Dynamic Simulation of a Decentralized District Heating System Using Modelica

Background

The decarbonization of heat supply is a critical goal for achieving sustainable energy systems. As one district heating network in Southern Germany transitions from centralized coal-based heat generation to a decentralized, renewable energy structure, new challenges arise. These include fluctuations in heat supply from various sources, such as biomass and large-scale heat pumps, which may lead to dynamic hydraulic issues like flow reversals and pressure imbalances.

In this thesis, dynamic simulations will be used to analyze these challenges, with the goal of ensuring stable and efficient operation of the decentralized heat network.

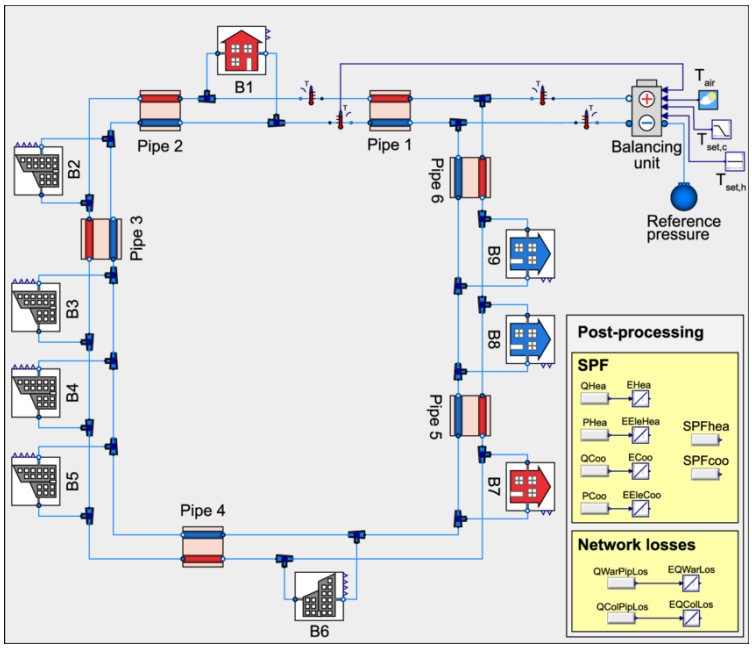

Figure 1: Exemplary simulation model for the design and analysis of district systems in Dymola [Research Gate]

Topic

The student will focus on simulating the dynamic behavior of the heating network under critical conditions using Modelica. The student will model various extreme operational scenarios, evaluate potential system failures or inefficiencies, and recommend adjustments to operational strategies and system configurations.

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The topic comprises the following **tasks**:

- **Familiarization with Modelica and the district heating system under consideration**
  - Understand the current network setup, focusing on critical thermohydraulic parameters.
  - Review existing work and tools developed in previous work
- **Developing the dynamic simulation models**:
  - Use Modelica/Dymola to model the heating system under varying operational conditions, focusing on hydraulic challenges such as flow reversals, pressure imbalances, and potential local fluid stagnation.
- **Simulating critical operating scenarios**:
  - Simulate scenarios based on potential extreme conditions identified in previous work packages, such as peak demand periods or fluctuating renewable heat inputs.
  - Model interactions between decentralized heat sources (such as heat pumps and biomass plants) and the district heating network to identify operational risks.
- **Analyzing and interpreting results**:
  - Assess the dynamic behavior of the system, including hydraulic performance, stability of mass flows, and potential risks for system failure.
  - Provide recommendations for adjustments to the system design or control strategies, such as optimized pumping strategies or the placement of additional storage solutions.
- **Documentation and presentation**:
  - Write a documentation on the modeling process, assumptions, results, and recommendations.
  - Present findings to the project team and integrate feedback into the final document.