# Load shifting of space-heating demand in district heating systems based on a reduced-order building model identifiable at substation level

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Buildings' space-heating demand is of fluctuating nature. During nighttimes or in absence of occupancy, it is fairly low; then it reaches peak-loads in the early-mornings or as the outdoor temperature drops. In a District Heating System (DHS), peak-loads are undesirable because they confine the operator to start-up expensive and polluting heat generation units. Meanwhile, buildings have an inherent thermal inertia, which offers flexibility in space-heating demand for a short-term heat storage and release without jeopardizing consumer's comfort. In our research, we propose a load shifting strategy of space-heating demand in DHSs based on a physical building model with a prominent attention to building's thermal inertia. Two aspects of the work are presented; first, the building model identification and second, the model-predictive control strategy.

Building models for space-heating demand control at a DHS level shall fulfill particular specifications. Out of many modelling techniques, we narrowed-down the list to semi-physical reduced-order models. Such models have a reduced number of equations derived from physical phenomena under specific assumptions, and feature a limited number of physically interpretable parameters. As they are dynamic ones, they are well-representative of the transition state where the thermal inertia effect is mostly perceived. They are computationally fast and convenient for online optimization. Parameters identification is carried-out using historical data. Whereas in most previous works in this field historical data includes intrusive internal temperature measurements, we restrict our approach to a set of signals that are practically accessible to a DHS's operator. This novelty allows a wide-spread implementation of optimal control-related technologies in DHSs. We present the modelling approach and validation using a set of data generated by a realistic numerical simulator of a building with its radiators-heating system connected to a DH substation.

Model Predictive Control (MPC) is a particular optimal control paradigm that aims at finding the trajectory of the control variables that minimize the cost function over a predicted future horizon and based on a model of the system. When implementing MPC to optimally control space-heating demand of a building served by a DHS, the control variable is the supply water temperature at the substation and the cost function to be minimized is a (possibly linear) combination of power price and comfort violation over a future horizon of 24-hours. The reduced-order building model is the mathematical link between the weather forecast (external temperature and solar irradiation), the comfort level (deviation of the mean set-point temperature from the standard comfort temperature) and the supply water temperature. The receding horizon principle implies applying the first output of the controller to the upcoming decision step, then repeating the optimization problem over the updated horizon. We describe the implementation of MPC for a building's space heating problem and compare its performance to a conventional control strategy.