RESEARCH NEWS

District heating networks

Simulation Tool for Climate-Friendly District Heating Management

District heating networks are growing increasingly complex as a result of feeding in renewable energy and the trend toward decentralization. In the AD Net Heat project, Fraunhofer researchers are simulating heat flows throughout the entire network, predicting load peaks and helping to plan new grids.

Municipal utility companies and heat suppliers are supposed to shift their district heating networks to CO_2-free operation in the next few years. But grid fluctuations caused by feeding in renewable energy and the increasing decentralization of these networks are making it harder to manage them efficiently.

Fraunhofer researchers have developed a simulation software tool called AD Net Heat that simulates and visualizes the heat flows in the network. "This allows us to make predictions about heat flows and demand at consumption points during live operation. Municipal utility companies and energy suppliers can use this data to observe and manage the network, with all its various dynamics, in real time. Peak loads at different times of day are also detected and balanced out early on," explains Dr. Matthias Eimer from the Fraunhofer Institute for Industrial Mathematics ITWM. This makes the district heating network more stable overall, and daily operation becomes more efficient and economical.

Control of district heating networks in real time

The Fraunhofer researchers have developed a digital twin of the physical grid. Fundamental information such as grid topology, the lengths and cross-sections of pipes and the number and position of feed-in and consumption points flow into the model. Aspects such as weather data, sunlight exposure and the typical consumption profile at certain times of the day and year are also factored in. Actual or planned feed-in data such as flow temperature and feed-in power are also specified. On this basis, AD Net Heat simulates the dynamics of the network as a whole, supplies key indicators relating to points on the outskirts of the network — typically problem sites — and provides warnings of critical operating states. It is also possible to optimize grid control and send the information back to the control center.

Thanks to the direct modeling of physical processes, the digital twin needs only a minimal number of sensors. The sensors are used only to calibrate unknown parameters, such as pipe properties that no longer align with the original condition due to aging processes. Additional sensors can then be used to validate simulation results.

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The digital twin offers multiple advantages for operators of heating networks and municipal utility companies. Optimized operation means, in many cases, there is no need to tap into additional energy sources that are very expensive at the time due to fluctuations in electricity prices. Beyond that, the flow temperature can be lowered, for example, in order to reduce unnecessary energy losses — without jeopardizing the reliability of the supply.

Large events taking place in the community, such as a concert or trade show requiring heat to be supplied to large indoor spaces, are also incorporated into the operational planning. After the recipient's location and the estimated demand for heat are entered, the software simulates the transportation of heat and outputs its consumption forecasts in response.

Help with planning new grids

But that is not all; the software solution also helps with planning and commissioning new grids. If the topology of a grid is defined, including the feed-in points for fluctuating energy sources such as solar heat and industrial waste heat, the software tool calculates the distribution of heat flows and the expected consumption. Planning firms run through a whole range of different scenarios for this, such as consumption at different times of the day or year, differences in the placement of generators and structural changes such as new transportation lines.

"By doing this, municipal utility companies and district heating suppliers are taking a big step toward a climate-neutral heat supply that conserves resources. They are also lowering their costs. There are two reasons for this. First, simulation in the digital twin allows for maximum use of renewable energy sources at the times when they are available. And second, the heat demand forecasts are very accurate and reliable. This makes it possible to design the pipe cross-sections to be a bit smaller, which saves materials," says Eimer.

The Fraunhofer researchers are currently working to make the user interface of AD Net Heat even simpler and clearer for users at heat suppliers and planning firms.

Since the calculation core is fundamentally designed to work with all network types, the simulation feature could also be used in the future for different energy grids such as those that transport electricity or gas.

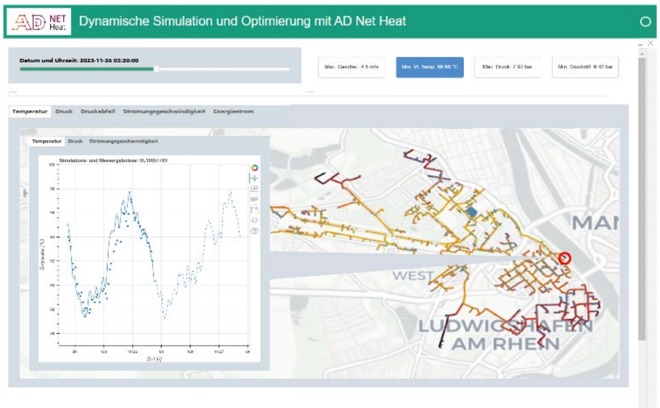

Fig. 1 The graphical user interface displays the current temperature and pressure conditions in the network. For each node, the chronological data can be shown in both the history and the forecast, and, if needed, compared with measurements.

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Fig. 2 Dr. Matthias Eimer and Johanna Heidrich, along with a team of researchers, developed the AD Net Heat software. The software simulates heat flows within the district heating network.

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