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Saving Energy by Improved Building Control

Buildings account for almost 40% of the final energy use in the world. The improvement of their automation and control systems presents one possibility to reduce energy consumption whilst occupant comfort is maintained or even improved.

The research project OptiControl (http://www.opticontrol.ethz.ch) addresses the development of novel building control strategies in three steps: (i) assessment of potential for improved control, (ii) in-depth analysis of selected cases, (iii) testing of new control approaches in a demonstrator building.

Here we report results from our potential assessment for office buildings. The assessment was based on a large number of detailed, whole-year simulations with a dynamic building model. In a first step we estimated for a given system, control (heating, cooling etc.) costs function, and set of comfort requirements the lowest possible energy use, the so-called energetic Performance Bound (PB). This was done by means of a receding horizon Model Predictive Control (MPC) procedure that assumed perfect knowledge of the building's dynamics as well as of all weather and internal gains disturbances acting upon the system.

In a second step energetic and comfort performance indicators of selected control strategies were compared with the PB and among each other. The strategies investigated were state-of-the-art rule based control, MPC Certainty Equivalence Control, and Chance Constrained Stochastic MPC approaches. Considered were different combinations of building types (with varying thermal mass, thermal insulation level, façade orientation, internal gains etc.), building systems (with varying ventilation, slab and room subsystems) and comfort requirements (wide vs. narrow thermal comfort range) at several representative European locations.

The results showed a surprisingly large variation in energy saving potential depending on building type, building system and location. Generally, the largest absolute savings potentials were found for buildings with a poor thermal insulation ("Swiss average" level), and the largest relative savings potentials for highly insulated buildings ("Passive House" standard). In several cases an improvement of rule based control was found to yield already substantial energy savings, whereas in many other cases further improvements towards the PB were found to be only possible thanks to advanced, predictive control approaches that involved the use of weather forecasts.

The found high variability in savings potentials highlights the need for, and the benefit of, datasets and tools that enable detailed performance assessments on a case-dependent basis. Further work is needed to evaluate the novel control strategies with regard to user acceptance, robustness, commissioning and operation aspects, and their compatibility with existing systems.

Sustainable building and construction

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