CITIES
Centre for IT Intelligent Energy Systems

Optimization under uncertainty of heat and power production in district heating systems

Objective

The objective of this CITIES demonstration project is to develop an optimisation method for the heat and power production planning in district heating systems and apply it to a real-world demo-case. The special focus of the demo project lies on the appropriate consideration of uncertainty at the time of planning, e.g., uncertain heat demand and uncertain production of non-dispatchable units like solar collectors.

The demo-case consists of a district heating company operating different types of units to supply the heat demand. The system includes thermal storage(s) and is directly connected to the district heating network. In addition, the participation of the district heating company in the electricity market is considered. The latter one is important, if the company has a combined heat and power (CHP) plant (generating heat and power at the same time) from which power can be sold to the market.

The optimization method developed in this demo project aims at scheduling the production for all units in the considered demo-case system taking the uncertain factors into account. Furthermore, the method allows to determine the optimal amount of power to be offered in the electricity market as well as the optimal bidding price considering uncertainty in the system.

Partners

- EMD International
- Hvide Sande Fjernvarme
- DTU (CITIES WP 7 and WP 5)

Background

The primary goal of a district heating company is to cover the heat demand at lowest possible cost using the different installed production technologies, e.g., gas boilers, electric boilers, solar collectors, heat pumps and/or combined heat and power (CHP) plants. Additionally, in the presence of a CHP plant, the company can obtain additional profits by offering produced power to the electricity market. An offer consists of the amount of power and the market bidding price. Both have to be determined before actual production takes place (e.g. at noon the day before for the day-ahead market).

When considering such a system, challenging trade-offs and dependencies appear:

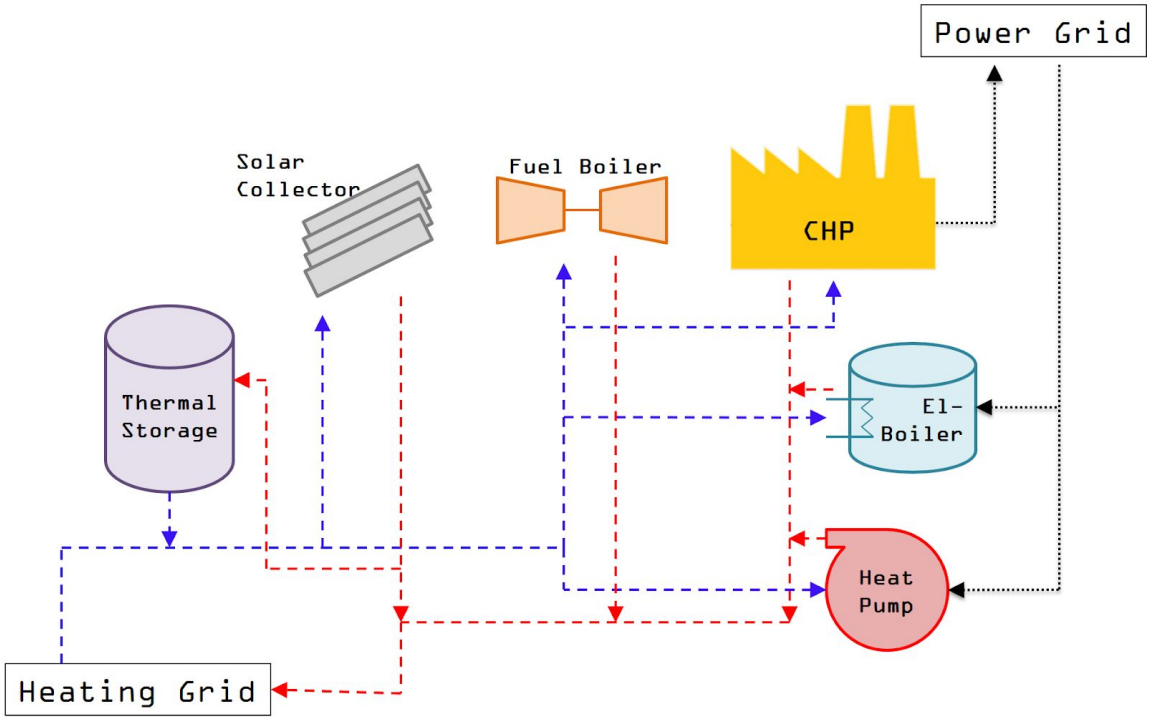
1. In general, the cogeneration of heat and power from CHP plants is more expensive and less efficient for producing heat (which is still the main goal). However, when considering selling electricity, the income can be subtracted from heat production costs and it may become profitable to use CHP plants.
2. Another possibility is producing heat by heat-only units. But even for those heat production cost fluctuate over time, e.g., if the operation costs depend on electricity prices.
3. Additionally, many systems contain thermal storages to store produced heat for a certain amount of time. In this case, decisions regarding the filling and discharging of the storage must be made.

Therefore, our method has to model the interplay of the production units, storages and market, make reasonable decisions using the flexibility and account for the uncertainty at the point of planning.

Connection with CITIES WP’s

WP7: Optimisation method and solution method
WP5: Forecasting

Description



All installed units at a district heating company can be scheduled in a joint optimisation framework, because they are operated by one company. The economic goal is to reduce the cost of producing heat while covering the heat demand. Therefore, decisions regarding the production of each unit have to be made, i.e., when to produce how much with each unit. In the case of a CHP plant, additionally the amount of power and price offered to the electricity market has to be decided.

This demo project aims at providing an optimisation method explicitly addressing the uncertainties while scheduling the production. Therefore, we will include uncertainties like heat demand and production by solar thermal units. We will address the planning with a stochastic programming approach. This concept has been shown successful for handling uncertainties explicitly in optimisation. The method includes different future scenarios that are based on forecasting methods. By including reasonable scenarios, the expected costs in many applications could be reduced.

Furthermore, our model has to include technical characteristics of the producing units (e.g. production capacities, efficiency, minimum up-and down times) and storage(s) (e.g. limitations) to have a realistic representation of the demo-case. The different units are considered connected to enable our method to model flows of heat and electricity between units and from/to the district heating network and power grid, respectively.

To evaluate our solution approach, the optimization method will be applied to a specific real-world demo case over a period of time. The results will be compared to already present deterministic optimisation methods (neglecting the uncertainty by assuming only one future scenario).

Expected outcomes

There are two expected outcomes of this demo project:

1. We propose an optimisation method to support managers of district heating companies with their daily operation decisions.
2. Based on our method, we will perform different analyses to gain new insights for the decision-making process of district heating companies. Relevant questions are, e.g., what is the gain from considering uncertainty explicitly in the optimization compared to neglecting it?

Time schedule

July 2017 to June 2019

Contact

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