Energy Management with Smart Thermostatic Valves

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The information from smart thermostatic valves is exploited to optimize the operation of the central heating system. In this contribution, we describe the evaluation procedure that allows us to determine the efficiency increase for such approaches and present associated energy savings results. The analysis shows that significant savings can be achieved for different heating technologies, especially when using heat pumps.

In recent years, many control strategies for reducing building and district energy consumption have been demonstrated. Most of them use predictive algorithms, *i.e.*, almost optimal control strategies. However, even if these strategies are promising, they are seldom deployed in practice because of the modelling burden. On the other hand, classic control strategies can be improved by adding simple expert rules which increase their reliability and effectiveness. However, such approaches require constant human interaction and are therefore rarely economic.

In this contribution, we present a data-driven, model-free approach that tries to achieve optimal solutions in an automated and economic manner. The idea is to use smart thermostatic valves as sensing elements in order to obtain a better information of the heat requirement distribution in the building according to the local thermal user settings, *e.g.*, room temperature set points. This information is then used to adapt and optimize operation of the central heating system, *e.g.*, by changing set points or heating curve parameters.

To evaluate such approaches a co-simulation software platform was developed, where the thermal building simulation platform DIMOSIM (www.cstb.fr) interacts with the python-based optimization algorithms. The entire process is driven by the optimization algorithm, which instantiates the simulation process via the generation of suitable DIMOSIM project files. The process communication is then achieved via a socket framework, where DIMOSIM is acting as server. During the simulation process, the measurement signals are passed to the optimization algorithm at regular intervals. The algorithm then determines optimum set points, which are fed back to the building simulator.

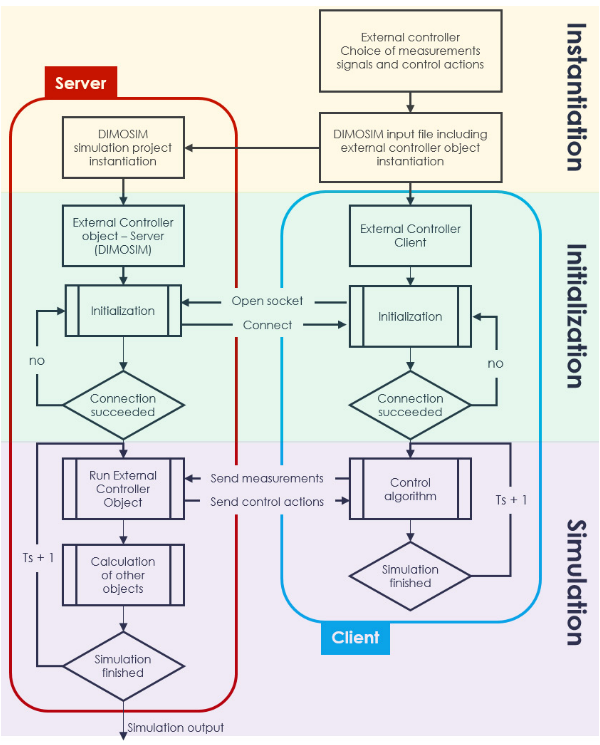

Figure 1: Interaction of building simulator and optimization algorithm.

Within the THERMOSS project, this approach was evaluated for a test site in the UK. The test site is a multi-apartment building with 43 dwellings and a total of over 150 radiators. The building currently uses an obsolete gas boiler technology and the upgrade towards either a modern gas boiler or emerging gas absorption heat pumps (GAHP) was investigated. For this purpose, the entire building was modelled in DIMOSIM and an evaluation for the 2015/2016 winter season with a total duration of nine months was carried out.

First, the consistency of the building modelling was validated by comparing the actual heating consumption of 192 MWh to the simulated consumption. For the typical set point settings provided by the building users an error of +7% was determined, which indicates a sufficiently good calibration of the thermal building model.

Second, the improvements coming from new heating equipment were evaluated. With a modern gas condensing boiler the total consumption can be reduced to 126 MWh whereas a GAHP results in 96 MWh. This corresponds to reductions of 34% and 50%, respectively.

Third, the potential savings from the data-driven automated optimization using data from smart thermostatic valves was evaluated. For the gas condensing boiler, the total consumption was reduced to 116 MWh, which corresponds to savings of 8%. For the GAHP savings of 24% were obtained (73 MWh). They originate from a consistent and continuous reduction of the flow temperature with respect to standard heating curve approaches used nowadays. For the gas condensing boiler this effect results in an increase of the average seasonal generation efficiency from 87% to 92% whereas for the GAHP the seasonal coefficient of performance (COP) is increased from 118% to 149%.

The evaluation demonstrates the significant improvements that are possible via the proposed data-driven optimization approach.

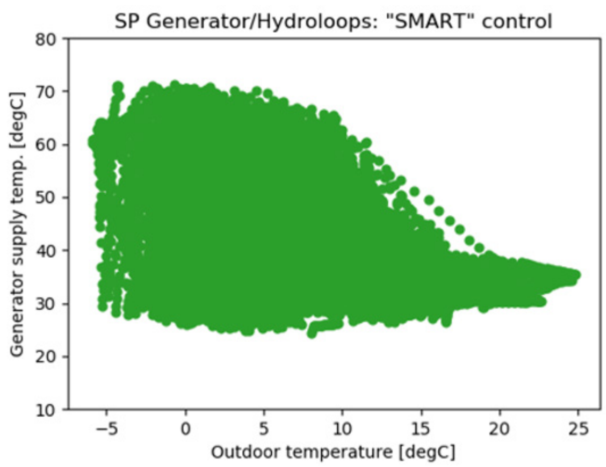

Figure 2: Flow temperature distribution of central heating unit.

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