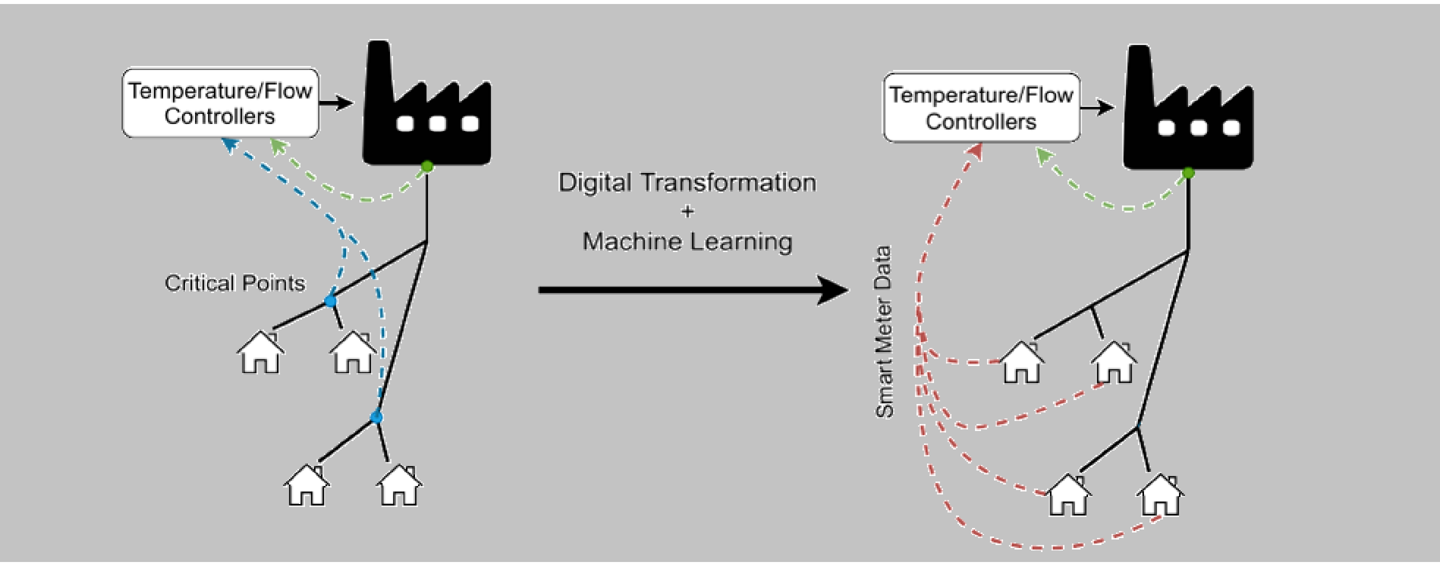

Data-Driven Methods for Efficient Operation of District Heating Systems

As part of the HEAT4.0-project's effort to obtain cheap and sustainable district heating using digitalization, progress has been achieved in heat load forecasts and in operation of the district heating system.

The operation of district heating systems is driven by the user's demand for heating. Heat load forecasts are used as input for production planning as well as for controlling the supply temperature at the plants and the temperature in the distribution system. In HEAT 4.0 new methods have been developed both for heat load forecasting and for controlling the temperature in the network; this is often called temperature optimization. An efficient operation of the future weather-driven energy systems calls for flexibility, and district heating can provide essential elements of the needed flexibility. Data-driven tools efficient and flexible operations of district heating systems are developed, and some of these tools take advantage of the frequent meter readings available today.

Head Demand Forecasting

A key aspect of heat demand, is its dependency on the weather conditions. It is well-know that meteorological forecasts are tuned for rural areas. As input for providing accurate load forecasts, we have used the tool MetFor, which utilizes multiple weather models as input, and combine these weather forecasts with one or more local weather stations in the city. This provides better and more accurate forecast for the specific location, and for cities this is very important. In a case study in Tingbjerg, Denmark it has been documented that the higher accuracy alone gave a possibility for lowering the supply temperature with 5 °C.

Furthermore, a tool for providing coherent short-term and long-term forecasts has been developed. In a joint effort with Varmelast in Copenhagen it has been shown that the accuracy of forecasts was improved with 15-20%.

Temperature Control

District heating is operated by changing the supply temperature and the flow by differential pressure. Typically, the supply temperature selected as a function of the ambient air temperature. All other factors solar radiation and wind speed as well as user profiles are not considered, and hence this tends to be conservative (supply temperature too high). Consequently, in HEAT 4.0 a state-of-the-art temperature optimization using Heat TO was used to demonstrate savings by using data-driven methods when controlling the supply temperature of the network. In HEAT 4.0 new methods for using meter data (see the figure above) for temperature optimization have been developed. With the data-driven approaches this gives unique possibilities for operating with temperature zones, and hence better possibilities for included e.g., heat pumps.

The temperature control relies on knowing the network temperatures in the system; typical measured at it's critical points, and reference curves at these points.
As critical point change over time, a new approach were developed based on a group of house smart-meters, which allows for time-varying temperature zones.

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NIRAS (project manager), Dansk Fjernvarme, Brønderslev Forsyning, Trefor Varme, Hillerød Forsyning, Danfoss, Kingspan/Logstor, EMD International, Enfor, Neogrid Technologies, Leanheat (Finland), NorthQ, Kamstrup, DESMI, Center Denmark, DTU, and Aarhus University.

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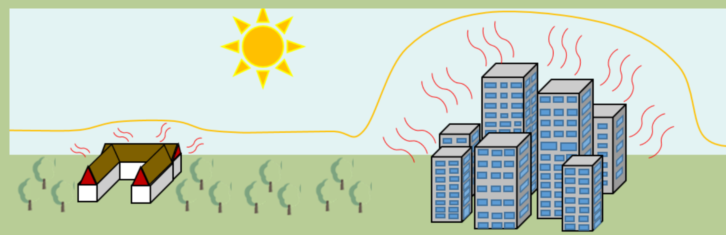
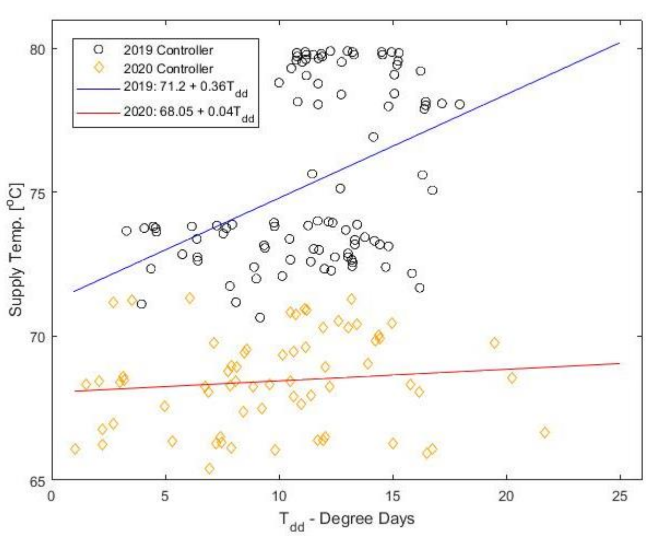
Heat Forecasting and Weather in a City Environment

As heat demand is strongly depending on the weather, making a forecast requires knowing important weather variables: **Air temperature, solar radiation, wind speed and direction**. A heat demand forecast is a modelling of the relation between these variables, while at the same time accounting for daily and seasonal heat patterns.

As standard meteorological weather forecasts are designed for rural areas, there can be a significant difference in urban areas and cities. The urban air temperature is affected by the human activities and buildings. Using local climate stations, the weather forecasts can be adjusted to weather in cities.





More about HEAT 4.0

- Innovation Fund Denmark's investment: DKK 25 million
- Total budget: DKK 36 million
- Duration: 3 years
- Official project title: HEAT 4.0 – Digitally Supported Smart District Heating

In HEAT 4.0 the state-of-the-art temperature optimization has been implemented in Brønderslev, Denmark. The results have been a lower supply temperature. The supply temperature with the new controller is 4-7°C lower. In Svebølle-Viskinge, a similar system has been installed. Here the temperature was lowered with approx. 12°C.

Methods for adaptive forecasts based on temporal hierarchies haven been developed. Hierarchical forecasting led to improve heat demand forecast accuracy. Using hierarchy of temporal heat demand forecast, we were able to demonstrate around 15% less uncertainty for the operational forecasts. Another study demonstrated the potential using spatial hierarchies

The developed data-driven methods are implemented in HeatFor (Heat load forecasting) and HeatTO (temperature optimization). The methods have a built-in autotuning, which implies that the system will automatically calibrate to changes of the network and at the end-users. The system will also automatically account for changing moisture content of the soil surrounding the pipes. At TREFOR they used previously a simulation-driven approach, and the conclusion is that the new data-driven approach are much easier to maintain, and lead to additional temperature savings.

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