# Predictive building automation using weather and occupancy forecasts:

# The New Monte Rosa Hut and OptiControl projects

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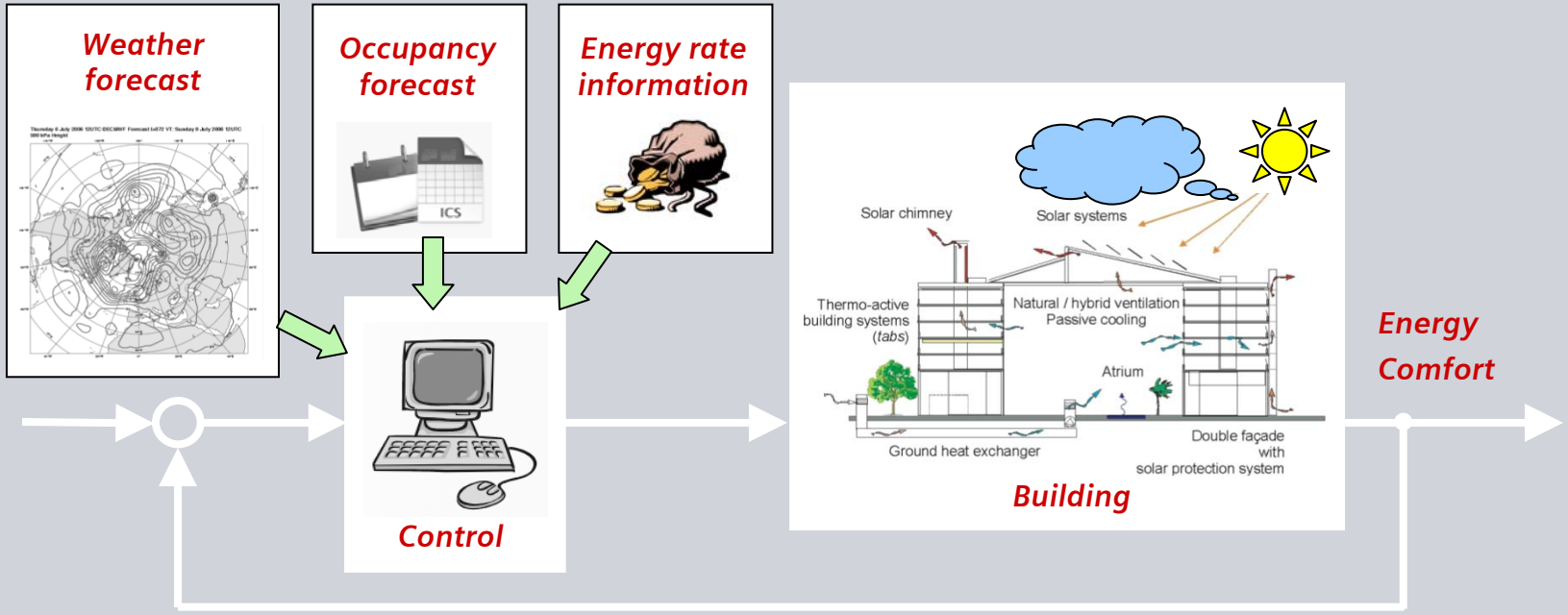
# Predictive building automation




**Objectives** Meet comfort specifications (within certain tolerances)
Minimize energy requirements or monetary costs

**Idea** Optimize use of energy from renewable sources based on a building's energy needs—use “interference” forecasts to improve planning

**Method** *Predictive rule-based control* or *model predictive control* using weather and occupancy forecasts, rate information

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# Two different types of predictive control

1

**Rule-based strategies,**
i.e. use of “if...then...” rules

*Conventional type of control, widely used in building automation*

*Additional rules are needed to incorporate forecasts such as weather forecasts.*

2

**Model predictive control (MPC)**

*New type of control, not widely used in building automation*

*Numerical optimization based on the model of the controlled system contained in the controller is used to incorporate forecasts.*

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# Benefits of forecasts in building automation

- Energy or energy cost savings
- Improved room climate
- Reduced peak electricity demand
- The behavior of controllers using weather forecasts is easy to understand for most people.
  This increases the acceptance of such control solutions and improves the interaction between users and the system, resulting in a higher overall performance.

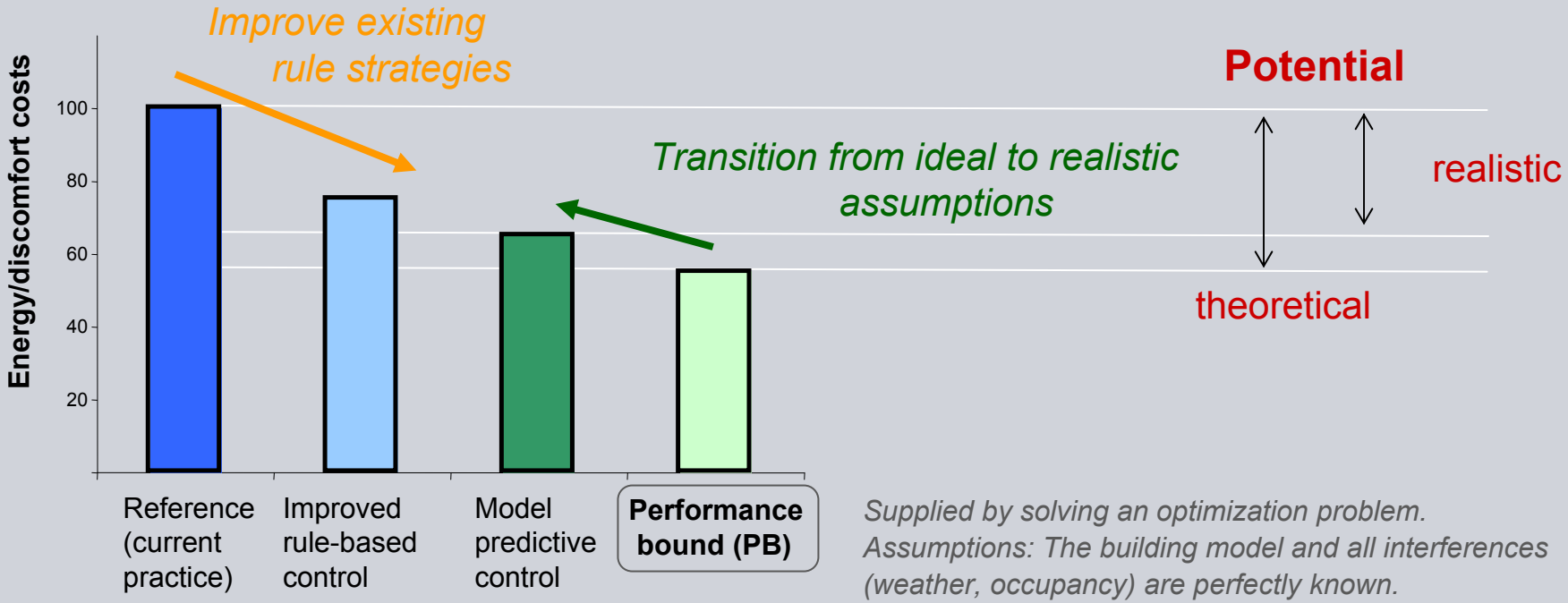
# The quest for better control strategies

**An efficient way to search for better control strategies**

1. Simulate the reference strategy and calculate the performance bound

If the (theoretical) potential is high enough:

2. Improve conventional rule-based strategies and/or design model predictive controls




*Supplied by solving an optimization problem. Assumptions: The building model and all interferences (weather, occupancy) are perfectly known.*

# The Monte Rosa Hut project: integrated building systems for optimal energy and resource management

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## Main objectives

- Development of an optimized energy management system based on the planned infrastructure in order to reach the desired degree of energy independence (≥ 90%)
- Monitoring and visualization of plant operations, plus external building surveillance and interaction with building management

## Project duration

June 2008 through December 2012

## Partners

Institute for Dynamic Systems and Control (IDSC), ETH Zurich
Lucerne University of Applied Sciences and Arts, Technology & Architecture, ZIG
Siemens Switzerland Ltd, Zug

## Sponsors

Swiss Federal Office of Energy (SFOE)

## Website (entire New Monte Rosa Hut project)

*www.neuemonterosahuette.ch*

# Monte Rosa Hut

New Monte Rosa Hut: a project of the Swiss Federal Institute of Technology Zurich (ETHZ) to celebrate its 150th anniversary

# Monte Rosa Hut
# Energy management

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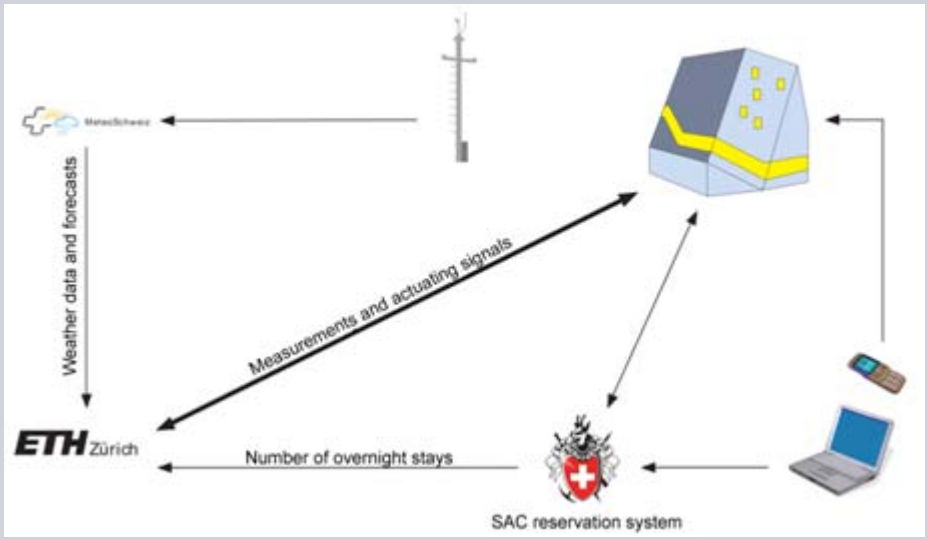
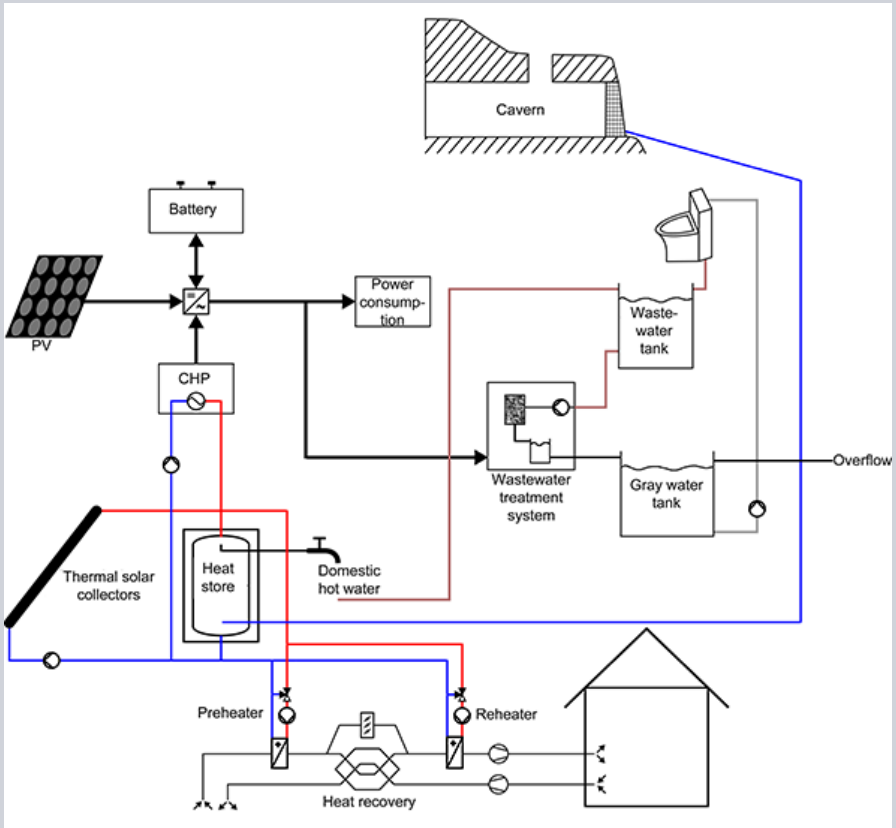
## Energy management components

- Energy production: photovoltaic system, thermal solar collectors, CHP plant
- Energy storage: battery, thermal heat stores
- Energy consumption: heating, ventilation, hot water, electric devices, wastewater treatment
- Automation system components:
  hut building automation system,
  weather station, weather forecasts,
  SAC reservation system, external
  automation (optimization) at ETH Zurich




Source: R. Novotny, SEV/VSE Bulletin




Source: M. Benz, S. Fux, ETH Zurich

# Monte Rosa Hut
# Energy management

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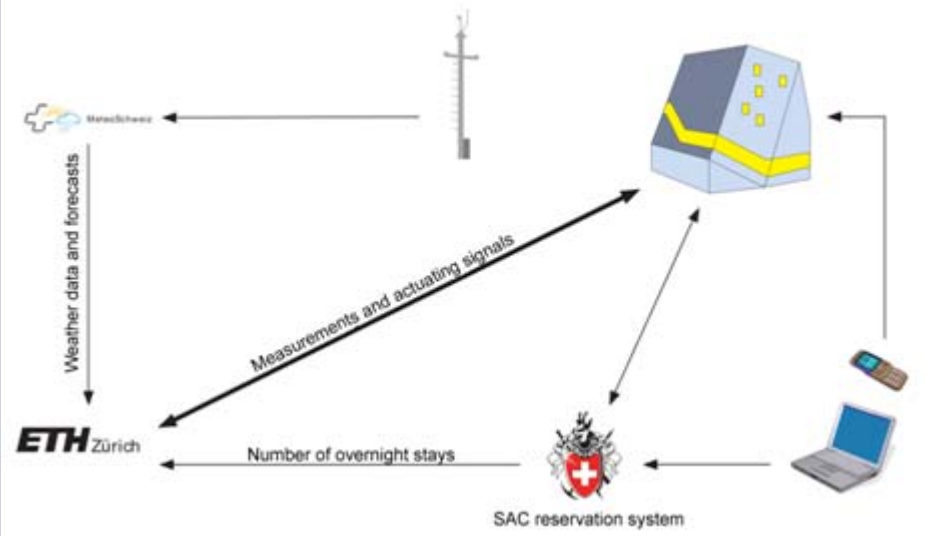
## Steps towards optimized energy management

- Set up energy management components
- Implement a basic rule strategy (conventional implementation)
- Model all relevant subsystems
- Validate the models using measurement data
- Design high-level energy management
- Simulate the entire system using energy management
- Use high-level energy management in the real system




Source: R. Novotny, SEV/VSE Bulletin

# Monte Rosa Hut
# Visualization

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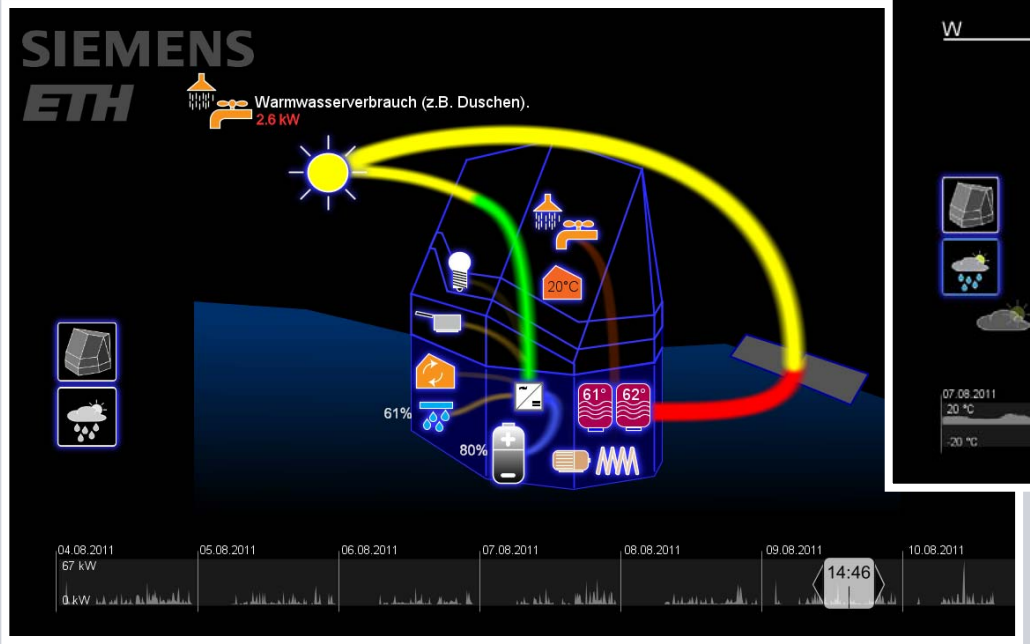
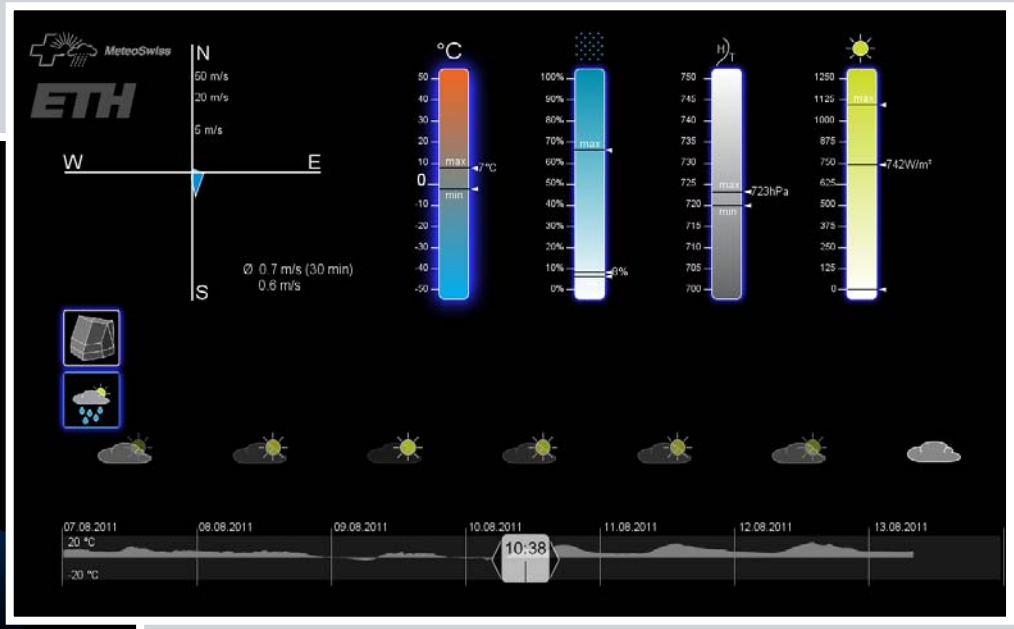
## Visualization of building automation

- In addition to the classic visualization of building automation (by Siemens BT), we have created a visualization of energy flows and weather conditions/forecasts intended for the public.
- Currently this visualization is not yet available to the public.



# The OptiControl project

## Main objectives

Develop methods to use weather and occupancy forecasts to:

- Increase energy efficiency and comfort in buildings
- Reduce peak electricity demand

Demonstrate the benefits of the methods in a real building

## Project duration

OptiControl-I: May 2007 through July 2010
OptiControl-II: May 2011 through April 2013

## Partners

Automatic Control Laboratory, ETH Zurich
Gruner AG, Basel
Siemens Schweiz AG, Zug
Building Technologies, Empa, Dübendorf (OptiControl-I only)
MeteoSchweiz, Zurich (OptiControl-I only)
Actelion Pharmaceuticals Ltd, Allschwil (OptiControl-II only)

## Sponsors

swiss*electric* research, CCEM

## Website

*www.opticontrol.ethz.ch*

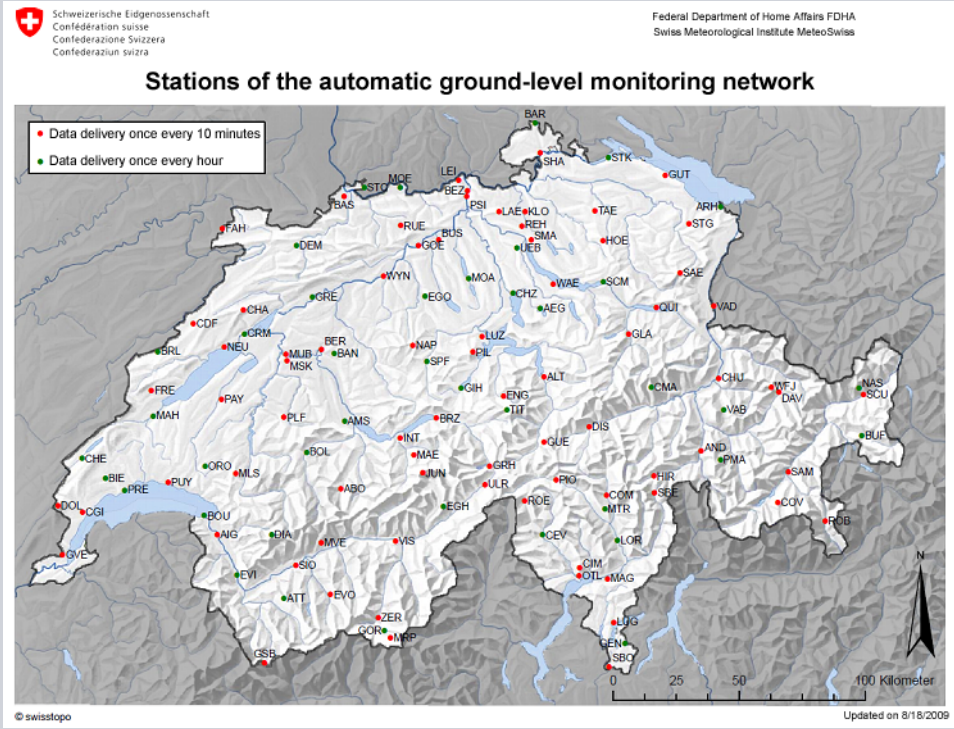
# OptiControl
# Adapting numerical weather data to local conditions

Processing steps for local forecasts:

1 Numerical weather forecast,
Direct Model Output (DMO) for the grid element of the building location

2 Correction of the DMO weather forecast using the most relevant measurement data provided by the meteorological service for the building location

**3 Correction of the weather forecast using the local measurement data captured by the building automation system**




Processing step 3 greatly improves the forecast, especially within the first few hours!

# OptiControl
# Integrated Room Automation

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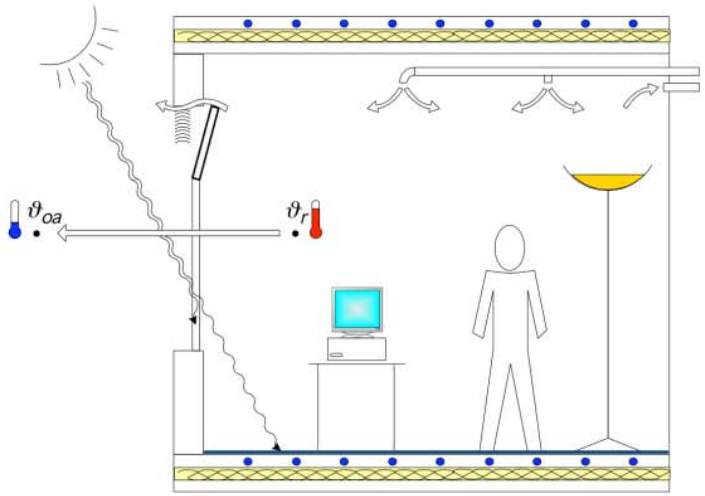
## Integrated Room Automation application




| *Automated Subsystems* | *Building System* S1 | S2 | S3 | S4 | S5 | S6 |
|---|---|---|---|---|---|---|
| Blinds | x | x | x | x | x | x |
| Electric lighting | x | x | x | x | x | x |
| Mechanical ventilation flow, heating, cooling | – | x | x | x | x | x |
| Mechanical ventilation energy recovery | – | x | x | x | x | x |
| Natural ventilation heating/cooling | – | – | – | x | – | x |
| Cooled ceiling (capillary tube system) | x | x | – | – | – | – |
| Free cooling with wet cooling tower | x | x | – | – | x | – |
| Free cooling with dry cooling tower | – | – | – | – | – | x |
| Radiator heating | x | x | – | – | – | x |
| Floor heating | – | – | – | x | – | – |
| Thermally activated building systems for h/c | – | – | – | – | x | x |

# OptiControl: newly developed control strategies for Integrated Room Automation

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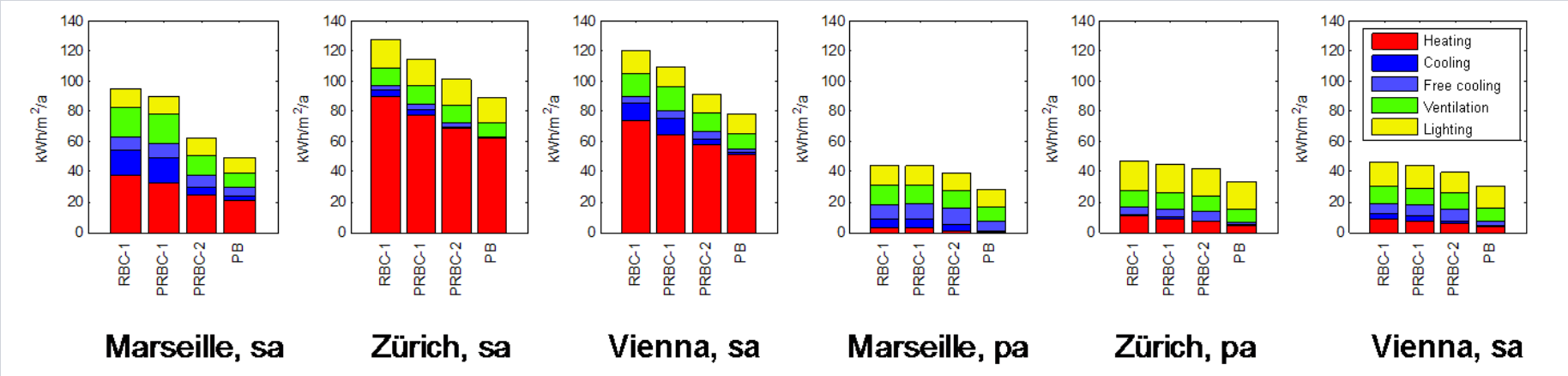
**A simulation study**

Average annual primary energy consumption for building system S2 of Integrated Room Automation, depending on the rule strategy.
Thermal insulation: Swiss average (sa) and passive house (pa).

| | |
|---|---|
| RBC-1 | Typical conventional non-predictive rule strategy |
| PRBC-1 | Newly developed predictive rule strategy I |
| PRBC-2 | Newly developed predictive rule strategy II |
| PB | Performance bound |




Additional results: [www.bactool.ethz.ch/web](www.bactool.ethz.ch/web)

# OptiControl
# Demonstration building

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**Basic information**

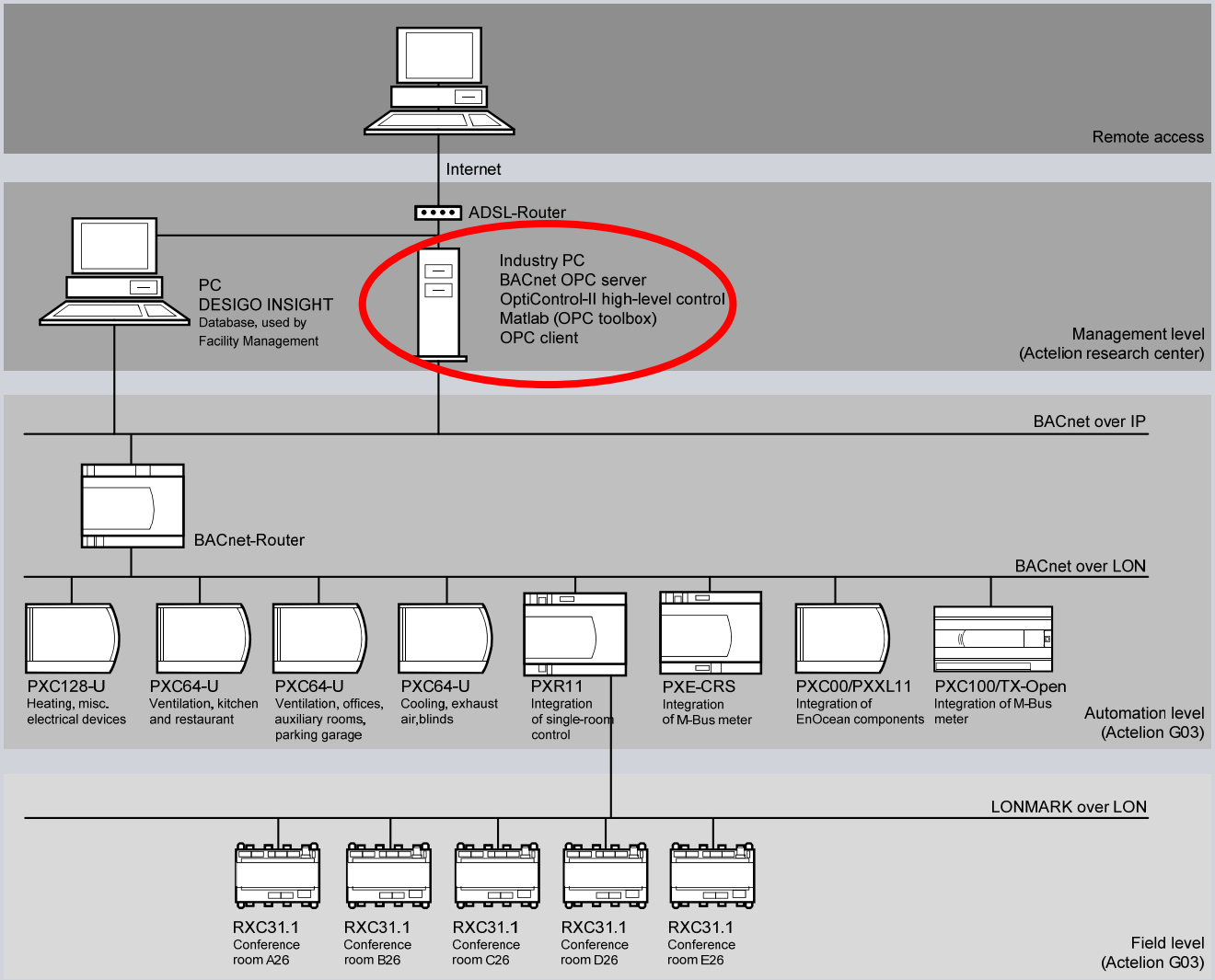
- Location: Allschwil near Basel, Switzerland
- Year built: 2007
- Size: 6 floors, gross floor space approx. 6,000 $m^2$
- Heating/cooling through thermally activated building systems (TABS), mechanical ventilation
- Usage: typical offices, administration

# OptiControl
# Demonstration building: added devices (outside)

# OptiControl
# Demonstration building: added devices (room)

# OptiControl
# Demonstration building: added devices (room)

# OptiControl
# Demonstration building: building automation system



# Closing remarks

## Predictive building automation is a promising option for the future because:

- It improves the energy efficiency and the room climate of many applications
- It optimizes the use of energy from renewable sources
- Many people understand the benefits of using weather forecasts

## The use of predictive building automation is boosted by:

- Affordable and powerful building automation systems—also suited for CPU-intensive model-based predictive controls
- High-performance communications networks
- Available low-cost additional measurement data and information
- Reliable and accurate local weather forecasts

## Results from real buildings using predictive building automation:

- Are currently available on a small scale
- Will soon become available for a wide variety of applications

# Questions & Answers