## universitätfreiburg

### Master Thesis Proposal – ESE/Math/SEE/MST

# Nonlinear Mixed-Integer MPC for District Heating Networks

District Heating Networks (DHNs) are a key technology for sustainable urban energy systems. Their efficient and cost-effective operation requires advanced control methods. This thesis focuses on the development and implementation of a Nonlinear Model Predictive Control (MPC) approach for DHNs, incorporating both nonlinear dynamics and discrete decision variables. The dynamics arise from spatial discretization of the heat transport equations, and the discrete nature stems from the on/off behavior of multiple producers. The resulting control problem is a Mixed-Integer Nonlinear Program (MINLP) with complementarity constraints. Emphasis is placed on algorithmic improvements such as warm-starting using previous integer solutions, problem-specific cuts, and refinement of the network model. The CAMINO toolbox [2] will be used to implement and solve the resulting optimization problems.

This work is part of the WOpS research project [3], and the results of the thesis will directly be tested in the DHN in Weil am Rhein—offering students a unique opportunity to **contribute to immediate practical impact**.



Fig. 1. The DHN of Weil am Rhein (left), the temperature inside each supply pipe in the DHN (right) [1].

**Master topic:** The aim of this master thesis is to improve and extend an existing Nonlinear Mixed-Integer MPC scheme for DHNs that can be solved reliably and efficiently in real time, enabling deployment in actual city-scale systems. A special focus lies on algorithmic enhancements such as warm-starting using previously computed integer decisions and incorporating problem-specific cuts to accelerate the solution process.

**Your skills**: A strong background in control and optimization as well as programming skills (Python/CasADi) are necessary.

**Supervisors and contacts:** Dr. Armin Nurkanović, Andrea Ghezzi, Prof. Dr. Moritz Diehl. Contact: <armin.nurkanovic@imtek.uni-freiburg.de>. Please send your transcript of records and a CV.

[1] Matthias Gramlich "Mixed-Integer Nonlinear Predictive Control for District Heating Networks". Master Thesis, University of Freiburg, 2025

[2] https://github.com/minlp-toolbox/CAMINO

[3] https://www.ise.fraunhofer.de/de/forschungsprojekte/wops.html

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