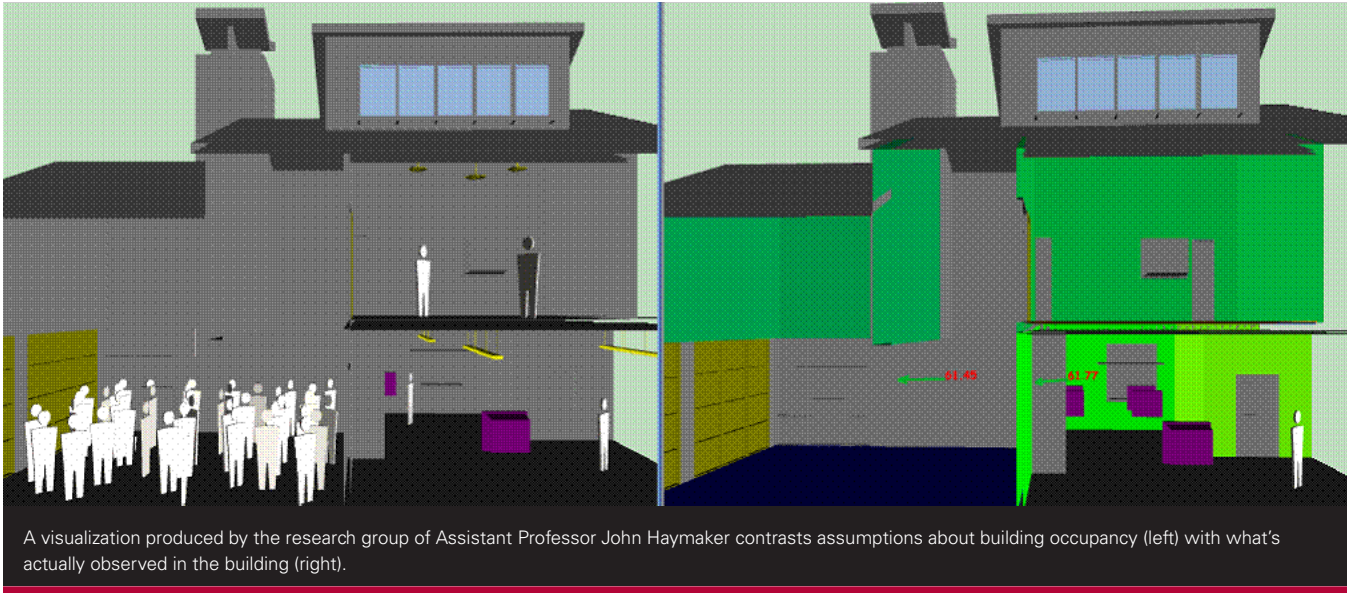


Professors strive to make building efficiency easier to accomplish



A visualization produced by the research group of Assistant Professor John Haymaker contrasts assumptions about building occupancy (left) with what's actually observed in the building (right).

BY DAVID ORENSTEIN

It doesn't take long to find examples where efforts to make buildings more energy efficient are falling short. When electrical engineering Professor Andrea Goldsmith sits too still at her desk, an overeager motion sensor turns her light off. When civil and environmental engineering (CEE) Professor Martin Fischer went looking for heating and cooling case studies, he found a building in San Francisco with such significant problems that it is now the subject of lawsuits. And when CEE Assistant Professor John Haymaker spent time observing architects, one of his more consistent findings was that they are too constrained by time and money to consider efficiency adequately. What this all means is that while architects, engineers, and builders often try to make buildings more energy efficient, they need better tools and technologies to succeed. Hoping to help, Professors Goldsmith, Fischer, and Haymaker have each launched research projects sponsored by Stanford's Precourt Institute for Energy Efficiency (PIEE) aimed at developing just such tools and technologies.

Success would mean lower energy bills and a cleaner planet. As PIEE director and management science and engineering Professor Jim Sweeney is fond of saying, "The cleanest energy is the energy you don't need at all."

Just building and operating more efficient heating and cooling would make a significant impact. Buildings use more energy in the United States than either industry or transportation. About a third of energy use in buildings powers heating and air conditioning, and in many buildings up to 40 percent of that energy is wasted, according to researchers at the Lawrence Berkeley National Laboratory. Eliminating waste just from climate

control, therefore, would reduce building energy usage—a major component of U.S. energy use overall—by as much as 12 percent.

MORE BENIGN DESIGN

John Haymaker's research focuses on providing resource-constrained and overburdened building designers with tools and guidance that will make it easier for them to improve energy efficiency.

Central to this effort is a concept called, appropriately enough, "importance." Haymaker and doctoral student Caroline Clevenger are trying to develop software that will tell a designer what aspects of a building will have the greatest impact on its energy performance. For example, will changing the insulation make a big difference, or will the kind of glass in the windows be the biggest factor? By identifying the parameters that have the greatest influence, Haymaker says, the software will give designers a shortcut to determining where to invest their limited resources.

The project is in its early stages but this summer Clevenger performed a trial with the help of 40 students, asking them to design a simple building to be efficient. In the experiment she gave only some of the students the results from the importance-finding software. The experiment is not yet sufficiently rigorous to be statistically significant, but Haymaker says, "the importance information seemed to help students come up with better solutions faster."

The research into importance grew out of Haymaker and Clevenger's observation that a presumably important factor, the building's occupants, are often very poorly modeled in building design assumptions. As part of that research they have built



software called OViz that offers a visualization of a building's occupancy through time and offers comparisons between the

“We are looking for ways of comparing the predictions made in design models with the actual operation of the buildings.”

assumptions of designers and the reality of how a building is actually used. OViz highlights which rooms are cooler or hotter than they should be and whether rooms are being occupied when they are presumed to be. Coupled with future technologies capable of ongoing monitoring, Haymaker says, the visualization could become a handy tool for building designers and operators to understand the relationships between a building's systems and occupants.

Also with PIEE support, Haymaker and doctoral student Benjamin Welle are integrating emerging tools for building information modeling and analysis into design processes that enhance project teams' ability to create energy efficient buildings that also maximize day lighting and human comfort.

Like Haymaker, Fischer has found that key assumptions made at the design stage are often flawed. The basic energy models that designers rely upon in evaluating their projects for heating and air conditioning efficiency could benefit from significant refinement, he says. The approach he's taking is to compare what the models led designers to believe with how the building, once built, is actually performing. A lot of engineers gather data about building performance, but they typically

don't use that to refine the models that designers start with.

“We can collect more data than we know what to do with,” he says. “It's entirely an art today to look at these data and find opportunities for improvement in terms of feedback to the designers. We are looking for ways of comparing the predictions made in design models with the actual operation of the buildings. We should be able to find in this big haystack of data the data sets that are worth looking at.”

Success will mean turning the art into a science, but Fischer makes no guarantees. Whatever factors are taking pristine theoretical models and turning them into flawed predictors of reality could well be difficult to parse.

“We are throwing ourselves, by design, into the middle of the messy world,” Fischer says. “It is a research question whether this problem is intractable or not.”

SMARTER SENSORS

While Haymaker and Fischer strive to improve the capabilities of building designers, Goldsmith, and electrical engineering colleagues Professor Stephen Boyd and consulting Associate Professor Hamid Aghajan are working on a key enabling technology for managing the energy consumption of any building: sensors. Thinking way beyond the thermostat, the team hopes to advance the fundamental technologies for “smart buildings.” The innovations could someday lead to buildings capable of making sophisticated, but largely imperceptible, decisions about how to save energy and money.

Goldsmith envisions making wireless temperature, motion, and light sensors that are very cheap and very low-power yet able to communicate and process information in intelligent ways.

Imagine an array of motion sensors in a room that could together be more sensitive than just one. Even more intriguing, consider a thermostat that monitors not only temperature but also spot energy prices. Such a device could, for instance, lower the temperature a degree when prices climb too high. Building occupants probably wouldn't notice—until they saw their lower gas bill at the end of a whole month.

Such ideas require innovations in three key areas, Goldsmith says: sensor hardware designed for very low power consumption, wireless network protocols to allow for the needed data exchange, and decision optimization to give the buildings their “intelligence.” The three professors on the project are perfectly placed in these areas. Aghajan focuses on low-power sensor design, Goldsmith specializes in wireless networks, and Boyd studies optimization.

In essence, the team's goal would be to make buildings participants in their own energy management.

“Most of what we have now is about very simple binary decisions: on or off,” Goldsmith says.

But ultimately a home could become smart enough to notice that its occupying family has left on a vacation. Then it could compensate for Dad forgetting to reprogram the thermostat before leaving, perhaps saving the family's finances—and the atmosphere—from needless damage.

Efficiency may be hard to achieve, but when it happens, everybody wins.

