PhD Public Defence

Title: Modeling and Analysis for Integration of Multi-Energy Systems

Location: Pontoppidanstræde 111, auditorium

Time: Wednesday 23 May at 13.00

PhD defendant: Qing Zeng

Supervisor: Professor Zhe Chen

Moderator: Associate Professor Weihao Hu

Opponents:
- Professor Claus Leth Bak, Dept. of Energy Technology, Aalborg University (Chairman)
- Dr. Eduard Muljadi, Department of Electrical Engineering, The National Renewable Energy Laboratory (NREL), USA
- Professor Jinyue Yan, Energy Engineering, Royal Institute of Technology (KTH) and Mälardalen University, Sweden

All are welcome. The defence will be in English.
Abstract:

The public awareness of climate change, fossil fuel resource depletion and sustainable energy policies promote the deployment of renewable energy sources. The integration of multi-energy systems provides the opportunity to improve the economic and environmental performance of energy utilization, owing to an optimal coordination among different energy systems such as electricity, gas, heating, cooling, transport, and so on. Recently, the interdependency among the electric power system, the natural gas system and the district heating system is enhanced by the widespread use of gas-fired power generators, heat pumps, combined heat and power units, and power-to-gas units. Thus, the integration of gas, district heating and electric systems is currently receiving increasing attention.

This PhD project aims at promoting the coordination of various energy resources to accommodate the fluctuated renewables and to shape an efficient and low-cost energy system. We study the integration of gas, district heating and electric systems in terms of four aspects: energy flow model, network expansion planning, operation strategy, energy market. Thus, the contributions of this project include three parts:

- **Energy flow model of the multi-energy systems.** A steady-state flow model is developed to describe the electricity, natural gas and district heating systems. Then a unified energy flow solution is proposed to analyze the energy distribution in the integrated energy system. The per-unit system is proposed to improve the computational efficiency.

- **Joint operation of the multi-energy systems.** A coordinated optimization model is developed to jointly operate the integrated energy systems with the aims of maximizing efficiency and minimizing cost. Since weather-dependent renewable sources are considered, the model is improved as a two-stage stochastic programming problem. It allows the optimal scheduling of reserves to facilitate real-time adjustment decisions, which results in minimum cost while integrating the highest level of renewable energy.

- **Co-expansion planning of the multi-energy systems.** A bi-level programming structure is developed to minimize both the investment and operation cost of the integrated energy systems. The upper-level optimizes the expansion plan and determines the network topology as well as the generation capacities, while the lower-level is formulated as an optimal economic dispatch under the operational constraints given by the upper-level decision. A hybrid algorithm is presented to solve this bi-level programming, including the modified binary particle swarm optimization (BPSO) and the interior point method (IPM).