District Heating – Mathematics Heats Up

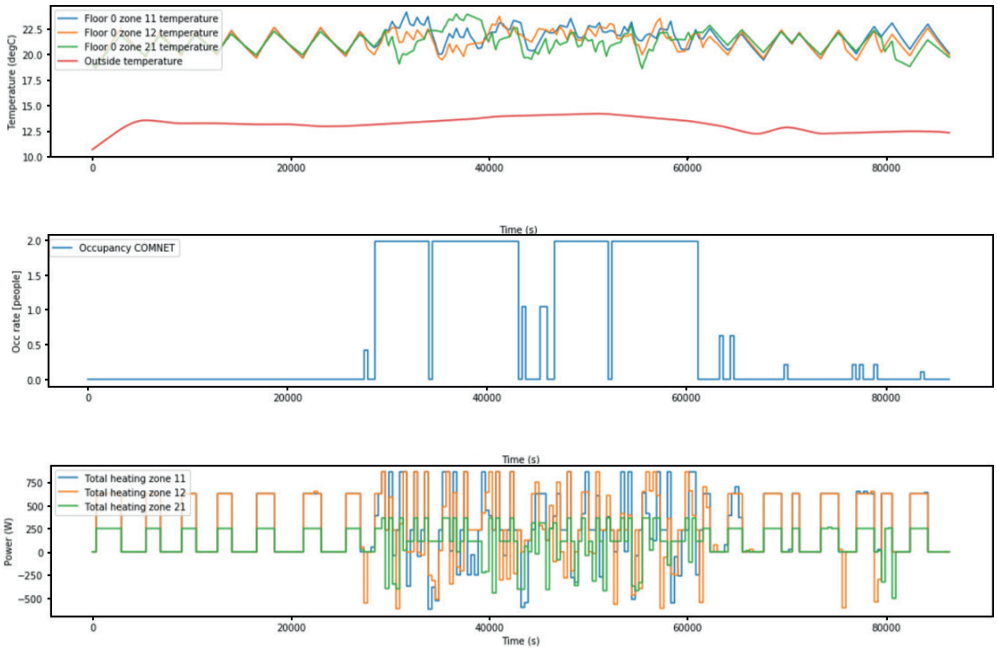
In the "District Heating" project, a team from our "System Analysis, Prognosis and Control" department is working on modeling digital twins of buildings using modern mathematics. Together with the Swedish institute Fraunhofer Chalmers Centre for Industrial Mathematics FCC, the aim is to use simulations to optimize heating with district heating.

73
percent of EU inhabitants live in urban areas.

Currently, heating is a major topic of discussion, especially with regard to the energy transition. In order to be more independent of gas, one hears more and more often that district heating and heat pumps should replace or supplement gas heating. District heating is a centralized heating system. In this system, heat reaches the building via pipelines from a power plant. There is no need for a separate heating system. Centralization allows the use of different energy sources, which are still mostly a mix of natural gas, waste incineration and hard coal. In the future, renewable energies are to be predominant.

District Heating Has Potential

The heating technology is particularly suitable for urban areas and building complexes, because the laying of the networks and the construction of the generation plants pays off when as many people as possible are connected to the district heating network. In 2010, about 73 percent of all 502 million EU inhabitants already lived in urban areas. The potential is therefore great, but district heating still plays a relatively small role. In Germany in particular, not much use is made of the technology compared with the rest of Europe. In Swe-



Simulation results on three levels: Simulated temperature curves of three rooms and outdoor temperature (top), room occupancy in persons (middle), energy gain and loss of the rooms under the district heating consideration (bottom).

den, on the other hand, almost all cities have district heating powered by biomass, and more than 50 percent already run on the central heating solution – and the trend is rising.

European Mathematics Optimized District Heating Technology

No wonder, then, that our Swedish Fraunhofer colleagues are driving research there. In the "District Heating" project, an ITWM team led by Sophie Hertzog has been modeling digital twins of buildings with researchers from Fraunhofer FCC since 2019 in order to optimize district heating technology. "At the beginning, there were very simplified models and we worked, among other things, with Modelica, a modeling language for modeling, simulating, optimizing, and analyzing dynamic systems," the scientist explains. First, various basic properties of the building are included: for example, the size, number of floors, location and orientation, number of windows or building materials. "The digital twin is then supplemented by more complex stochastic input and we consider questions such as: How many people are statistically in this type of building? How do they use the windows for ventilation? Or the blinds for shading? What kind of hot water consumption is there? Which electrical devices radiate heat?" the researcher says.

Currently, a software tool that has been developed is used to forecast heat in buildings in this way. In the future, the focus will then be on energy consumption. In addition, the control of heating systems is also being looked at on the basis of the work. Model predictive controllers (MPC) could then ensure that the amount of energy needed flows depending on the time of day.

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