Saving Energy by Improved Building Control

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Introduction

Buildings use ~40% of final energy worldwide.

- What can be gained thanks to improved control?
- How important is predictive control?

Approach

1. Determine Performance Bound (**PB**) = Lowest possible energy use for a given system and cost function.
2. Compare with existing control strategies, e.g.
   – Short Term Optimal Control (**STOC**),
   – Rule Based Control (**RBC**).

Methods & Data

- Annual Primary Energy Consumption (**PEC**) estimated by means of whole-year, hourly time step simulations with a dynamic building model.
- Building zone: Office; Thermal insulation levels ”Passive House”, “Swiss Average”; Construction types “light”/”heavy”; Façade orientations N/E/S/W and SW; Window area fractions 30%, 80%; Internal gains levels “low”, “high”.
- Weather data: global radiation on the vertical orientations of the building, outside air temperature (T_{air}), wet-bulb temperature; 9 European sites for the year 2006.

• Building Systems	*S1*	*S2*	*S3*	*S4*
Blinds (automated)	x	x	x	x
Electric lighting	x	x	x	x
Mech. ventilation with energy recovery	–	x	x	x
Natural ventilation (night-time only)	–	–	–	x
Slow cooled ceiling	x	x	–	–
Free cooling with wet tower	x	x	–	–
Radiator heating	x	x	–	–
Floor heating	–	–	–	x

- Heat production: earth coupled heat pump; Cold production: mechanical compression chiller.
- T_{air} dependent thermal comfort range.
- Standard occupancy and ventilation schedules.
- PB: estimated with the aid of Model Predictive Control (MPC) assuming perfect building model plus perfect weather and internal gains forecasts, optimization horizon **H** = 72 h.
- STOC: MPC, perfect building model, H = 1h.
- RBC: Non-predictive Siemens control strategies #2 (state of the art) and #3 (newly developed)

Results

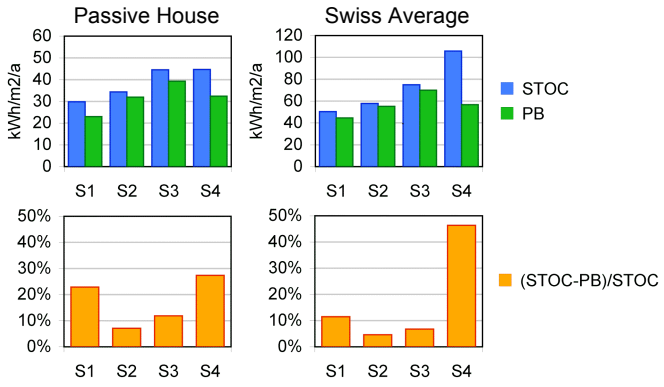

Fig. 1: Overview of STOC improvement potential. Each bar gives an average value from 32 building cases (façade orientations N/E/S/W) at sites Geneva, Basel and Lugano.

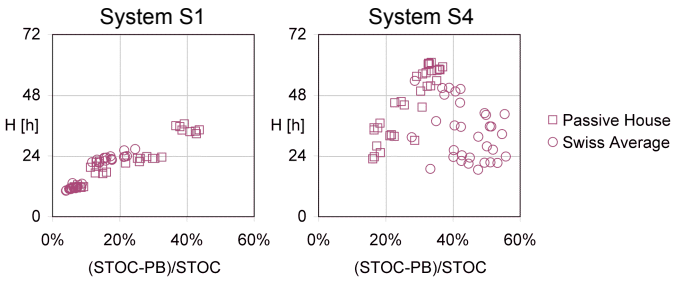

Fig. 2: Required prediction horizon (H) to reach the PB as a function of STOC improvement potential. Each panel shows 64 building cases (façade orientations N/E/S/W). Data are average values for sites Geneva, Basel and Lugano.

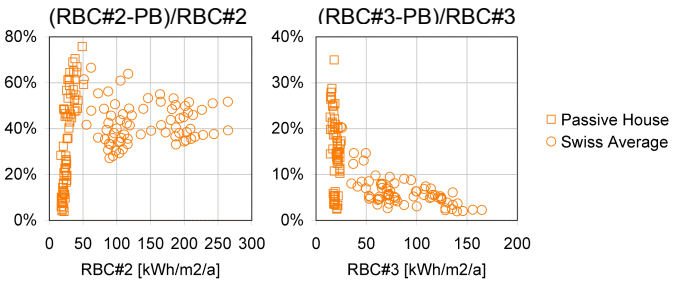

Fig. 3: Improvement potential of RBC strategies #2 and #3 for System S1 and façade orientation SW. Each panel shows data for 16 building cases at 9 European sites.

Conclusions

- Demonstration of significant savings potential.
- Potential is highly system and case dependent.
- It can be partially exploited by improved non-predictive control.
- Remaining cases or cases with large prediction horizons suggest additional improvement might only possible by means of predictive control.

Further information: http://www.opticontrol.ethz.ch