Weather predictions and building automation will be tested in a pilot facility at 2,795 meters. Siemens researcher Dr. Jürg Tödtli (photo below) and partners are key players in the project.

Forecasts that Come Home

Regional weather forecasts are becoming increasingly detailed. Researchers in Switzerland hope to use this data to automatically optimize energy use in buildings while keeping costs to a minimum. Siemens engineers are providing practical help.

There are some ideas that take a long time to mature. A good example is the concept of using our increasingly accurate weather forecasts to optimize a range of building functions. Heating, for example, could be automatically increased when a cold front is on the way and reduced as soon as warmer temperatures are predicted. This would ensure a comfortable room climate and save on energy.

But today's building automation systems usually measure only current ambient values such as the outside temperature and incident solar radiation to control heating, air-conditioning systems and window blinds. At most, a smart building manager might occasionally adjust these systems as appropriate depending on the forecast and personal experience. But today's systems are not set up to perform such adjustments automatically. That is expected to change in a few years.

To facilitate this change, Swiss researchers intend to combine modern weather forecasts with innovations in building technology and control engineering in a project called "OptiControl." One member of the project is the Siemens Building Technologies Division (Siemens BT) in Zug, near Zurich. "Our objective is maximum comfort with minimal energy costs," says Dr. Jürg Tödtli, who manages the European research activities for heating, ventilation and climate-control products at Siemens BT. "Of course, before the project ends, we won't know how beneficial weather forecasts are, but I see a major opportunity here."

Since May 2007, about a dozen researchers and five institutions have been involved in OptiControl. In addition to Siemens, the latter include the Swiss Federal Office for Meteorology and Climatology (MeteoSchweiz) in Zurich, the Research Institute for Materials Science and Technology (EMPA) in Dübendorf, and two institutes of the Swiss Federal Institute of Technology (ETH) Zurich: the Automatic Control Laboratory and the Systems Ecology Group of the Institute for Integrative Biology.

The project also includes three Siemens employees. In addition, Siemens BT developed the basic outlines of the project and contributed its knowledge of the market for control engineering in buildings.

Self-Sufficient Alpine Hut. A first impression of OptiControl will be provided by the Monte-Rosa Alpine Hut of the Swiss Alps Club (SAC), which will open on July 1, 2009. The hut is a joint project of ETH Zurich and SAC, with support coming from numerous sponsors and partners. The hut's automation system is being supplied by Siemens. Since the hut will be located at an altitude of 2,795 meters, it must be largely self-sufficient. Power will be supplied by a photovoltaic system supported when necessary by a combined heat and power unit operated with liquefied petroleum gas.

OptiControl will be used to help manage the building. "For instance," explains Tödtli, "when the battery and the wastewater tank are half full and sunshine is predicted in the near future, the control system might initiate the wastewater purification process, which consumes electricity." This way, the system prevents solar energy from remaining unused due to premature charging of the battery. On the other hand, when bad weather is forecast, the purification process would be stopped, because otherwise there would be a risk of using up the power reserve in the battery and having to switch to the precious liquefied petroleum gas.

In addition to such "rule-based" processes, OptiControl offers "model-based predictive control," in which it uses a model for the thermal behavior of the building. In this case, the automatic control mechanism must be fed with data such as the heat transfer coefficient of the walls and the heat storage capacity. In combination with the weather forecast, prior user settings, and measurements for the temperature inside and outside, the control system can then calculate the optimal profile for the temperature of the heating water, for example. Functions of this sort are not possible without powerful electronics. "I wrote the first essay on the use of weather forecasts for building automation over 20 years ago," recalls Tödtli. "But only now are there processors that have enough power and are cheap enough; our method demands a lot of memory and computational capacity." Every 15 minutes, the OptiControl mechanism adjusts the system. To do this, it uses not only the implemented rules and models, as well as sensor readings, but also the weather forecast for the next three days.

"Unfortunately, no one knows the exact cost-benefit ratio of all of this," says Project Manager Dr. Dimitrios Gyalistras from the Systems Ecology Group at ETH Zurich. It is therefore not really known at this point how much energy can be saved with predictive control system. Researchers hope to establish more clarity in this regard. An initial simulation indicates a potential of 15 percent in a typical office room with integrated control of heating, air-conditioning, window shutters and lighting.

By mid-2008, a large-scale study will provide more numbers for hundreds of different scenarios and about a dozen locations — figures for one-room offices and for suites in Zurich, London, Vienna and Marseille, for example. The EMPA is contributing its expertise in building modeling. "In practical applications, the expense of installation and operation must be as low as possible," says Thomas Frank, a Senior Scientist in the Building Technologies department. In this regard, one issue that must still be resolved is how simple the models can be while still achieving satisfactory operation of the control system. "Probably about a dozen parameters will be needed," Frank estimates. "All of that can theoretically be calculated from the blueprint of the architect. What we still don't have are standardized interfaces between the architects' CAD programs and the building management software."

Weather Data Via the Internet. Since early 2008, MeteoSchweiz has been using a weather model with a spatial resolution of 2.2 kilometers. Based on ground-level grid squares with this edge length, 60 layers of the atmosphere are defined, and MeteoSchweiz's computer calculates the future weather for each cell. This makes local forecasts much more precise than previously, when the model had a grid resolution of seven kilometers. "The objective of saving energy is worth almost any amount of effort," says Dr. Philippe Steiner, who oversees the development of models at MeteoSchweiz. The organization's meteorologists provide information on 24 weather parameters, each of which can predict conditions for three days on an hour-by-hour basis. The data includes temperatures and information on wind speed and solar radiation. In the future, it will be transmitted directly into buildings via the Internet.

"Processing the data to generate forecasts involves a huge amount of mathematical calculation," says Professor Manfred Morari, head of the Automatic Control Laboratory of the ETH Zurich. "As it plans the next control command, OptiControl has to take into account the fact that more, as yet unknown information will be added in the form of new weather forecasts." For each additional step of advanced planning, the number of possibilities increases by a factor of ten to 100. The trick is to get a simple microprocessor to perform these complex calculations. "OptiControl makes no sense if you need a supercomputer for it," says Morari. "The issue of what the market will accept is essential." This understanding of the customer's needs is contributed by Siemens, with its worldwide presence and many years of experience.

The OptiControl project will end in 2010, and its first products aren't expected to appear before then. "Ultimately, the software could run in a small automation station on the wall," predicts Tödtli. "No special PC will be required and the hardware for building control won't be expensive either." But plenty of work lies ahead. Field tests are taking place at Siemens BT's laboratory in Zug. There, entire rooms are being set up to analyze the effects of a huge climate control system that generates artificial environmental conditions. The scientists can thus measure how well a building control system reacts to fluctuating outside temperatures and how precisely it can adjust the required room climate. OptiControl will also have to demonstrate its potential in that setting. "More than anything else, a good cost-benefit ratio is important," says Tödtli. ■ *Christian Buck*