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Optimisation-based bidding and scheduling in district heating

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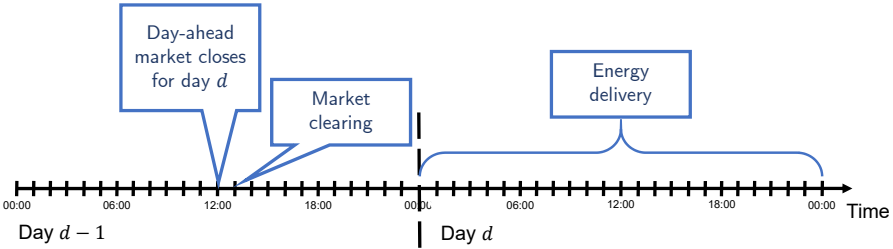
Introduction

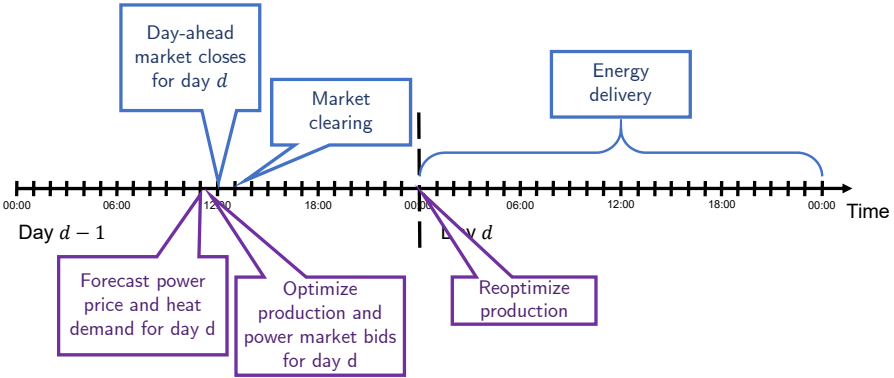
Operational optimization and bidding for district heating companies

- Production scheduling of all units
- Create hourly and block bids for CHP units for the day-ahead market
- Collaboration with EMD International A/S
- Started in the CITIES project

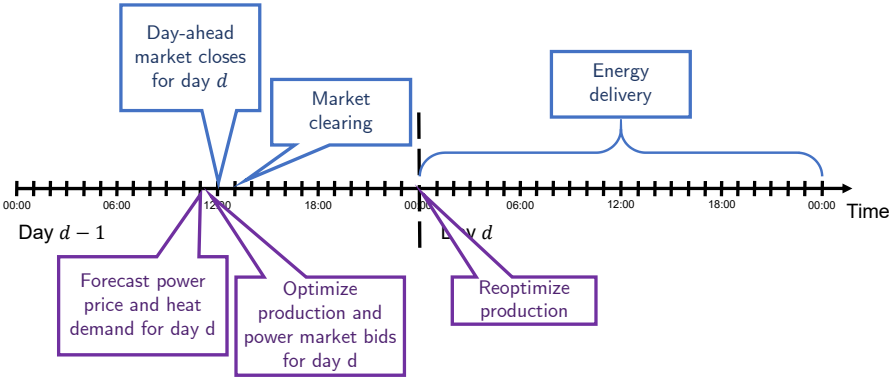
Optimisation and market interaction



Optimisation and market interaction



Optimisation and market interaction



Research goal: Develop a methodology for automated optimization and bidding

- reduce the heat production costs
- utilise synergy effects of heat and power sectors

Research

Bidding methods for CHP units in literature:
[Conejo et al., 2002, Rodriguez and Anders, 2004, Schulz et al., 2016, Dimoulkas and Amelin, 2014, Ravn et al., 2004]

- Take a power producer perspective
- Bidding based on electricity price forecast

Research

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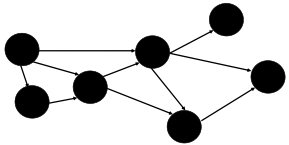
Our approach: Bidding amount and prices based on heat production

- **H**eat **U**nit **R**eplacement **B**idding (HURB) method [Blanco et al., 2019] (CITIES)
- Stochastic program considering renewable production [Blanco et al., 2018] (CITIES)
- Block bidding based on stochastic programming [Schledorn et al., 2021] (HEAT 4.0)
- Operational scheduling and bidding for simplified Brønderslev system [Guericke et al., 2022] (Heat 4.0)

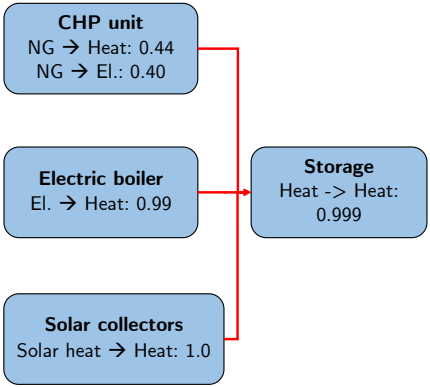
New features of the optimization

Generic stochastic network-flow based formulation of the energy flows in the district heating network

- Based on vertices and arcs
- Generic energy flows (heat, electricity, solar heat, process heat, gas, ...)
- Energy sources and demands sites with output and input requirements, respectively
- Units, storage and connections between networks are vertices with transformation factors
- Units can have additional constraints such as dependencies, up times, down times, exclusion



Network representation



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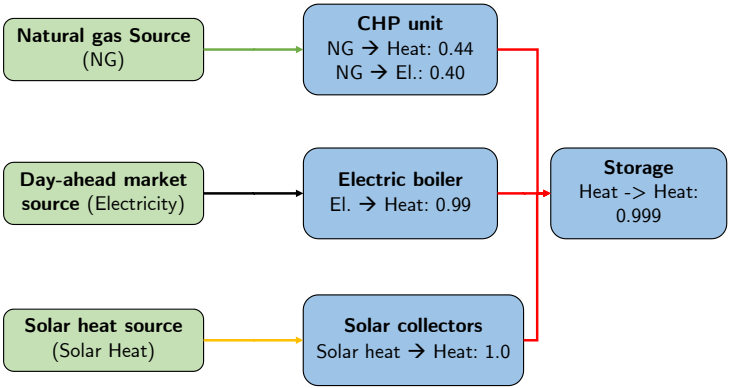

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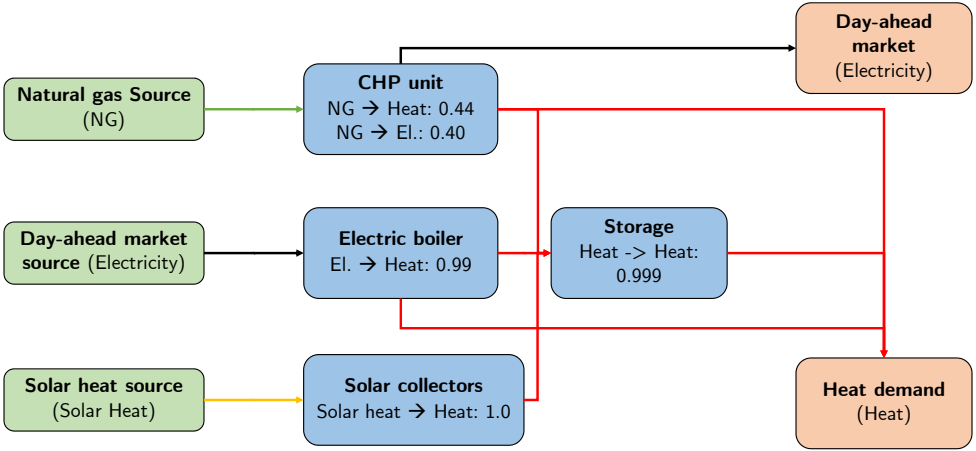

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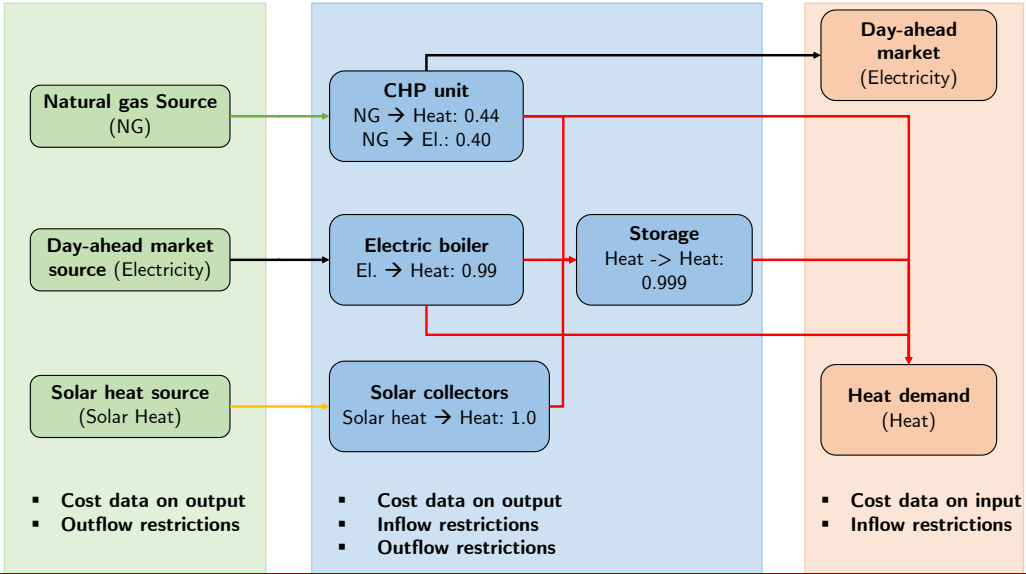

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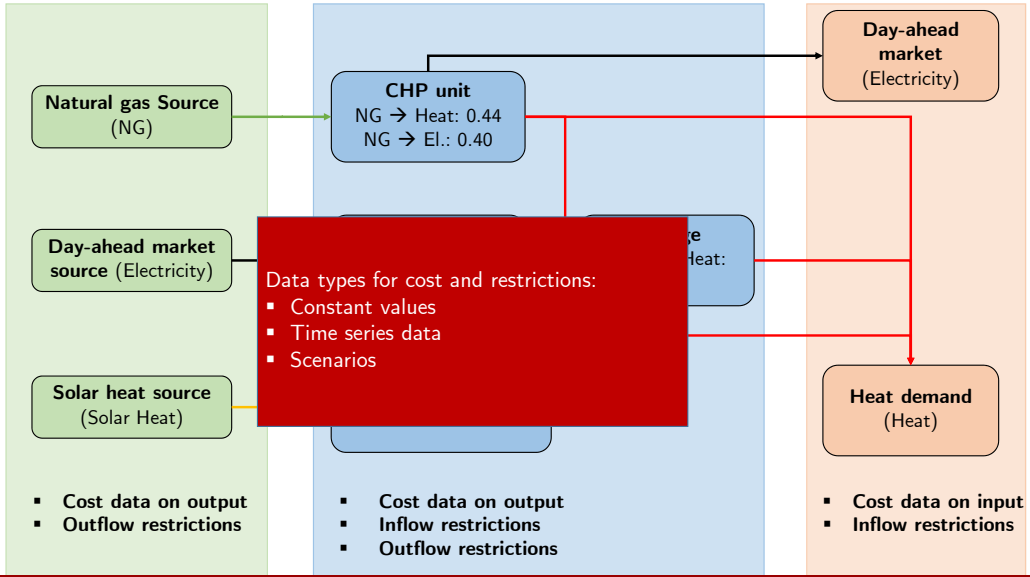
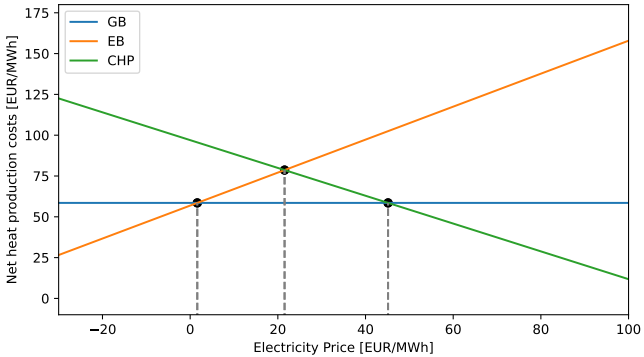


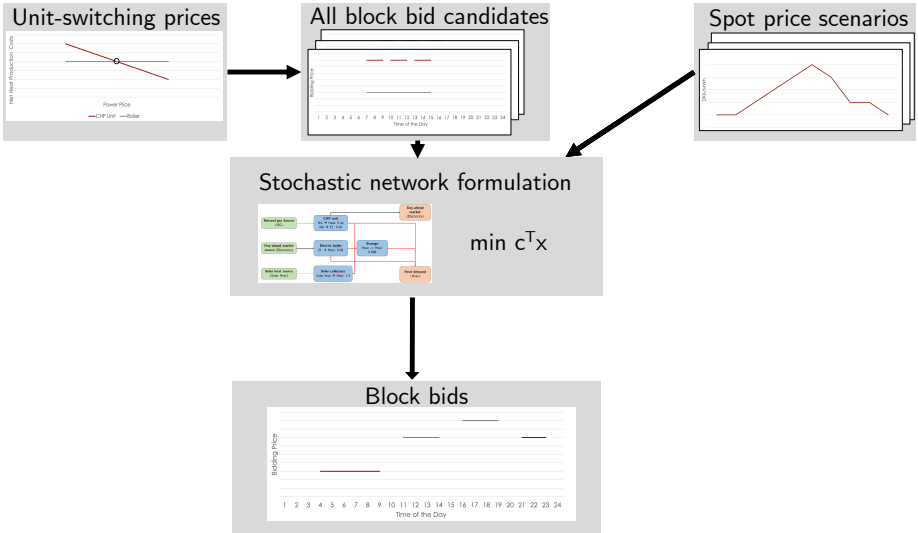
Bid generation

- Bidding prices are unit-switching prices, i.e, at which electricity price does the CHP unit get cheaper than another unit
- Comparison of cost for producing 1 MWh-heat using network model



- Full capacity of CHP units

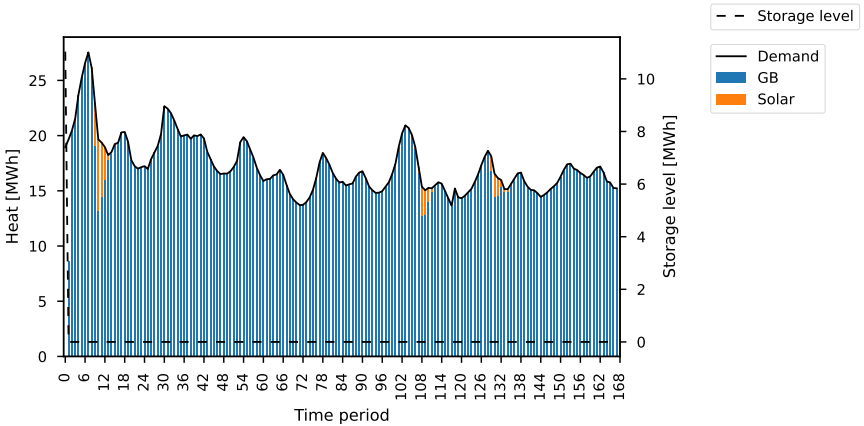
Block bidding [Schledorn et al., 2021]



Illustrative case study on simplified Brønderslev system [Guericke et al., 2022]

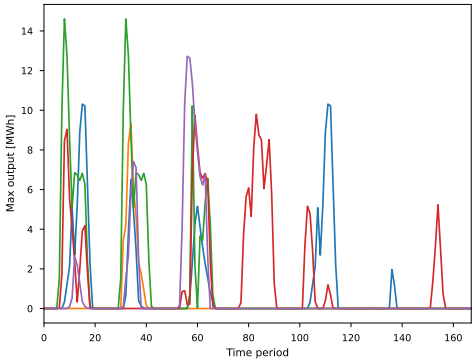
- Historical Science Cloud data (1 week in October 2020)
- Market-independent units: boiler (natural gas); solar thermal unit
- Market-dependent units: 7 CHP units (natural gas), boiler (electric)
- Optimization for 7 days in rolling horizon manner
- 2 cases: with and without day-ahead market bidding (no balancing/special regulation markets)

Preliminary results (no day-ahead market bidding)

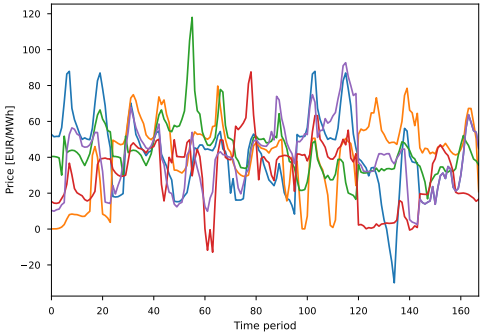


Uncertain data across 5 scenarios

Solar heat:

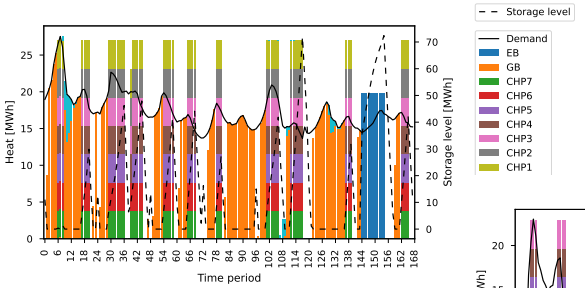


Day-ahead prices:

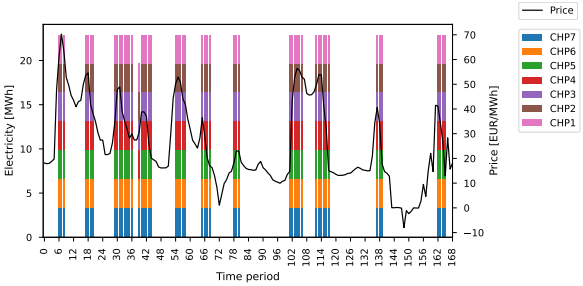


Preliminary results (with day-ahead market bidding)

Heat production:



Electricity production:



Summary and outlook

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- Generic method for different district heating systems modelling arbitrary energy carriers
- Integration of scheduling and electricity market bidding under uncertainty
- Applied to historical data from Brønderslev (and Hillerød)

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Work in progress

- Application of model to full Brønderslev and Hillerød systems
- Integration of hourly bids
- Analysis of system flexibility (cross-system optimisation with EMD, Enfor, Neogrid)

Thank you for your attention.

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