Demand oriented Modelling of coupled Energy Grids

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Abstract

The ongoing integration of renewable energy sources into the different energy grids is one of the major tasks for the next decades. The overall goal behind this integration is the decarbonisation of the energy consumption in the different structural sectors (industrial, service, residential, mobility). Due to the highly volatile and increasing power input of the renewable energy sources, the need for coupled energy grids and flexibilities is rising.

Especially on the distribution level, the question arises how the different grid designs (electricity, gas, heat) will look like and how these networks are going to connect and interact. To find the ecological and technological optimum, different coupled design options have to be analysed.

To address these questions, different libraries and software tools are available. In general, these tools share one common philosophy. A fixed grid structure is given and forms the basis of the model to which the consumers are connected.

The natural process in the development of cities and districts is that the demand structure is defined by the urban framework and its developing demand and decentralised production. The energy grids have to develop towards these needs and therefore the grid design, connections and interactions are the variables of this adjustment process. The given or designed spatial structure of the settlement delivers the loss relevant lengths between the consumers, producers and the demand density, which are needed for the sizing of pipes, cables and the design of the resulting networks.

The future energy grid will undergo considerable changes through decentralisation, an increasing share of renewable energy supply and sector coupling technologies. In order to investigate the potentials of these technologies and other feasible innovations in grid design, the modelling of energy grids needs to be able to map the existing structure as well as future options. Thus, a modelling philosophy for energy grids should be based upon flexibility to allow the research of multiple configurations of technologies, types of energy supply and grid structures.

In case of energy grids, the network structure, as in routing and connections of pipes and cables to consumers, is not fixed and can change depending on the energy supply strategy and time. For example, it might happen that an energy concept for a district based entirely on decentralised oil heating systems is converted to an energy supply via district heating, PtH or gas heating. In this case the overall grid structures are changed and extended, but the demand structure, as in the distances between consumers and their location, stays constant. Based upon this, the modelling of energy grids only from a standpoint of grid structure with fixed types of pipes and cables, which are derived from the given technologies, is no optimal solution to target research projects regarding the development of future energy grids. The use of such models would make simulations with changing technologies difficult since changes in energy generation can involve a change in grid structure. Instead, modelling based on demand structure is more feasible, since it will usually not undergo modifications with changed technologies or grid structure.

This paper describes the development of a modular approach for modelling and simulation of coupled energy grids within different kinds of settlement structures. One presented thesis is that the spatial distribution of the demand structure is given by the urban framework and should be the origin of the modelling of coupled energy grids on the distribution level. Thus, the logic is that the grid is developing towards the given and developing demand structure and not vice versa.

Following these assumptions, a modular approach was realised by creating a so-called *GridConstructor*. This constructor allows it to easily build user defined urban frameworks and combine them with a single grid or multiple grids (electricity, gas, heat). These grids can be coupled via different systems. In conclusion, first results of coupled grid simulations are presented.

Keywords:

Thermodynamic and energy systems applications, Large-scale system modelling