

Modelling of large-scale heat pumps for district heating and cooling

Summary

The aim of this research project is to develop model for large-scale heat pump integration into district heating and cooling system. This model should handle variable parameters of heat sources (waste heat, seawater, solar heat, etc.), heat pump configurations and operating conditions for district heating and cooling. The project will address following scientific questions: What will be the effect of heat pumps internal heat loss reduction on the efficiency of district heating/cooling systems? What is the realistic HP capacity potential considering the proximity to existing DH areas? Which investments are required, when large heat sources should be used to feed into existing DH? What is the potential of large heat pumps in district heating and its role in future energy sector in Estonia?

Research field:	Chemical, materials and energy technology
Supervisors:	Prof. Dr. Anna Volkova Prof. Dr. Eduard Latõšov
Availability:	This position is available.
Offered by:	School of Engineering Department of Energy Technology
Application deadline:	Applications are accepted between June 01, 2022 00:00 and June 30, 2022 23:59 (Europe/Zurich)

Description

In the EU, heating and cooling is responsible for half of the final energy consumption, from which around ¾ is produced by fossil fuels. Even though district heating (DH) accounts for only 12 % of the heat supplied to EU citizens, the proportion varies greatly by country. Especially countries from the northern region have a high share of DH. The proportion of DH in Denmark, Sweden, Finland, Poland and the Baltic states is above 50 %. Therefore, transforming the DH sector in these regions is important, but also a great chance and help for achieving the ambitious climate goals. Heat supplied by sustainable low-temperature DH networks can be considered as one of the best heat supply options for urban buildings due to lower heat losses and the possibility of using RES. A supply temperature between 50 °C to 60 °C is the most important feature of the 4th generation DH. Energy supply and transition systems and end users will benefit from a low temperature. Implementing power-to-heat (P2H) solutions is a good way to increase the flexibility of the energy system, as P2H options will help address both heat and electricity consumption fluctuations. Besides, when the electricity used for P2H comes from RES, then the use of P2H technologies, such as heat pumps (HPs), will help to introduce RES into the energy system.

One of the P2H options that has been used widely in Denmark is the use of large-scale HPs to supply DH. Since 2010, 106 HPs with a thermal capacity above 100 kW have been implemented in Denmark. The total installed thermal capacity of these HPs results into 368 MW and the trend is growing.

Large-heat pumps can become good solution for district heating and cooling decarbonization and increase of heat/cold produced from non-fuel sources.

Model development of large-scale heat pump integration both into district heating and district cooling system will contribute to this sector transition towards sustainability and decarbonization.

Responsibilities and (foreseen) tasks

- Determination of the topology of a process for large heat pump integration into district heating/cooling system.
- Model development for the simulation of large-scale heat pump's system-level dynamic behaviour model implementation in programming environments such as for example Matlab or Modelica.
- In-depth characterization and analysis of the system-level behaviour under dynamic operating conditions using methods and concepts from nonlinear dynamics.
- Development of advanced (nonlinear) control strategies for regulation of the large heat pumps based on the above modelling and characterization of the system-level dynamics.
- Using optimization models to perform detailed calculations on the levelized cost of heating, when HPs are used in specific DH areas.

- Contribute to the organization of research and practitioner workshops where project findings are presented

Applicants should fulfil the following requirements:

- a master's degree in engineering (preferably in thermal engineering, power engineering or environmental engineering)
- a clear interest in the topic of the position
- excellent command of English
- mathematical modelling of thermal systems;
- knowledge of nonlinear dynamics, model reduction & advanced data analysis.
- working knowledge of heat pumps performance
- programming environments such as e.g. Matlab or Modelica (or alternatives)
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of team
- capacity and willingness to provide assistance in organizational tasks relevant to the project

The following experience is beneficial:

- Spatial planning experience
- Working knowledge of district heating systems
- Good understanding of district cooling
- Practical experience with TRNSYS, EnergyPro, Solvo

The candidate should submit a research plan for the topic, including the overall research and modelling strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year PhD position in highly motivated and active research group of Smart District Heating Systems and Integrated Assessment Analysis of Greenhouse Gases Emissions, participating in international and national research projects on district heating, district cooling, waste heat, heat pumps.
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of energy and thermal engineering.

About the department

The Department of Energy Technology (DET) at TalTech is the leading research institution in Estonia that studies various aspects of energy production and energy supply option. It is the only institution in Estonia involved with thermal engineering and district heating at the university level. DET maintains ongoing partnerships with government authorities and agencies, municipalities, energy policymakers, heat suppliers, and consumers. The activities of the DET include energy planning, chemical engineering, environmental engineering, thermal engineering, thermal power plants, heat economy, thermal energy and district heating. DET is involved in national and international projects, including the development of low temperature and ambient temperature district heating solutions, climate change mitigation with CCs and CCU technologies, large heat pump potential evaluation, bioeconomy.

Research group of Smart District Heating Systems and Integrated Assessment Analysis of Greenhouse Gases Emissions Group deals with developing new technical solutions for the transition of district heating systems towards an intelligent, highly efficient and regenerative energy supply concept and with integrated assessment analysis of greenhouse gases emissions. The main research topics are related to transition and improvement measures for existing and technical solutions for planned district heating systems. Research group participates in national and international research and educational projects.

Additional information

For further information, please contact Prof. Anna Volkova anna.volkova@taltech.ee or <https://taltech.ee/en/department-energy-technology>



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