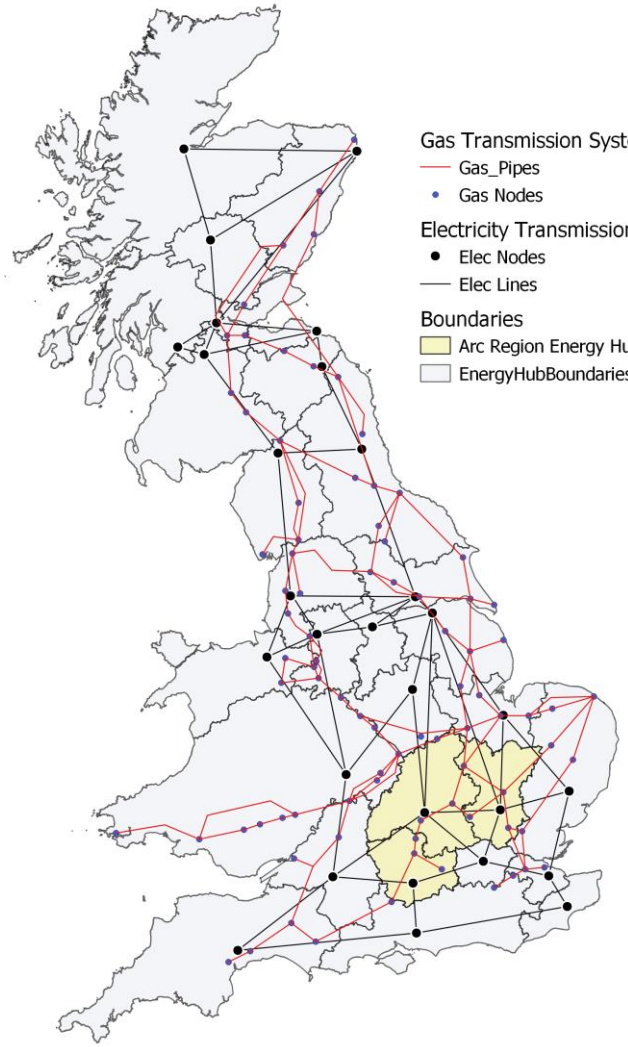
- Built on an ***operational optimisation*** framework.
  Objective : Minimise total operating cost of the energy supply system

- Detailed modelling of combined ***electricity and natural gas transmission networks***.

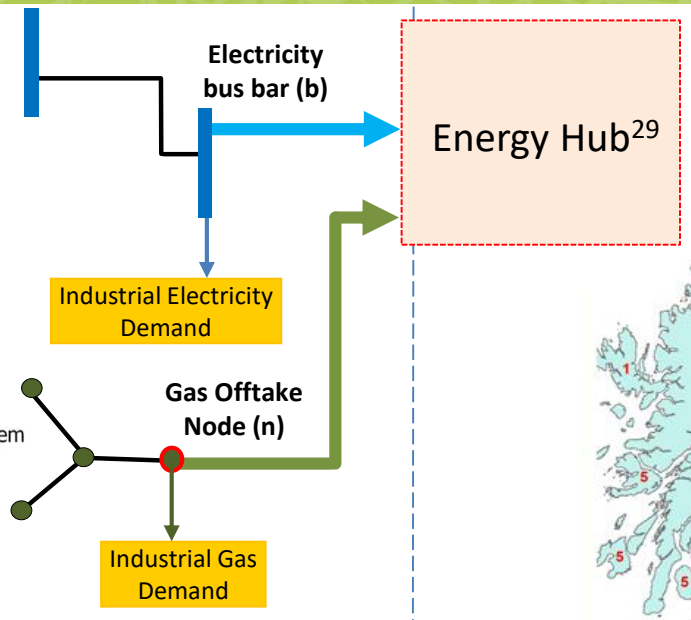
- ***Local energy systems modelling*** using an **energy hub** approach enables:
  - Combined operation of electricity, natural gas and heat distribution systems.
  - Exploration of new energy vectors e.g. Hydrogen
  - Investigation of alternative energy supply options that are available locally e.g. Waste to energy, bio-energy
  - Simulation of energy demand for transport. e.g. EVs and vehicle to grid schemes.

- Functional capabilities:
  - Bi-directional electricity interconnector flows
  - Demand side management (load shifting)
  - Intermittent renewable generation modelling
  - Water supply, Transport and Solid Waste infrastructure interdependencies

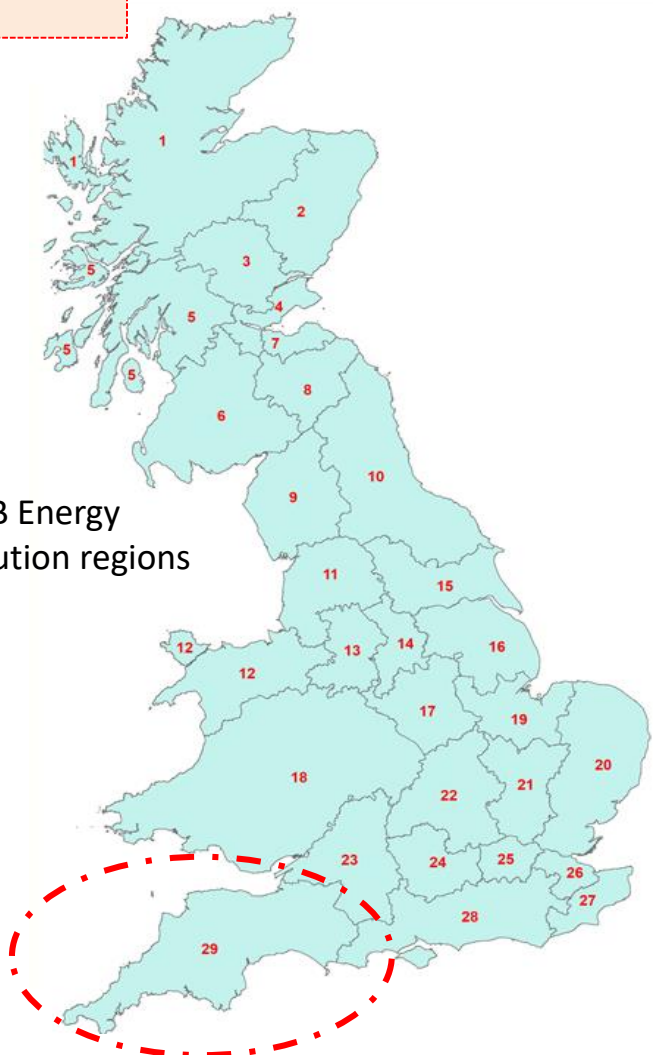
# Energy Supply -
## Representation of transmission and distribution networks



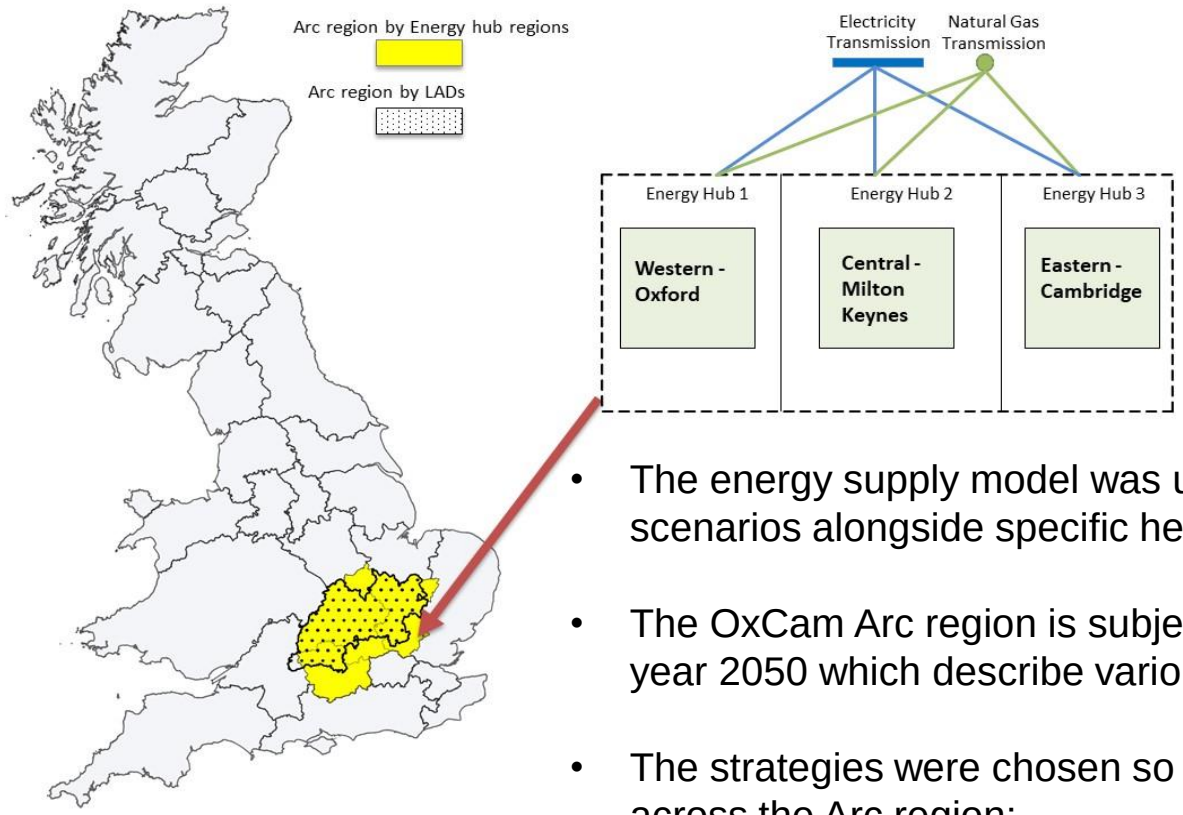

GB gas and electricity transmission networks




GB Energy distribution regions



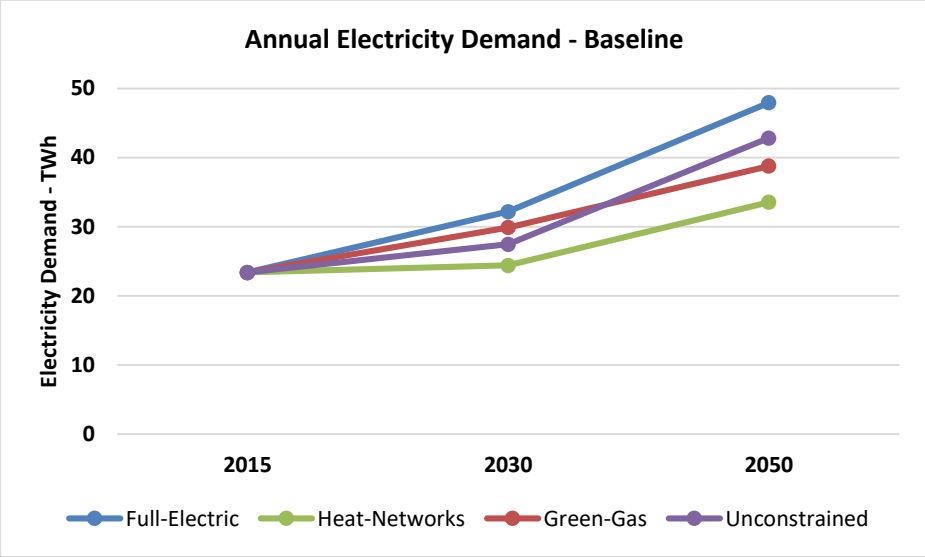
# OxCam Arc analysis - **Outline**

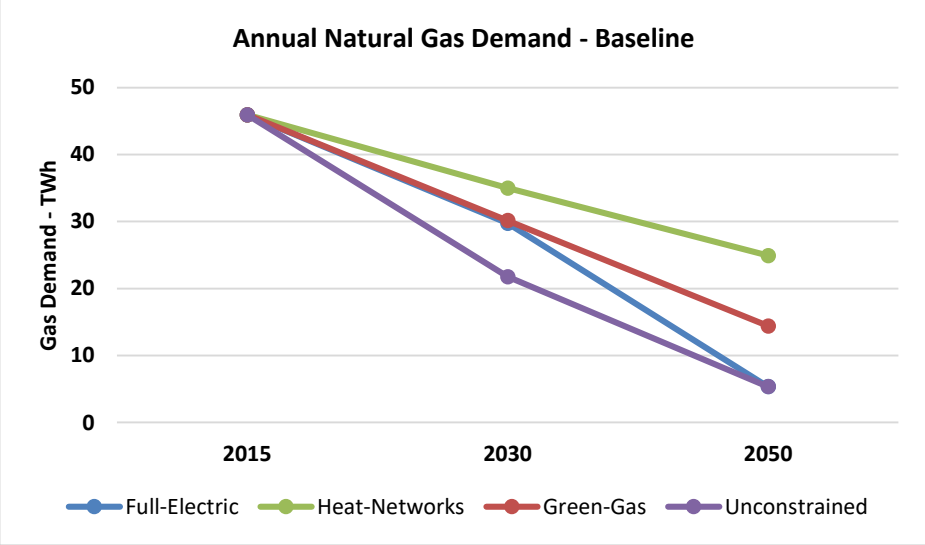



Representation of OxCam arc region using the Energy Hub boundaries

- The energy supply model was used to assess the impact of arc scenarios alongside specific heat supply system strategies.
- The OxCam Arc region is subjected to various supply side strategies to year 2050 which describe various pathways to meet energy demand.
- The strategies were chosen so that they cover a range of possibilities across the Arc region:
  - Full electric
  - Green gas
  - District heat network systems

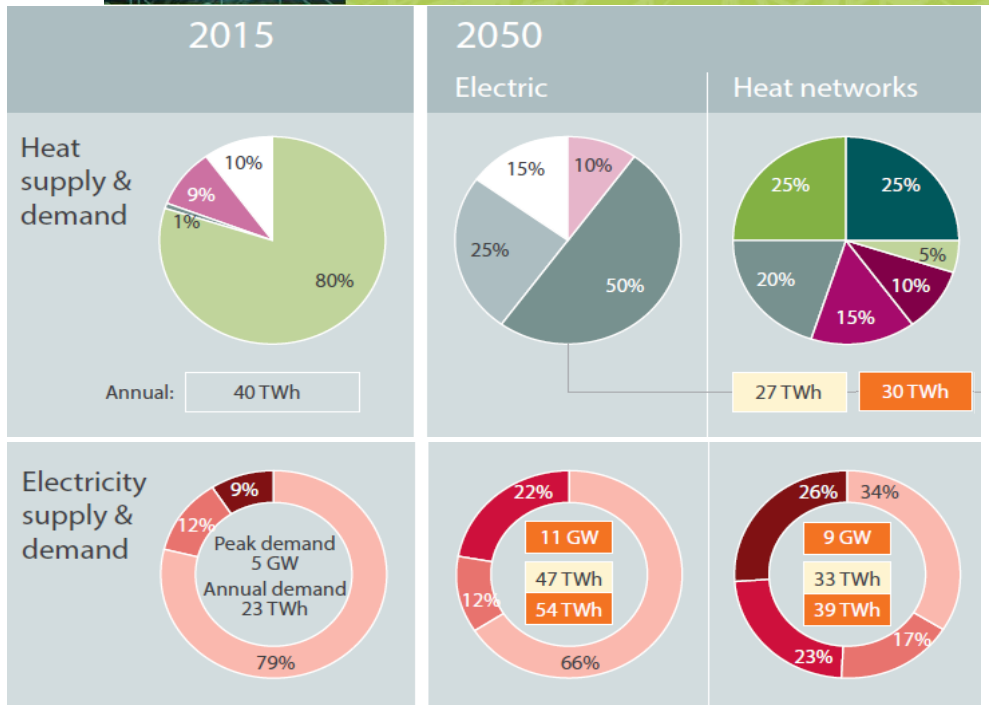
# OxCam Arc analysis -
# Electricity and natural gas demand

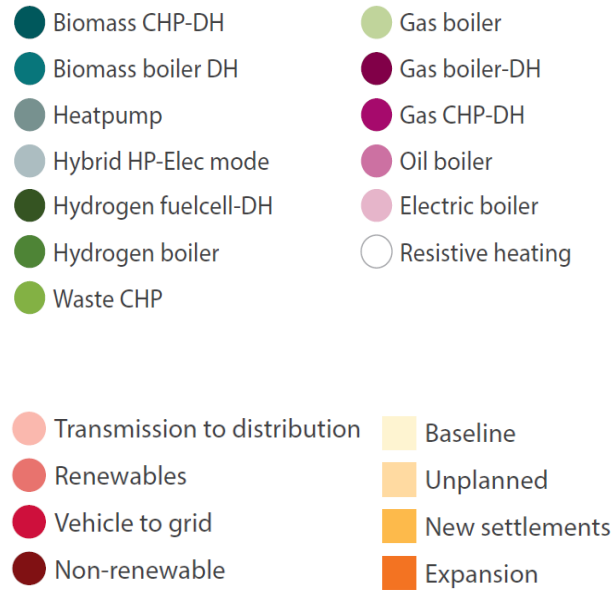



- Annual energy demand in 'electric' strategies across all scenarios in 2050 are lower than in 2015.
- Electrification of heat across all scenarios doubles the annual and peak electricity demand in 2050 (compared to 2015).
- At least 50% decrease in gas demands in 2050 across all scenario compared to 2015.
- "Electrification" further reduces natural gas consumption in 2050 by 90% compared with 2015 levels.

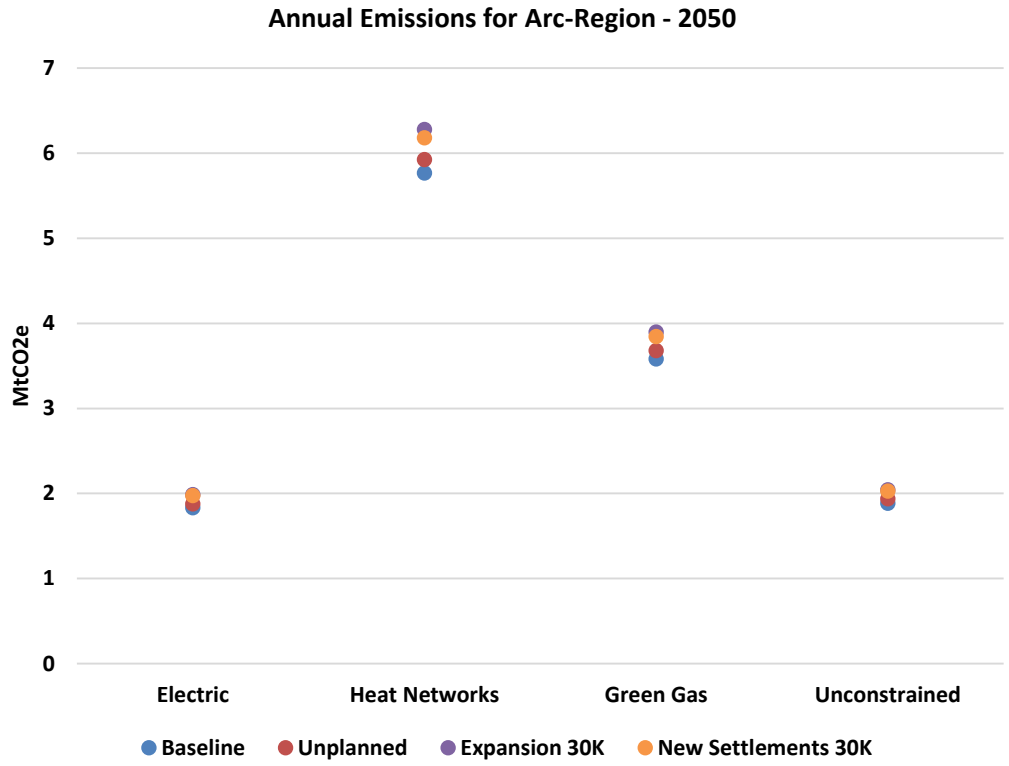
# OxCam Arc analysis - **Energy Supplies**




- Heat demand declines (25-30%) in 2050 (compared with 2015) in all scenarios and strategies.
- Electric vehicle to grid services could generate up-to 25% of the Arc's electricity needs by 2050.
- Local renewables contributed up-to 17% of the Arc's electricity needs in 2050, primarily from photo-voltaic (PV) panels.
- EVs, local renewables and CHP units connected to heat networks suppled up-to to 66% of the Arcs electricity needs in 2050 (Heat network strategy).
- The national electricity transmission system is required to provide substantial supplies in 2050.

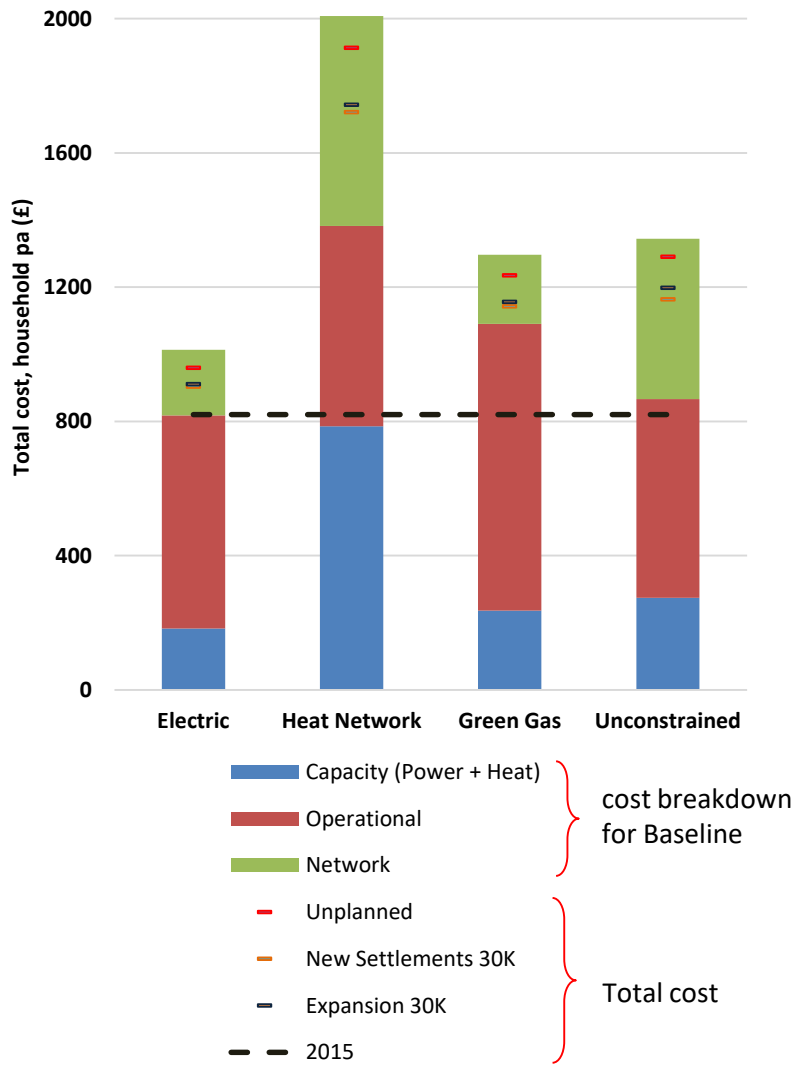
# OxCam Arc analysis - Emissions




- High growth scenarios have the highest annual emissions (2050) in each strategy.
- Electrification of heating and use of decarbonised electricity reduce residential and commercial emission to near zero in 2050.
- Continued (although reduced compared with 2015) use of solid-fuel and oil within the ‘difficult’ to decarbonise industrial sector in 2050.

# OxCam Arc analysis - Annual Costs - Summary

Annualised cumulative total costs (2015–2050) of implementing energy supply strategies, per household, per annum




- New settlements and expansion scenarios have the lowest costs per dwelling per annum.
- “Electrification” is lowest cost strategy across all scenarios adding on average an extra £130 annually per household compared with 2015.
- “Green Gas” has the highest operational costs as large scale hydrogen production remains expensive up-to 2050.
- “Heat Network”(s) incur large capacity and network costs, an additional £1180 annually per household compared to 2015.
- Electrification of heating in the arc region was shown to be the most cost-effective way to meet emission targets across all arc scenarios.