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

RESEARCH INTERNSHIP / BACHELOR OR MASTER THESIS

Innovative district heating networks as part of an efficient, sustainable and interconnected energy system

Motivation and 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 sustainable 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 experiments in a unique multi-energy laboratory that replicates a neighborhood with five buildings. We are constantly seeking motivated and dedicated students for research in these areas.

One focus topic of our research are prosumer-based bidirectional district heating networks (see Fig. 1). Prosumers are network participants who can function as producers or consumers and switch between these modes over time. This behavior results in bidirectional energy and mass flows in the heat network, which is a significant difference to conventional networks. In the most extreme manifestation, prosumer-based networks no longer have a central power plant; instead, participants supply each other, maximizing synergies. Scientific examination of these extreme forms provides valuable insights that can be applied to less complex systems and conventional heat networks.

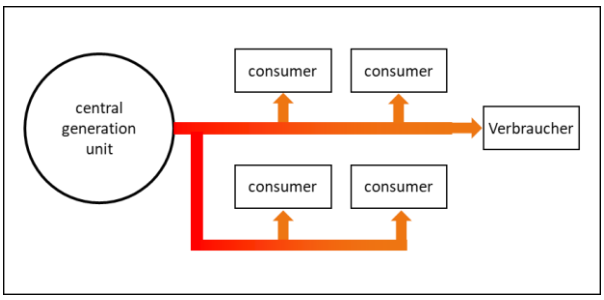

Figure 1: Energy flows in a conventional district heating network

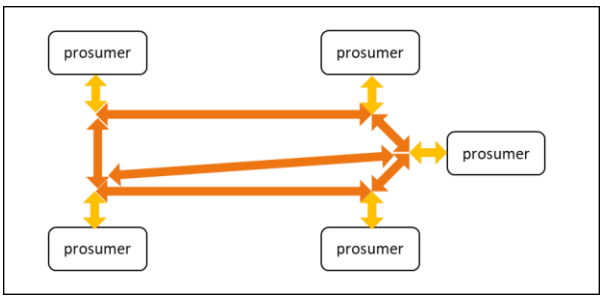

Figure 2: Energy flows in a bidirectional heat network based on prosumers

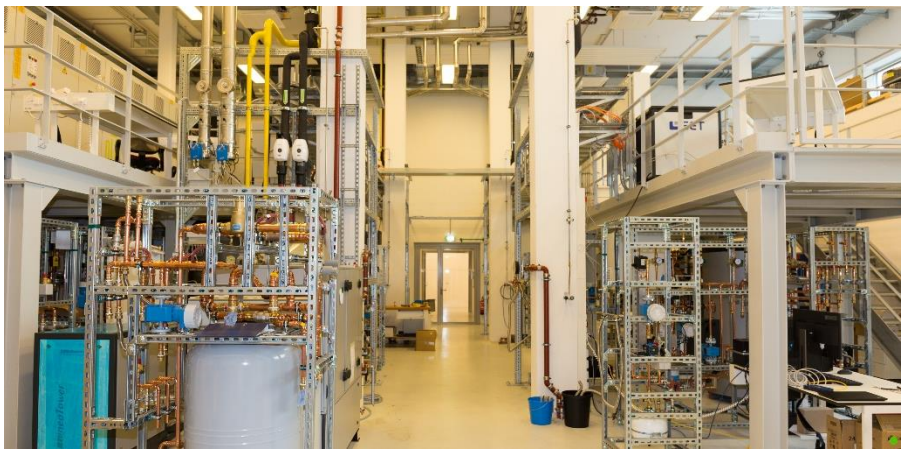

Figure 3: Front view of the CoSES lab with an experimental bidirectional heat network

Current Topics

Each of the topics listed below represents an independent student thesis. We are happy to provide more detailed information on each topic upon request. For individual topics a more detailed description is available publically on our CoSES Wiki.

- Putting Theory to the Test: Experimental Validation of Control Approaches for Heat Transfer Stations in Bidirectional Prosumer-based Heat Networks.
- From Concept to Application: Commissioning and Experimental Characterization of a Scientific Testbed for a Bidirectional Small-scale District Heating Network.
- Smart Control in Thermal Networks: Leveraging Reinforcement Learning for Bidirectional Substation Operation
- Intelligent Network Monitoring: Machine Learning Methods for Efficient District Heating Network State Estimation based on Limited Field Measurements.
- Stability and Sensitivity Analysis of an Agent-Based Control Approach for Bidirectional Heat Transfer Stations in Network Interconnection.
- Prosumer-based Heat Networks as a Solution for Bavaria? - Model Study on Necessary Framework Conditions and Suitable Locations for Prosumer-based Heat Networks in Bavaria.
- Operating the Next Generation of District Heating Networks: Transferring a Control Approach to 5th Generation District Heating Networks.
- Hierarchical District Heating Networks Following the Model of Electricity Grids: Investigation of Technical Feasibility through Simulation Studies.
- Benchmarking for the Exploration of Future District Heating Networks: Development and Parameterization of a Reference Network for Prosumer-Based District Heating Networks.
- Designing Tomorrow's District Heating Networks Today: Advancing Design Methods for Prosumer-based District Heating Networks.
- Trading Heat with Neighbors: Algorithm Development for a Simple Local Heat Market Considering Technical Constraints.
- Understanding the Technical Interplay: Analysis of the Mutual Influences of the Network and Participants in Prosumer-based District Heating Networks Using Simulations.

Application:

For the initial contact, please choose a maximum of 2 preferred topics from the list above or propose your own initiative topic. Additionally, please fill out and include the following questionnaire before submitting your application: Questionnaire.

Application documents including resume (CV), current transcript, questionnaire, and a brief message indicating the preferred topics should be sent to thomas.lickleder@tum.de .

Literature

[1] D. Zinsmeister *et al.*, “**A prosumer-based sector-coupled district heating and cooling laboratory architecture**,” *Smart Energy*, vol. 9, no. February, p. 100095, Feb. 2023, doi: 10.1016/j.segy.2023.100095.

[2] T. Lickleder, D. Zinsmeister, I. Elizarov, V. S. Perić, and P. Tzscheutschler, “**Characteristics and Challenges in Prosumer-Dominated Thermal Networks**,” *J Phys Conf Ser*, vol. 2042, no. 1, p. 12039, Feb. 2021, doi: 10.1088/1742-6596/2042/1/012039.

[3] T. Licklederer, T. Hamacher, M. Kramer, and V. S. Perić, "**Thermohydraulic model of Smart Thermal Grids with bidirectional power flow between prosumers**," *Energy*, vol. 230, p. 120825, Feb. 2021, doi: 10.1016/j.energy.2021.120825.

[4] I. Elizarov and T. Licklederer, "**ProsNet – a Modelica library for prosumer-based heat networks: description and validation**," *J Phys Conf Ser*, vol. 2042, no. 1, p. 12031, Feb. 2021, doi: 10.1088/1742-6596/2042/1/012031.