Optimization of Hybrid Multi-Carrier Energy Supply Networks

Executive summary

The project concerns with the mathematical modeling and global optimization of energy supply networks based on multiple-energy carriers for urban family houses.

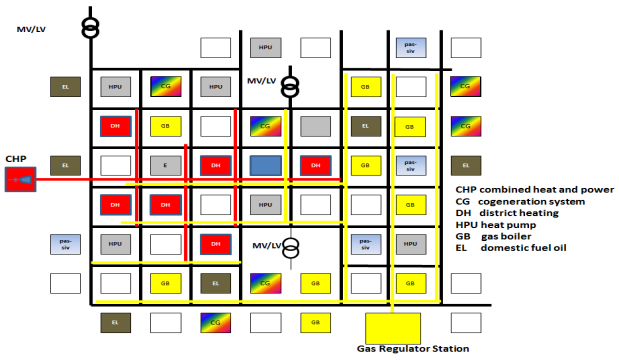

Figure 1: scheme for an energy supply network

Challenge overview

The goal of the project is to realize an energy efficient town planning. In particular, the optimal choices for combined heat and power units, for gas-driven condensing boilers and for electricity-driven heating pumps are one of the main tasks in our cooperation. However, these tasks yield challenging problems in mixed-integer nonlinear programming (MINLP), which are hard to solve numerically. The Rechen-zentrum für Versorgungsnetze Wehr GmbH (RZVN) has developed various optimization strategies that are mostly based on different linear programming approaches for the underlying model. Then, routines from mixed-integer linear programming (MILP) are applied, usually for a huge number of free variables.

Implementation of the initiative

The cooperation between the RZVN and the University of Konstanz (UKN) was initiated in the year 2013 by a master thesis. Since 2014 the UKN and the RZVN have been working together in a research project that investigates modeling and optimization advances of hybrid multi-carrier energy supply network design. This three-years project is financed by the German Minister for Economic Affairs and Energy. At the first stage (analysis and modeling), it was a permanent cooperation between both sides (two Ph.D. students and Dr. König). Once the mathematical model was developed and evaluated, the group of Prof. Volkwein concentrates on developing and adjusting advanced optimization techniques for parts of the energy network, where the MILP solutions are improved by applying MINLP.

Results and achievements

A typical example of the optimal hybrid energy supply network by our approach is presented by the illustration below, where three energy carriers (natural gas, electricity, district heating) and three energy-conversion technologies were considered. In order to solve the MINLP problem, it is necessary to carefully analyze the specific structure of the underlying model equations occurring as constraints in the optimization. We successfully have applied two global optimization methods on our model: piecewise linear approximation and spatial branch-and-bound.

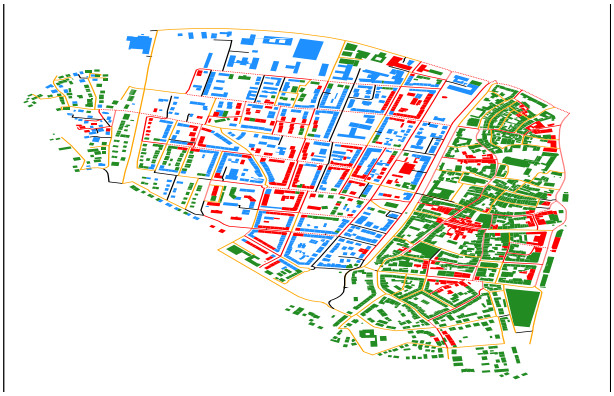

Figure 2: optimized network for a real town

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