Use of Weather and Occupancy Forecasts for Optimal Building Climate Control (OptiControl)

Project Presentation

The OptiControl Team
http://www.opticontrol.ethz.ch/

OptiControl – Overview

Aims:

Development of methods to exploit weather forecasts and occupancy-related information aiming at

➢ improving the energy efficiency and comfort of buildings;
➢ reducing peak electricity demand.

Expected Results:

• Methods
• Software/tools
• Benefit-cost analyses
• Application to demonstrator
OptiControl – Approach

• Case studies
  (Selected “Applications”, typical buildings, representative sites etc.)

• Extensive use of computer-based modeling & simulation
  (Controller development, potential assessment, tests etc.)

• Emphasis on Model Predictive Control (MPC)

• Stepwise refinement & simplification of methods and models

• Field tests of the new control approaches in demonstrator object(s)
OptiControl – Research Partners

- ETH Systems Ecology Group
  Modeling and simulation; project management

- ETH Institut für Automatik
  Control theory; controller development & tools

- EMPA Building Technologies Laboratory
  Building physics, HVAC & energy systems, modeling, field tests

- MeteoSwiss
  Meteorological data and predictions (Europe–local)

- Siemens Building Technologies
  BAC research and product development
**OptiControl “Applications”**

1. **Integrated Room Automation (IRA)**

   Integrated automation of light, blind, heating, cooling and ventilation
   (including TABS and floor heating subsystem variants)

   ![Integrated Room Automation Image]

In preparation:

2. **Cooling by night-time ventilation**
3. **Energy Recovery**
4. **Generic Energy Flux Control**
Case Study Sites

Zürich
Basel-Binningen
Genève-Cointrin
Lugano
Modena
Marseille-Marignane
Clermont-Ferrand
Mannheim
Hohenpeissenberg
Wien Hohe Warte
Modeling & Simulation Environment

- Buildings Definitions
- Building specif. & params
- Location specif. & data
- Occup. specif. & data
- Controllers & Library
- Occupancy Datasets
- Predicted weather data
- Predicted occup. data
- Weather Pred. DB
- Occupancy Predictions
- Statistics, Perf. Indices, Graphics etc.

MoEDSiPA

Modeling
Exper. Definition
Simulation
Post Analysis
Controller Assessment

Information Levels:
1. “perfect world – we know everything”
2. “real world, no weather forecasts”
3. “real world, with weather forecasts”

[Diagram showing improvement of present-day control strategies and transition from perfect models to realistic world]
Sample Results: Definition of Simulation Experiments

8 building zone types:

- Façade orientation: Southwest
- Thermal insulation level: Swiss average, Passive house
- Construction type: Heavyweight, Lightweight
- Window area fraction: 30%, 80%
- Internal gains level: low, high

HVAC System (OptiControl System #01):
- Blinds
- Electric lighting
- Heating: radiators
- Cooling: slow ceiling
  - mechanical chiller
  - free cooling with wet tower
Sample Results: Control Strategies Considered

- Ref2  State-of-the-art rule based control
- Ref3  Improved rule based control (new)
- MPC-CE MPC-Certainty Equivalent control *
- PB    Performance Bound

\[ n = \text{Narrow thermal comfort range} \]
\[ w = \text{Wide thermal comfort range} \]

*) Using “COSMO-7” weather forecasts by MeteoSwiss, preliminary results.
Results (1) – Improved Non-Predictive Control

![Graph 1: Ref2_n - Ref3_n vs. Ref2_n [kWh/m2/a]]

![Graph 2: (Ref2_n - Ref3_n)/Ref2_n vs. Ref2_n [kWh/m2/a]]
Results (2) – Potential of Weather Forecasts

![Graph showing the potential of weather forecasts](image)

**Ref3\_w - PB\_w**

![Graph showing the ratio of differences to Ref3\_w](image)

\[(Ref3\_w - PB\_w)/Ref3\_w\]
Results (3) – Comparison of Control Strategies

West / Wien / Swiss average / heavy / windows 30%

South / Zurich / Swiss average / heavy / windows 30%

South / Marseille / Swiss average / heavy / windows 30%

South / Zurich / Passive House / Light / windows 80%
Conclusions

- First results are promising
- Benefit of weather predictions varies strongly from case to case
- Appropriate tools are important
- Our sophisticated studies can be useful for identifying simple, improved control strategies