Abstract

- Utilizing simplified static models of different types of consumers in a district heating and cooling (DHC) network is used to design a new control approach that will guide the operators to optimally control the network in different operational scenarios. The new control approach enables:
  - energy consumption minimization
  - economic operation,
  - peak load reduction/shifting, and
  - environmentally friendly operation.

- A full-scale dynamic simulation of the DHC network in Luleå, Sweden is used to evaluate the approach. The presented test case represents a typical medium size DHC network.

The District Heating and Cooling Network

Main Components
- Sources (heat or cold generation)
- Pumping stations
- Distribution piping network.
- Consumers

Traditional Control Structure

- The differential pressure at certain points in the network is controlled by adjusting the pumps speed.
- The supply water temperature is usually a function of the outdoor temperature, measured somewhere in the network. Adjusting the heat or cold generation level is used to achieve the required supply water temperature.

Drawbacks

- The consumer might not get the required heat (or cold) in time due to the transport phenomena that might take hours or when the plant is affected by disturbances.
- The supply temperature need to be kept higher than needed to overcome sudden rise/drop in the outdoor temperature.
- The current generation will only depend on the current local temperature.

Proposed Approach

- Considering different categories of consumers, a consumer model is developed that can predict the instantaneous energy consumed in the network for a given time and outdoor temperature (Static model for consumption).
- Calculate the average network losses and predict the possible production that will meet this demand under steady state operation (Static model for generation).
- Find a lower supply temperature curve and define it as a base temperature curve that can operate the system under steady state operation.
- Using the generation model, determine the generation for the next hours using an accurate weather forecast. The forecast horizon will depend on the size of the network and the transport delays in the system.
- Determine the forecasted change in the production power. Based on this change, calculate the amount of energy required to be stored/retrieved in/from the network (the water).
- Based on the total volume, calculate the required increase/decrease in the water temperature that will achieve this change, taking into consideration the circulation of water and the amount of the flow at the power production unit. Accordingly, adjust the base supply temperature.

Simulation

- **OPTi Forecaster** A consumer model was developed based on a six categories of clients. Moreover, a similar production model was developed.

- **OPTi Curve** Reduce the Standard curve by an overall 2°C. Based on the forecast, calculate the change in the production hour over the future horizon (in this case 6 hours) and adjust the base curve. The figure below show the case for a real historical case when the temp rapidly changed from 0 to -28°C. The new curve shows an average reduction of 1.25°C.

- **OPTi Sim** Using the OPTi-Sim (the digital twin of Luleå city DHC network), the standard curve and the OPTi curve were compared. The OPTi-curve shows a reduced average production power of around 1.5 MW and also reduces several peak instances. Field trials will be conducted in the near future to validate the new control approach.

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