Mixed-integer model predictive control of district heating networks

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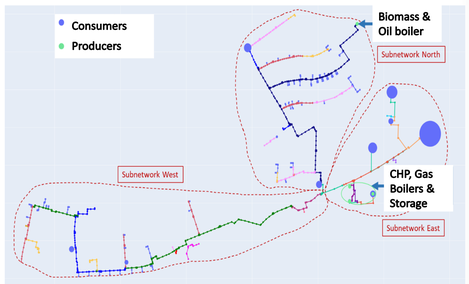
Introduction

Increased complexity in DHNs:

- Many producing units
- Large share of renewables
- Rule-based on/off policy designed “by hand” may not be feasible

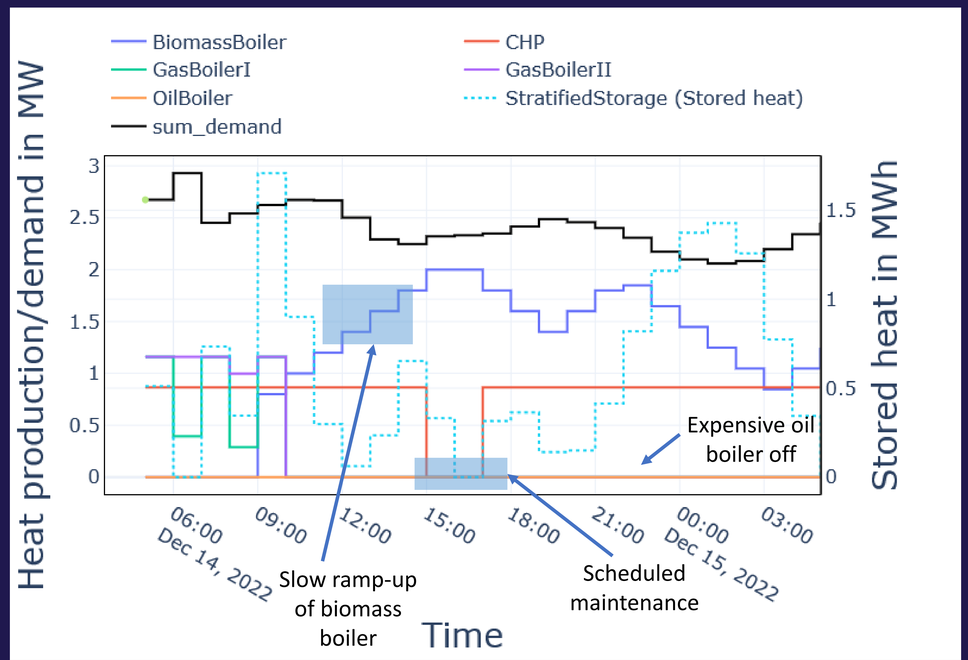


Network structure Weil am Rhein

Approach and use-cases

- MPC: solve every sampling time an optimal control problem (OCP)
- OCP is a mixed-integer linear program (MILP)
- Use AI-based weather forecast developed within **WOpS**[1]
- Three demonstration networks including Weil am Rhein[2]: 74 consumers, five producers, one heat storage (6.5 MWh)

Mixed-integer MPC enables optimal operation of complex district heating networks with a **large share of renewables**



MPC control strategy for a district heating network over 24 hours

Center for Renewable Energy
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Problem formulation

MPC - solve every 15 minutes an MILP:

$$\begin{aligned} \min_{z} \quad & c^\top z \\ \text{s.t.} \quad & Az = b \\ & Cz \geq d \\ & z = (x, y) \in \mathbb{R}^n \times \{0,1\}^m \end{aligned}$$

Objective:

- Minimize production costs and CO_2 emission

Constraints:

- Energy conservation in the network
- Min. on and off times of production units
- Ramp-up, and ramp-down behavior of the production units
- Hardware limits: capacity, temperatures, power output

Current developments

- Run tests in Weil am Rhein during the heating season
- Extensive comparison to historical data and existing control strategies
- Extension to mixed-integer nonlinear programming models (MINLP)
- MPC-tailored MINLP solution methods

[1] Wärmefluss-Optimierung zur Sektorkopplung, BMWK, 03EN3054-A

[2] Zoschke, T., Schmidt-Engelbertz, L., Wolff, C., Nurkanović, A., Pineau, C., Lyons, Q., Frison, L., Rohbogner, G., Weiß, D., Diehl, M., Oliva, A. (2023). "Production Optimization of an Existing District Heating Network with Multiple Heat Producers." In: Proceedings of the 18th International Symposium on District Heating and Cooling, September 3–6, 2023, Beijing, China.