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Operational planning and bidding for district heating systems

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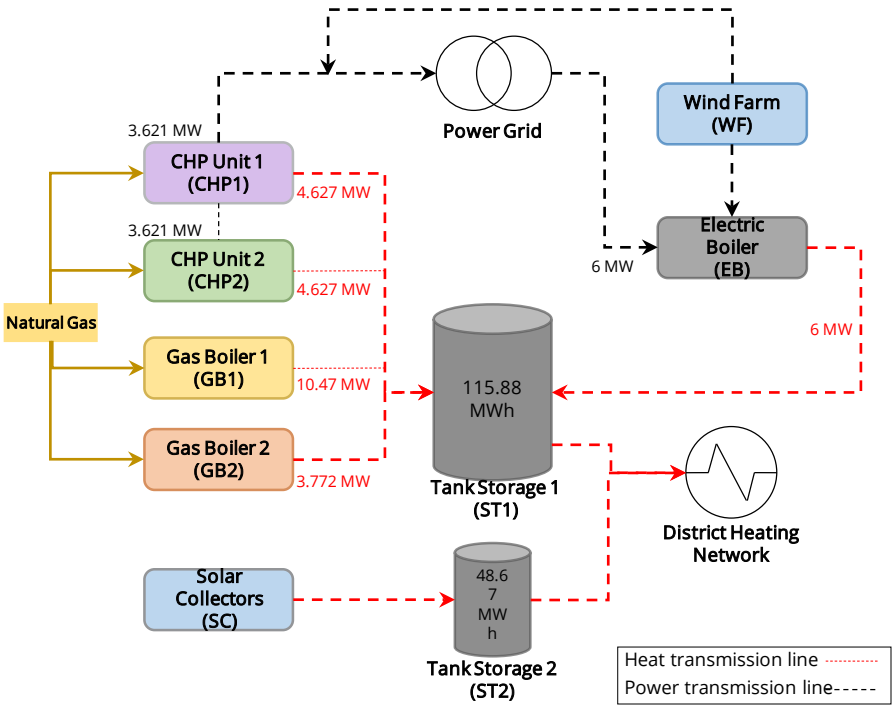
Introduction

In countries with an extended use of district heating (DH), the integrated operation of DH and power systems can **increase the flexibility** of the power system and achieve a higher integration of renewable energy sources (RES). DH operators can not only provide flexibility to the power system by **acting on the electricity market**, but also profit from the situation to lower the overall system cost.



System setup of our case study

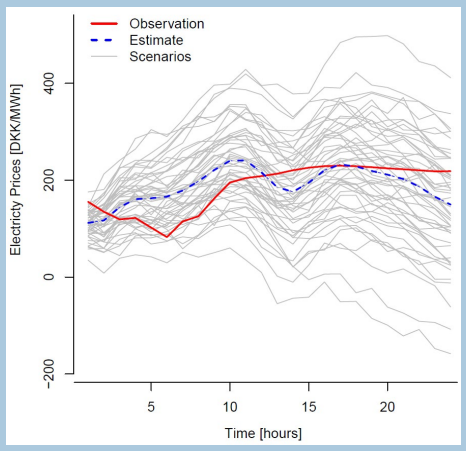
However, the **operational planning and bidding** includes several **uncertain** components at the time of planning: electricity prices as well as heat and power production from RES.

We propose a **planning method** that supports DH operators by scheduling the production and creating bids for the day-ahead and balancing electricity markets. The method is based on stochastic programming and extends bidding strategies for virtual power plants to the DH application. The uncertain factors are considered explicitly through scenario generation. We apply our solution approach to a real case study in Denmark and perform an extensive analysis of the production and trading behaviour of the DH system.

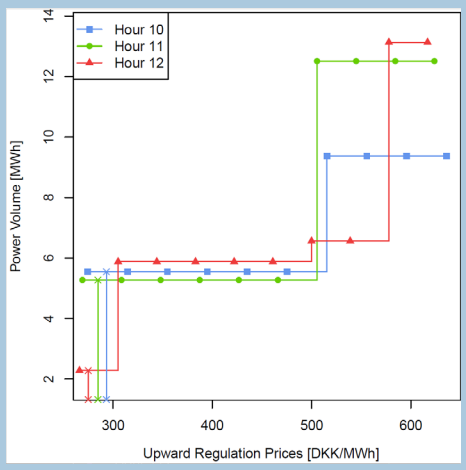
Solution approach

To create bidding curves for the day-ahead and balancing electricity markets, we extend the method of [1] to a district heating context. We use a two-stage stochastic program with scenarios for the uncertainties (electricity prices, RES production). The decisions are the bidding amounts to the market (first-stage decisions) and the power and heat production amounts (second-stage decisions). We get multiple pairs of production amounts and electricity prices, because we obtain solutions for several scenarios of electricity prices. These can be consolidated to a bidding curve for the market.

The models for day-ahead market and balancing markets are similar, but differ in the time horizon and already fixed decisions.
We use the method for extensive analyses of the production and bidding behaviour of DH operators on day-ahead and balancing markets.



Example: Electricity price scenarios



Example: Bidding curves

Key findings

- Electricity price and wind power production uncertainty have a large effect on the solution of the system, while uncertainty of the solar thermal production has a minor effect due to the large thermal storages.
- Including the balancing market into the solution approach improves the overall system behaviour, i.e., trading on the balancing market results in additional profits.
- Due to their flexibility and coupling to the market, electric boilers are an important technology for DH operators to earn from regulating power markets.
- The consideration of the DH system as one portfolio of units in the optimization increases the flexibility and reduces the costs.

[1] Pandžic, H.; Morales, J.M.; Conejo, A.J.; Kuzle, I. Offering model for a virtual power plant based on stochastic programming. Appl. Energy 2013, 105

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