Munich Institute of Integrated Materials,
Energy and Process Engineering (MEP)
Technische Universität München

RESEARCH INTERNSHIP / MASTER THESIS

Smart Control in Thermal Networks: Leveraging Reinforcement Learning for Bidirectional Substation Operation

Background

The decarbonization of the heat sector poses a central challenge for the future energy supply. Innovative district heating concepts can play a key role by enabling the integration of diverse and sustainablef heat sources, efficiently utilizing synergies among network participants, and providing increased flexibility for the entire energy supply through coupling with the electrical grid. At our institute, we are researching the technical implementation and control of such innovative district heating networks. Our approach is twofold: on one hand, we conduct theoretical investigations based on modeling, simulations, and optimization; on the other hand, we carry out practical ex-periments in a unique multi-energy laboratory that replicates a neighborhood with five buildings.

One research focus is on innovative district heating and cooling networks of the 4th and 5th generation. A distinguishing feature of these networks are decentral prosumers that can feed-in or extract thermal energy from the network to optimize the power flows amongst the participants for maximum efficiency. This evokes bidirectional power and mass flows in the network, leading to new thermohydraulic challenges for the network operation.

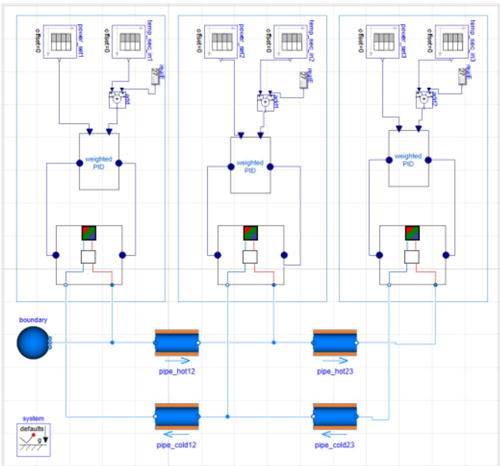

Figure 1: Network simulation with ProsNet in Dymola

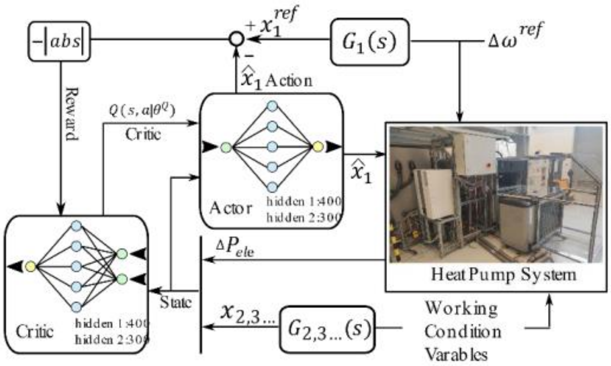

Figure 2: Training configuration of a deep neural network agent for heat pump control.

Topic

Thermal substations hydraulically separate and thermally couple the network-side and the prosumer-side. With a rising penetration of prosumers the substations become the key element for network operation and control the power exchange on a technical level. Heuristic- and model-based controllers have been designed by the research group. However, the system behavior is highly nonlinear, different substations mutually influence each other over the network, physical models require high parametrization effort and the adaptivity to changed network settings is limited. Therefore, as a next step, a data-driven control approach shall be developed based on reinforcement learning (RL) using local measurements in the individual substation.

The topic comprises the following tasks:

- Familiarization with the background and models of the control system
- Choosing a suitable RL approach and a development environment (e.g. Python)
- Setting up a toolchain for the interaction of simulation (measurement) and RL-controller-environment, data acquisition
- Setting up and training the RL controller
- Benchmarking the developed RL-controller against an existing controller
- Result processing, evaluation and presentation
- Preparation of a report describing the key aspects and findings of the conducted work
- Disseminating clean source code via an open-source repository and presenting the results to a scientific audience

Literature for the start: Licklederer2024a, Elizarov2021, Ludolfinger2023a, Song2023

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Interviews with applicants will be conducted mid of April,
Thesis starting date is around beginning of May 2024.