Predictive building automation – Research results from a field trial
Special event in Allschwil, Thursday, September 20, 2012

Press release

Scientific field trial confirms the effectiveness of innovative control strategies

Allschwil, September 20, 2012. As part of the OptiControl project, ETH Zurich, Siemens Switzerland and Gruner AG, together with EMPA and Meteo Switzerland, are researching solutions for the integrated, predictive climate control of buildings. The project is supported by swisselectric research and the Competence Center Energy and Mobility. Since the fall of 2011, the theoretical findings have been field-tested in a typical office building owned by the company Actelion in Allschwil near Basel, Switzerland. Initial results show that the new control strategies permit more robust and more energy-efficient control while maintaining a high level of comfort for the building users.

Predictive building automation aims at optimizing the operation of a building's technical subsystems based on predictions of relevant variables such as weather and room occupancy. The OptiControl project combines the latest developments in building technology, weather forecasting and control technology. It addresses both, predictive rule-based, and model predictive control strategies. The project combines modeling and simulation studies with tests and measurements in a representative building and operator and occupant surveys.

Scientific procedure

In Phase I of the project, new predictive rule strategies were developed on the basis of computer simulations. The project partners focused on the so-called integrated room automation, which deals with the integrated control of heating, cooling, ventilation, lighting and shading of individual building zones.

In Phase II, which has been underway since autumn 2011, the findings obtained from Phase I are being tested in an existing office building. For this purpose, additional

sensors to monitor energy usage, occupant comfort and system operation were installed in a building owned by the Actelion company in Allschwil near Basel, Switzerland. The measurements taken range from electrical and thermal energy consumption, room temperature and brightness, CO_2 concentration, relative humidity and opened windows to the presence of room users. Along its direct evaluation, the measured data is interpreted using extensive dynamic building simulations.

The building measurements and the individual automation and control tasks are integrated into a new supervisory control strategy. This strategy coordinates the interplay of all components while considering user comfort requirements, energy consumption and costs. Among other things, the strategy takes into account the building's thermal dynamics, internal loads, and weather forecasts by MeteoSwiss.

Energy and cost savings between 10 and 15 percent

The application of predictive rule-based control (RBC) and model predictive control (MPC) were demonstrated successfully in the Actelion building. The chosen hierarchical control concept has proven to be successful in practice. According to this concept a supervisory, predictive control strategy sets operating modes and setpoint values as the boundary conditions for the subordinate control.

The newly developed predictive RBC strategies are fully automatic and for the system operator easy to use. Users can easily enter the appropriate settings for the supervisory control, and there is a clearly defined procedure for its initial parameterization and commissioning. It was estimated that the use of advanced RBC strategies cuts the primary energy consumption and costs for the Actelion building's five office floors by as much as 10 to 15 percent as compared to standard control.

The MPC procedure relies on the recurring application (for example, every 15 minutes) of a mathematical optimization procedure. The latter is executed automatically and takes into account the building's thermal behavior based on a dynamic model. At present, the construction of a suitable model poses the biggest challenge. There exists a semi-automated procedure to generate a thermal model of the building from geometric and engineering data. In further steps, submodels are added for the building technical systems, the weather-related energy flows and the internal loads. The development effort can be reduced thanks to the availability of various predefined

modules (e.g., for thermally activated building systems, mechanical ventilation, energy recovery) and statistical procedures (e.g. for determining solar gains through windows). Initial simulation studies suggest that the energy and cost savings achievable by MPC for the OptiControl target building are at least as large as those of the advanced RBC strategy.

Building operator plays a key role

In addition to total energy consumption, the new control strategies are also being investigated for their effectiveness with regard to monetary cost, user comfort, peak power demand, and acceptance by engineers and building occupants. For the optimization of a building it is essential that the engineers collaborate closely with the owner and operator from the very beginning. In the case of the demonstration building, the owner (Actelion) was prepared to make several investments into the research project: upgrade and maintenance of the building installation, coordination with internal workflows, meetings on site and off site, review and preparation of documentation, implementation of the user surveys, internal communication, access to facilities also outside of business hours, etc.

The work on the demonstration building clearly showed that a rapid and safe identification of malfunctions and optimization potentials is only possible based on suitable monitoring, including the installation of possibly needed additional instrumentation. Thus, monitoring is the first necessary step for an optimization of a building's technical systems and operation. The next step to be taken for a further improvement of the building's energy efficiency and occupant comfort consists in the introduction of simple, possibly predictive rule-based control strategies.

The technical staff of the Actelion building is generally very satisfied with the new control strategies. Moreover, a web-based occupant survey has shown that also the building users are still very satisfied with the climatic conditions at their workplace.

Medium- and long-term implementation

Some of the tested RBC solutions will be introduced in standard applications offered in Siemens products, for example for the control of thermally activated building systems or for integrated room automation. Model predictive, integrated control strategies could prevail in selected applications. However, to this aim additional develop-

ment work and further experience with other buildings are needed. The integration of predictive control strategies in mass-market building automation products further makes the availability of international standards for forecast data (weather data, energy prices, etc.) necessary.

The results of the Actelion field trial show that the implementation of innovative control concepts should come into effect as early as in the planning phase of buildings. More specifically, the building management system, sensors, actuators and control components must be optimally adapted to the given building. In this context, modeling and simulation present essential tools for planning and quality assurance. For example, they make it possible to test a control strategy before it is employed in a real building. Later on, the building and its model can be operated in parallel for mutual testing and, the identification of optimization potentials, or fault detection. However, planners and engineers must first develop the necessary knowledge.

The tests in the OptiControl demonstration building will continue until March 2013. The expected publication date for the final report is April 2013.

Further information

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