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Tailored high-resolution numerical weather forecasts for energy efficient predictive building control

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The high proportion of the total primary energy consumption by buildings has increased the public interest in the optimisation of buildings' operation and is also driving the development of novel control approaches for the indoor climate. In this context, the use of weather forecasts presents an interesting and – thanks to advances in information and predictive control technologies and the continuous improvement of numerical weather prediction (NWP) models – an increasingly attractive option for improved building control.

Within the research project OptiControl (www.opticontrol.ethz.ch) predictive control strategies for a wide range of buildings, heating, ventilation and air conditioning (HVAC) systems, and representative locations in Europe are being investigated with the aid of newly developed modelling and simulation tools. Grid point predictions for radiation, temperature and humidity of the high-resolution limited area NWP model COSMO-7 (see www.cosmo-model.org) and local measurements are used as disturbances and inputs into the building system. The control task considered consists in minimizing energy consumption whilst maintaining occupant comfort.

In this presentation, we use the simulation-based OptiControl methodology to investigate the impact of COSMO-7 forecasts on the performance of predictive building control and the resulting energy savings. For this, we have selected building cases that were shown to benefit from a prediction horizon of up to 3 days and therefore, are particularly suitable for the use of numerical weather forecasts. We show that the controller performance is sensitive to the quality of the weather predictions, most importantly of the incident radiation on differently oriented façades. However, radiation is characterised by a high temporal and spatial variability in part caused by small scale and fast changing cloud formation and dissolution processes being only partially represented in the COSMO-7 grid point predictions. On the other hand, buildings are affected by particularly local weather conditions at the building site. To overcome this discrepancy, we make use of local measurements to statistically adapt the COSMO-7 model output to the meteorological conditions at the building. For this, we have developed a general correction algorithm that exploits systematic properties of the COSMO-7 prediction error and explicitly estimates the degree of temporal autocorrelation using online recursive estimation. The resulting corrected predictions are improved especially for the first few hours being the most crucial for the predictive controller and, ultimately for the reduction of primary energy consumption using predictive control.

The use of numerical weather forecasts in predictive building automation is one example in a wide field of weather dependent advanced energy saving technologies. Our work particularly highlights the need for the development of specifically tailored weather forecast products by (statistical) postprocessing in order to meet the requirements of specific applications.