Examination and Optimisation of a heating circuit using TOR

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Introduction

Technical machines and components are very energy efficient, but systems still offer many opportunities for savings. By the time we know the operation point of a single component in the system we can rate the real energy consumption and efficiency. We apply methods of Technical Operational Research to an existing heating system and show possible improvements. We gain these suggestions from considering the whole system to be revised instead of just one module.

The Optimisation Process

The conference centre *darmstadtium* in Darmstadt is a prominent example of energy efficient buildings [1]. The heating system of the building consists of different source and consumer circuits connected by a Zortström-distributor. Our aim is to reduce the energy costs of the system as much as possible. Therefore we analyse the supply circuits. The supply of the building is energized by a biomass-boiler (**Figure** 1, left) and a connection to the local community heating circuit (**Figure** 1, middle). Electrical energy drives the pumps in these two circuits. The first step towards an optimisation is a complete examination of the system. The tasks for the examination are: 1. Compilation of an objective list for the system, 2. Collection of the characteristic curves of the components, 3. Measurements of the load profiles of the heat and volume flow demand. Based on this information, we set up a physical simulation model of the heating circuit and calculated the daily heat demand (**Figure** 1, right) depending on the time of the year.

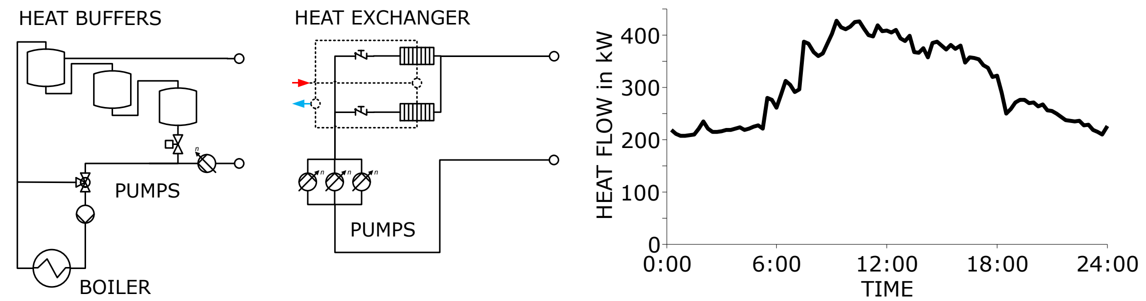

Figure 1: Left: Hydraulic diagram of the Boiler circuit. Middle: District heating circuit. Right: Average daily load cycle.

The next step is the creation of a Mixed Integer Program (MIP). This program has to contain all physical and technical constraints, as well as the load demand in a linearized form. The decision variables are the discrete and continuous control settings of the system. *Which heat source is to be used? Which rotational speed for a pump is the best?* The optimisation objective is to minimise the total energy costs for one year. MIPs are often used to optimise scheduling problems. Thus powerful commercial solvers can be used to solve the problem.
The calculated control strategy allows savings of 7941 *€/a*. In addition we considered a topological option for the hydraulic diagram by relocating the heat buffers. The optimal control strategy for this systems allows savings of 9578 *€/a*.
The last step is the validation: We insert the optimisation result into the physical simulation model and prove them to be a valid solution for the physical problem.

Conclusions

Instead of increasing the energy efficiency of a single component, we consider the whole system for a change. This allows us to review and revise the heating system of the *darmstadtium*. Even good systems can be improved by applying an appropriate method. A global optimal system topology can only be found, if the whole system stays in the focus of the planning process. Improvements within modelling and algorithms allow us to optimise the topology of the whole system without any restrictions.

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References:
[1] http://www.darmstadtium.de/index.cfm/content/green_meetings/pa_li_id/318.cfm, last visited 17.11.2014.