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OPTIMIZING THE DESIGN AND CONTROL OF DECENTRALIZED WATER SUPPLY SYSTEMS – A CASE-STUDY OF A HOTEL BUILDING

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Abstract: Booster stations are used in buildings to supply higher floors with the needed pressure and volume flow, if the supply pressure of the water supplier does not suffice. In high buildings, like skyscrapers, they are usually needed to supply all floors with water. The energy efficiency of these systems can be improved compared to currently used centralized systems by a decentralized topology approach. To design these systems, mathematical optimization based on Mixed-Integer Nonlinear Programming (MINLP) is a promising tool, which allows computing optimal topologies. In this paper, we investigate the optimal topologies of decentralized water supply systems for skyscrapers, which can be modeled by a tree-structured graph. We consider a multi-objective optimization problem. One objective is the total sum of investment costs. The second is the power consumption of the whole system. The underlying model consists of a two-stage variable system, where the binary first stage variables represent the investment decisions, and the second stage variables represent integer and continuous variables for the optimal control of the bought pumps. For optimizing the power consumption, we use the rotating speed of pumps as the key variable to control the energy efficiency. The selection of pumps and pipes are modeled by first stage binary variables. As an input to the optimization program, we use a predefined set of pumps. For modeling the technical characteristics of these pumps, we use polynomial functions and regression analysis. The underlying MINLP is solved by state-of-the-art nonlinear solvers, like SCIP 4.0. As an example use-case, we apply the method to the water supply of a specific real-world high-rise hotel building. We investigate the effects of different sets of available pumps and compare the optimal topologies for different expected runtimes of the system.