

Holistic optimisation of distributed multi energy systems for sustainable urban areas

Research context

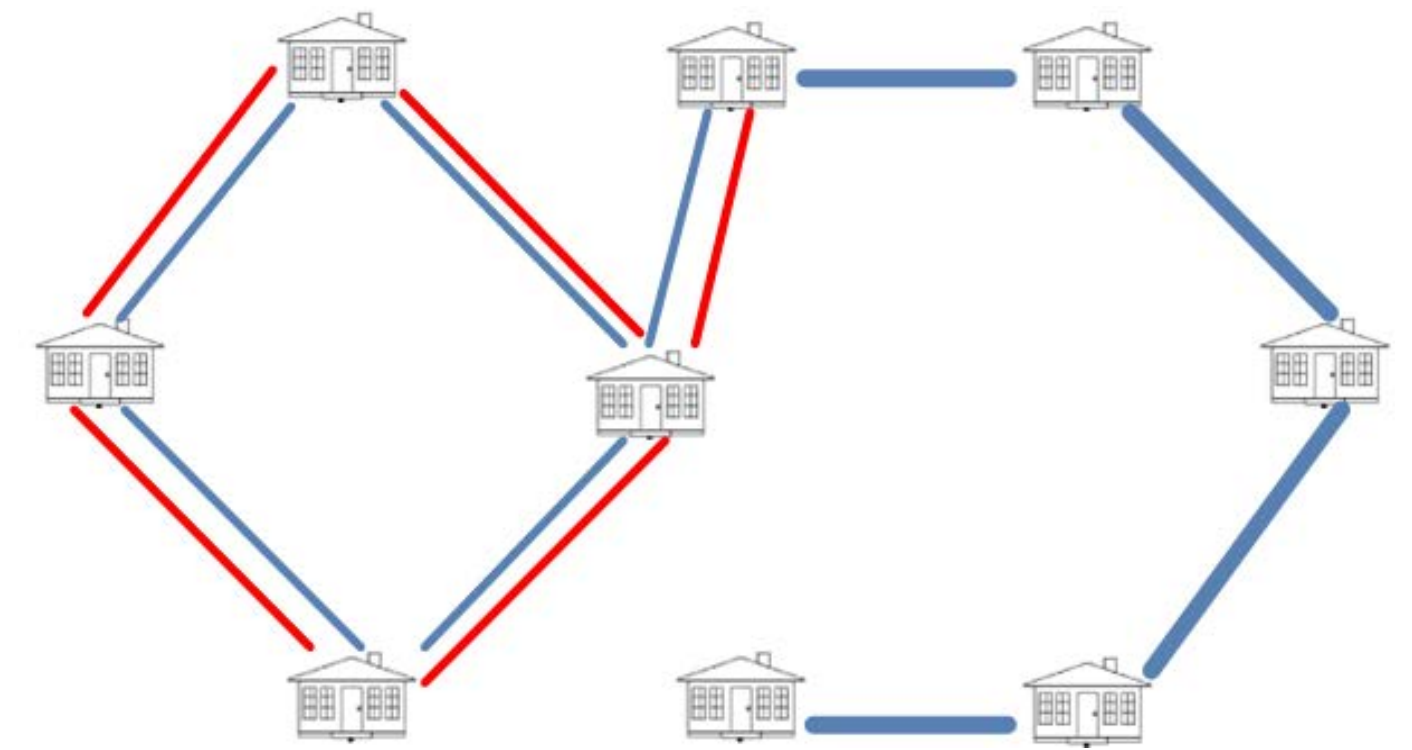
Distributed multi energy systems can be a key enabling factor in meeting future energy needs. They satisfy simultaneously various energy demands (e.g. heat and electricity) at the distribution level by integrating multiple energy resources.

Important research questions are:

- How existing urban areas can be best transformed into sustainable ones?
- Should future distributed multi energy systems be based on thermal or electrical distribution of energy?

Electricity networks can use existing infrastructure, and remain efficient over longer distances, but may need to be upgraded to cope with the higher penetration of renewables and to ensure stability of the grid.

Thermal energy networks can better use available sources of heat, and energy may be more easily stored, but over large distances they can be expensive and have high thermal and pumping losses.

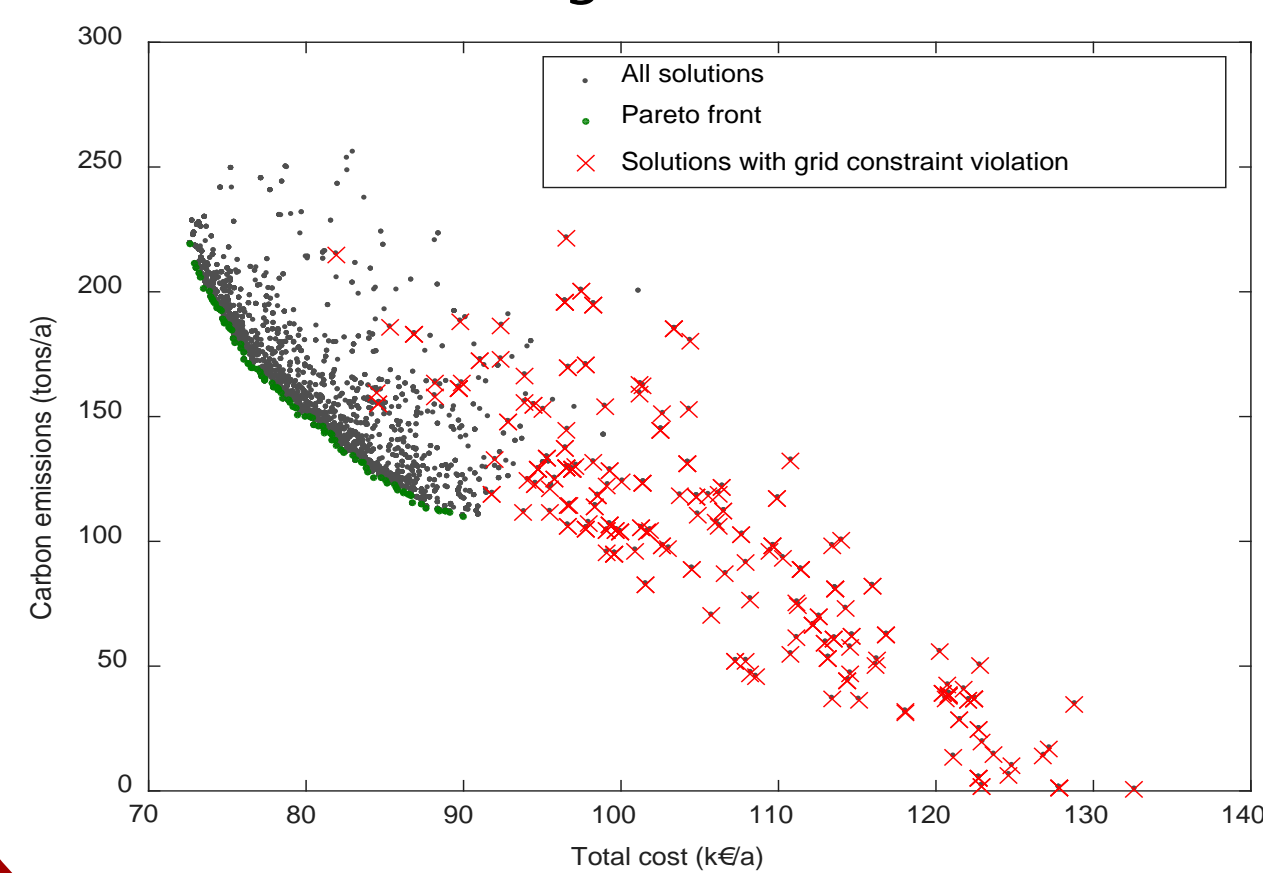


Combination of new heating network and improved electrical networks may be the solution

Design of distributed multi energy systems

Optimisation for design and operation

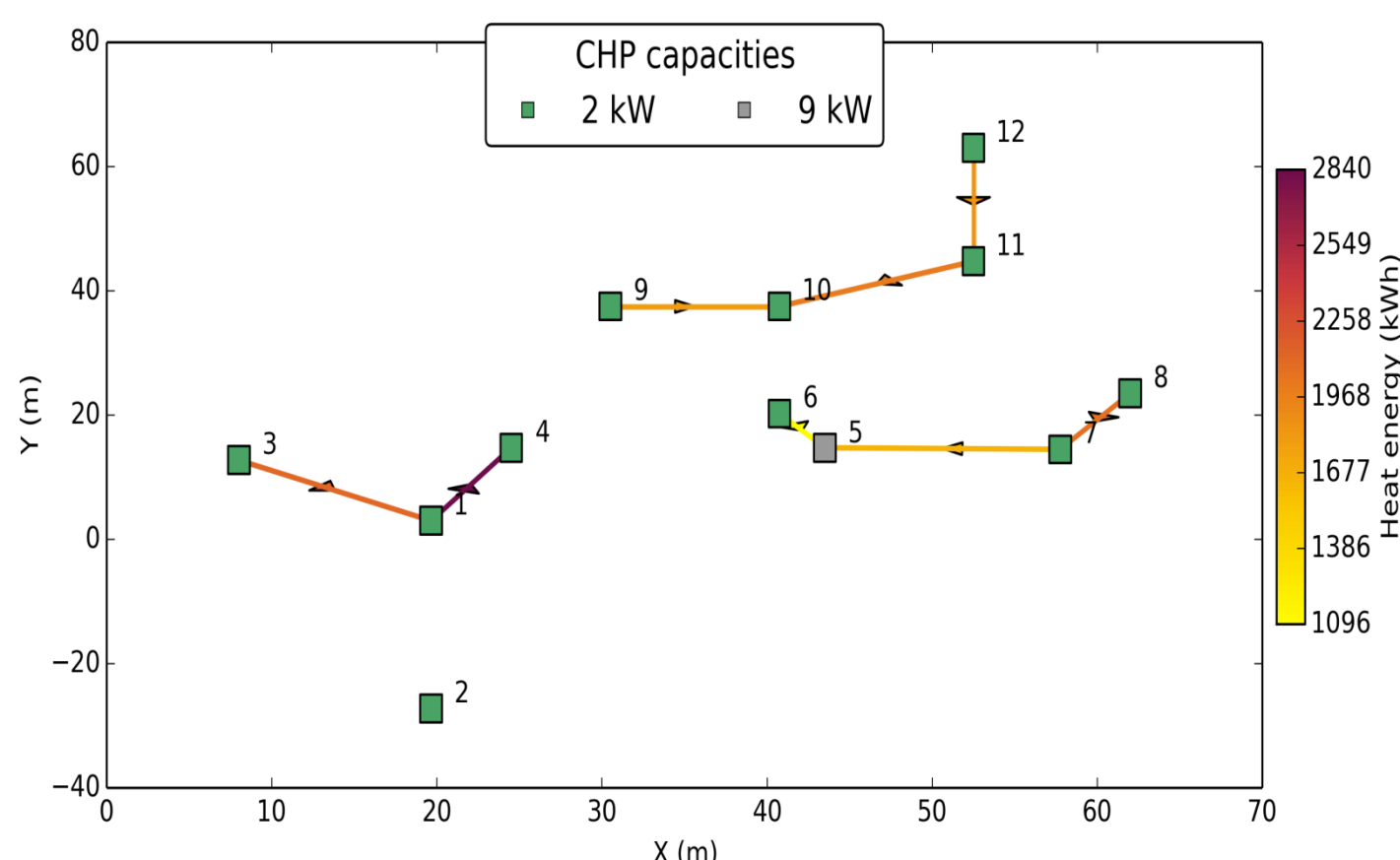
Such systems are more complex to design and operate because they combine multiple energy streams. Optimization is needed to select suitable equipment from numerous alternatives, as well as suitable operating strategies to match the time-varying energy demands of buildings.



Pareto front of multi-objective optimisation

Decentralized district heating network

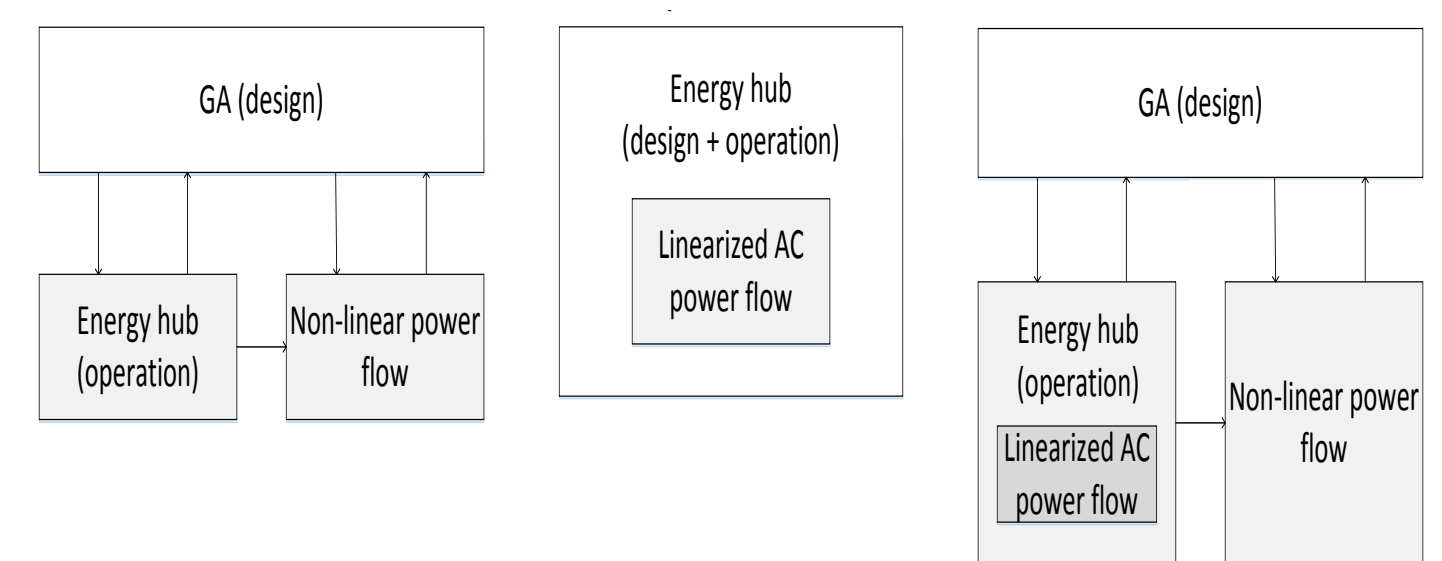
District heating systems should not be designed for the present energy systems but for the future. Decentralised district heating is a concept where heat can be produced from different buildings which are *prosumers* and distributed heating subnetworks can be created to connect them.



Example of prosumers forming heating subnetworks

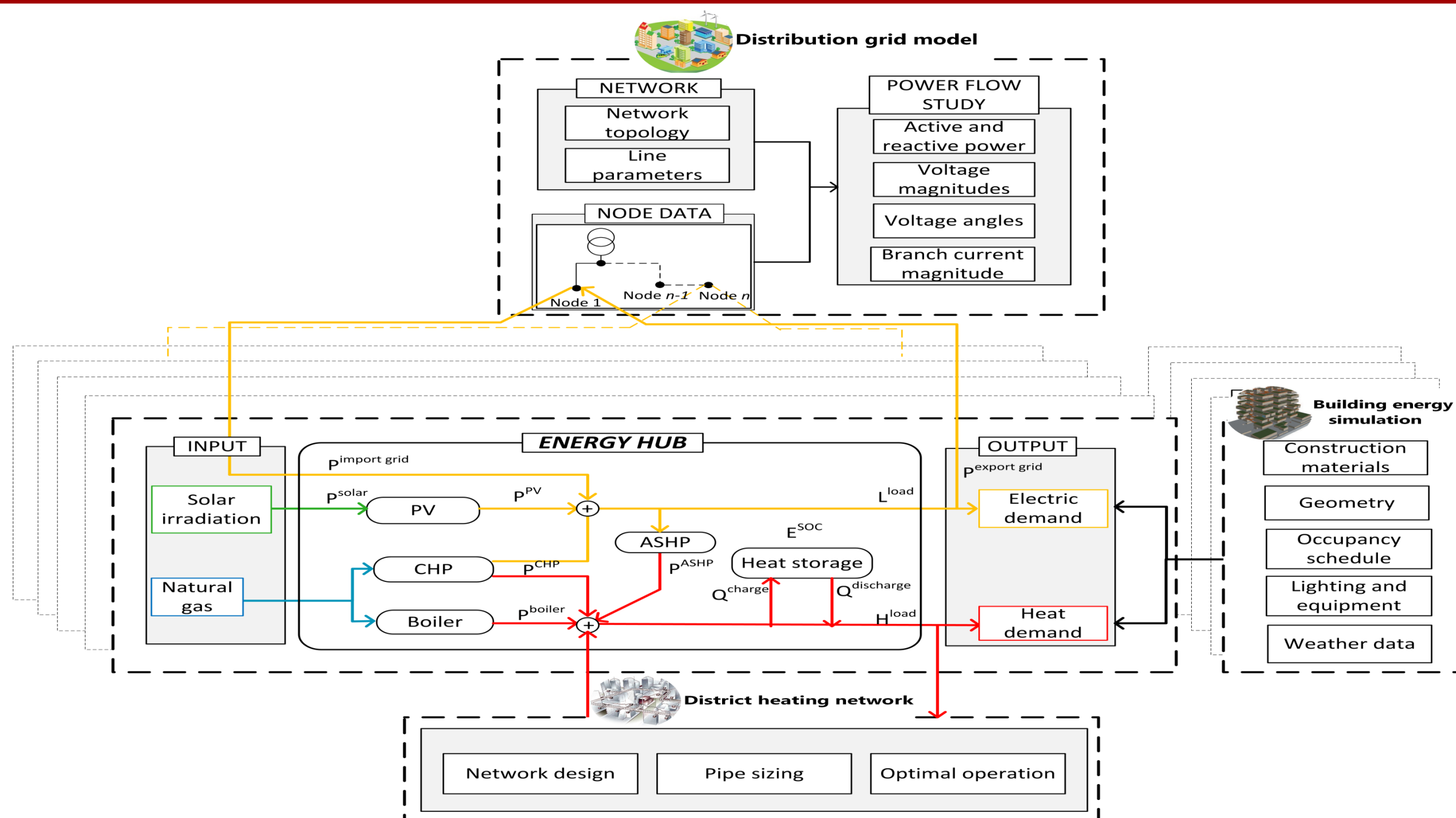
Electrical grid constraints

One challenge is to integrate a large share of renewables, which are inherently intermittent in the existing electrical grid which was designed for centralized generation. Distribution grid stability constraints and congestion management must be taken into account, which requires solving (non-linear power) flow equations.



Three methods for integrating distribution grid constraints

Holistic optimisation framework



Overview of the holistic optimisation framework for the distributed multi energy system

Holistic optimisation models of distributed multi energy systems are needed to explore how existing urban areas can be best transformed into sustainable ones.

The framework developed by this project combines models of distributed energy resources, electrical grids, decentralised district heating networks and building energy systems into one integrated optimisation model in order to find synergistic effects between them.

Models are integrated using the energy hub concept - an approach for defining the conversions and storage of different energy streams.