London-Loughborough EPSRC CDT

Centre for Doctoral Training in Energy Demand

Vision and leadership for a sustainable built environment

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Efficient Integration of Heat Networks with Low-Carbon Power Generation

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BACKGROUND

Several options exist to decarbonise heat demand in the built environment, some which include a high degree of electrification of low temperature heat demand.

With the high level of electrification, it is expected that a large share of this will be of renewable origin which is generally intermittent.

District heating networks are a technology that allow centralised heat generation to be distributed and allows a more diverse range of heat sources to be used taking advantage of the efficiency and economy of scale as well as the integration of thermal energy storage due to its potential in peak load shifting.

Integration of heat and power networks are an encouraging opportunity to manage and mitigate temporal imbalances of supply and demand in energy systems with a high fraction of intermittent renewables such as wind energy.

Supply and demand follow different patterns in different domains and integrating them can lead to synergies in generation, storage and consumption. Resulting in a higher reliability, flexibility and efficiency for the enegy system.

As district heating is a distribution technology, CHP units and heat pumps are not mutually exclusive but the operation schedule is critical and heat storage provides a level of flexibility between the two.

Both the carbon intensity and cost of power generated hour by hour will vary depending on the amount of renewable generation available and stored.

Hence the size of heat stores to minimise fossil fuel usage and to economise district heating plant operation will be critical.

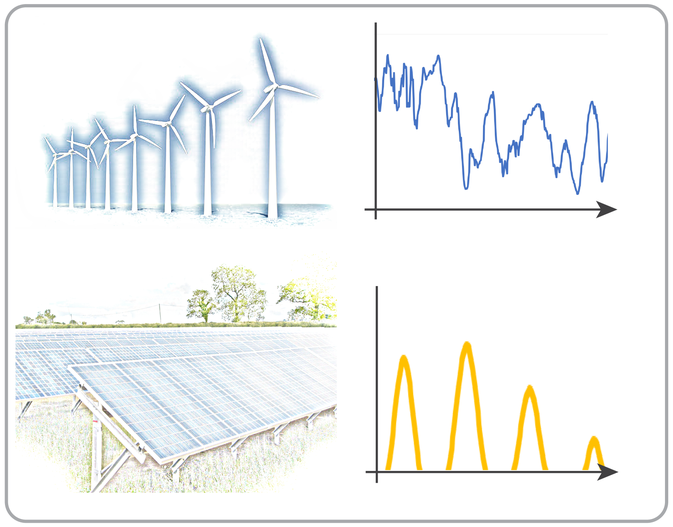
Research Questions

A. What operation algorithms minimise life time costs and carbon emissions for district heating networks in a renewable energy system with large scale district heating and combinations of heat storage, heat pumps and CHP?

B. What combination and sizes of district heating components, in terms of heat plant and storage is optimal economically in terms of capital investment and to mininise operating costs.

C. What is the economic value of thermal energy storage for power grid balancing compared to conventional storage technologies and how much can this replace conventional energy storage?

NATIONAL SCALE RENEWABLE POWER GENERATION MODEL



LEGACY BASELINE GENERATION

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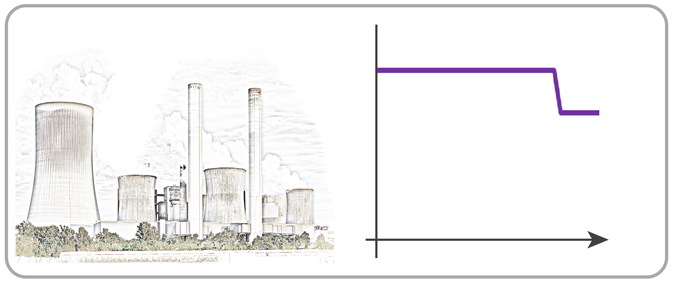
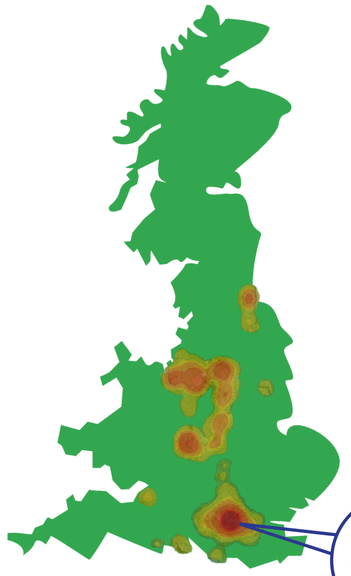


USING NATIONAL CONSUMPTION DATA, THE MARGINAL SYSTEM COST OF ELECTRICITY GENERATION IS CALCULATED FOR A CAPITAL INTENSIVE SYSTEM - i.e. THAT WHICH CONTAINS LARGE FRACTIONS OF OFFSHORE WIND AND GRID STORAGE

METEOROLOGICAL DATA USED TO PREDICT HEAT LOAD AND RENEWABLE POWER GENERATION COUPLING HEAT DEMAND WITH INTERMITTENT POWER GENERATION



DISTRICT HEATING NETWORK MAPPING

DISTRICT SCALE HEATING LOADS MODELLED

BUILDING ARCHETYPES

BUILDING THERMAL MODEL
SPECIFIC HEAT LOSS AND THERMAL MASS

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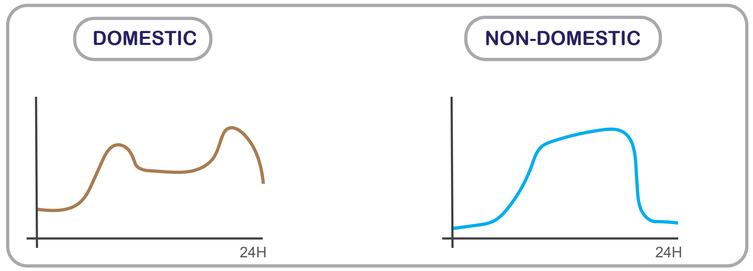
HOURLY ACTIVITY LOAD PROFILES



DISTRICT SCALE HEATING LOADS MODELLED HOURLY FOR BUILDING COMPOSITION OF URBAN DISTRICTS HEATING NETWORK

CHP POWER

POWER FOR HEAT

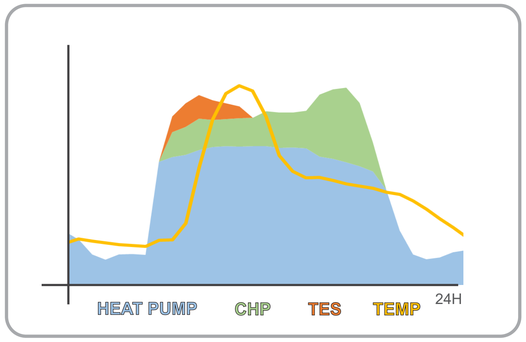
£ CO_2

DISTRICT HEATING
POWER PLANT OPERATION

HEAT PUMPS
COMBINED HEAT POWER
THERMAL ENERGY STORAGE

HEAT DEMAND

HEAT SUPPLY



OPTIMISATION ALGORITHM

UCL

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