CHALMERS

MASTER THESIS PROJECT:
OPTIMIZATION OF DISTRICT HEATING SYSTEMS FOR COMBINED HEAT AND POWER PLANT FLEXIBILITY ANALYSIS

Sweden has considerable district heating systems powered by combustion of waste or biomass, or excess heat from industrial processes. Combined heat and power (CHP) plants are efficient regarding fuel, cost and emissions compared to separate generation of heat and electricity. Traditionally, CHP plants have been operated to provide a certain heat load to a district heating (DH) network, while the power produced has been considered a bonus. With the transition to a low carbon energy system new services may be required by the CHP plants. For example, with high integration of wind power, the need for flexible and reliable power generating capacity might cause CHP plants to operate based on the power demand to a greater extent, with the possibility to increase revenue from electricity sales. However, the plants need to deliver heat to the district heating network, so opportunities for flexible CHP operation adapted to the power system might be limited by the DH network characteristics and demands. In summary, the market conditions for power generation are changing rapidly and the proposed project will analyse the potential in increased operational flexibility of CHP plants depending on the type of district heating system and electricity system context (low or high price volatility).

AIM

The overall aim is to develop optimization models of district heating systems for analysis of operational patterns, especially for CHP plants, in different system contexts. More specifically, the project will include a mapping of the district heating networks in Sweden based on an existing database, with respect to plant portfolio and system size, that leads to the identification of typical system configurations. Linear optimization models are developed for the identified typical district heating system configurations. Previously developed DH models might be used as a basis for the model development but will require modifications and further development. Process simulation models can, if needed, be used as a support for estimation of technical input data. The developed optimization models are used to study the operation of the DH networks in different electricity system scenarios, and with different levels of flexibility in CHP plants and/or the DH system. Thus, the focus of the work is mainly on district heating system level, with a strong connection to linear programming methods. The final goal is to be able to generalize trends, similarities and differences, in the operation of DH networks with CHP plants.

PRELIMINARY STRUCTURE OF WORK

Below is a tentative structure of the work, which of course may change after initial discussions. Also, results of the initial work may change the focus of the work. The aim is to make a new contribution and to limit the work to be within the scope of a MSc Thesis while maintaining a high quality.

- Establishing a first time plan of the work.
- Initial literature review of combined heat and power plants, district heating systems, optimization modeling and relevant topics.
- Establishing a method framework.

Division of Energy Technology
Department of Space, Earth and Environment
Chalmers University of Technology
SE 412 96 Gothenburg, Sweden

Chalmers tekniska högskola AB
Reg.No: 556479-5598 VAT No: SE556479559801

- Based on a database of CHP plants and district heating (DH) systems, sort DH networks into type systems and identify key trends and common traits.
- Development of linear optimization models for the type group networks identified with a representation of combined heat and power plant flexibility. The models should optimize the operation of the DH networks with regard to heat demand, price data and technical constraints.
- Analysis of similarities and differences between the DH type systems with regard to operational patterns, especially combined heat and power plants, in different electricity system scenarios.
- Reporting.

ORGANISATION

The proposed project may be performed by one or two students with a chemical or mechanical engineering (or similar) background at the Division of Energy Technology at Chalmers. Courses in Heat and Power Systems Engineering, Energy Systems Modelling and Planning and/or Linear optimization are meriting. The research group has a long history in working with heat and power generation, flexibility and energy system modeling. The following people will be supporting the work at Chalmers:

Supervisor: Johanna Beiron, beiron@chalmers.se

Examiner: Fredrik Normann, normann@chalmers.se

For more information about the Division of Energy Technology check out our website:

http://www.chalmers.se/en/departments/see/research/energy_technology/Pages/default.aspx