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Simulation of bidirectional heat transfer stations in district heating grids

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The secondary-side integration of renewable energy into district heating systems can be considered as complex in many cases. The properties of the renewable energy must be considered such as their available temperature level, their performance class and their logistics. Energy management systems that guarantee a system-wide control of district heating systems are already state of the art. However, a bidirectional heat transfer station (for heat supply and uptake) in combination with an intelligent control strategy for the entire district heating system (for new constructions and for existing systems) still has to be developed. Requirements of the primary (e.g. energetic optimization of the heating plant, minimizing distribution losses) and secondary side (e.g. security of supply) must be taken into account.

The simulation model in Matlab/Simulink, consisting of two parts, allows to investigate the bidirectional heat transfer station. The first model part depicts the primary side of the district heating system as detailed as possible, including the central heat source and the heat distribution system. Data from a real-life medium-sized district heating system is used as reference. Measured data based on a minute interval integrated into the model. Among others, a model validation can be carried out using the minimal differential pressure between forerun and return at different points in the grid.

The second part of the model forms the secondary side and is individually set for each prosumer. A solar collector (ordinarily an evacuated tube collector) or waste heat from a commercial refrigeration machine (temperature is increased by a heat pump) serve as decentralized heat source. The model considered multiple layer storages located at different consumers. The integrated layer storage can exchange energy with either the directly at the location of the customer being charged by the decentralized heat source and discharged by the heat output of the corresponding consumer or with the district heating system, where charging and discharging depend on the storage temperature and the prevailing temperatures of the system forerun and return. Additionally, the type of prosumer integration into the system has a decisive influence on the regulation. Therefore, a distinction has to be made between return and forerun riser and an integration of the return to the forerun.

The model of the secondary side can be used to predict the time of heat input (into the district heating system) and the temperature level of this heat. The two model parts allow an energetic and economical investigation of district heating systems with a large number of prosumers. This is enabled by combining the secondary and primary side model. The primary side model receives data on the prosumers' strategy from the secondary side model. Hydraulic problems such as flow reversals can be also investigated.