GREEN *edge*

COMPUTER MODELING: FORGE AHEAD WITH CARE

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Using computer models to predict a building's energy use before it has been built has been perhaps the single most important advancement in building energy efficiency in recent years. Today modeling helps us design better buildings. Modeling is required in order to prove energy savings in Leadership in Energy and Environmental Design (LEED) buildings, and to demonstrate compliance with energy codes and utility rebates.

However, too much faith has been put in energy modeling without properly understanding its limitations and strengths. Software models idealize building systems and are often very inaccurate when compared to actual energy use. The few studies that have looked at modeling's inaccuracies have largely been ignored. New emphasis is needed on measuring buildings' energy performance after construction, and on understanding modeling limitations. As designers we need to use models appropriately and push for better modeling tools that make optimal design faster and more successful. Over-reliance on flawed models can have costly results. Energy modeling is not a substitute for good design principles that lower energy use.

We were interested to discover that computer simulation of temperature and indoor environmental conditions was first developed in the U.S. in order to understand bomb shelter effectiveness. Energy modeling of buildings gained momentum in the energy crisis of the 1970s when it was realized that there was a huge untapped resource of energy efficiency in buildings. In those days only mainframe computers could run energy simulations. Input files had to be submitted via 300-baud modems and then run overnight. Today a simulation takes just seconds on almost any desktop computer (although building the model takes much more time).

Despite increased processing speeds, some inherent limitations to modeling have not been overcome. Modeling creates idealized depictions of buildings. In some models all of the lights are turned off at exactly the right time instead of the variation that occurs in real spaces. Model plug loads are specific and often fixed, whereas energy use fluctuates in real conditions. All control systems work perfectly in models; we wonder whether any of our readers have experienced such a utopia? Those of use who have compared actual utility bills to simulated energy use know that building performance models tend to dramatically underpredict energy use. It is most often the idealization that is the root of the difference. One notable example is economizer cooling. In a building simulation, outside air economizers work perfectly. However a recent study of several hundred buildings in California found that 64 percent of the economizers on package units had failed. This alone can increase a building's energy use by 10 to 20 percent, invalidating the modeled results.

A Bonneville Power Administration (BPA) study of energy modeling problems published in 1990 revealed several interesting things. Models that lacked data from actual energy bills were off by "20 percent or more, and occasionally by as much as 100 percent or more." Another surprising finding was that different modelers who modeled the same building came up with dramatically different results. This reflected a fundamental flaw inherent in modeling. To quote the report: "All modelers make mistakes. Their modeling efforts, more than any other factor, contribute to poor model performance." The study also found that modeled energy savings, expressed as percentages of total energy use, were prone to errors and highly variable. When different models of the same building were compared, the energy savings predictions varied by as much as 63 percent below actual results to as much as 100 percent above real performance.

Ironically models often fail to reflect the dynamism, mistakes and unintended consequences that occur during occupancy — but the same errors and foibles of human nature degrade the design and functionality of the models themselves.

Modeling has progressed since the BPA study was written. However, further improvement is needed and many of the shortcomings have not been addressed. Important new strategies for reducing energy use are outside the capabilities of most current models. Raised floors, displacement ventilation, natural ventilation, daylighting, and radiant heating and cooling systems are difficult if not impossible to model accurately. Often efficiency strategies are overlooked because the models do not easily lead us to those opportunities. Such simple and elegant strategies as lower pressure drop piping and ducting and more efficient fan and pump selections are accepted as givens and not modeled. EnergyPlus is being touted as the successor to DOE2. Unfortunately useful interfaces for EnergyPlus are few and the inputs are

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extremely difficult. These new and more powerful tools remain susceptible to many of the inherent problems with modeling.

Modeling is here to stay. We need models in order to create "what if" scenarios for consideration, and to provide some indicators of a building's energy performance. This is essential for the LEED system. Nevertheless we need to have a deeper appreciation of modeling limitations. We have to spend more time measuring actual energy use, comparing it to our current models, and using that data to develop better simulation tools. Progress has been made on models in Europe, Canada and Australia that we can no longer overlook. For some systems, specialized models such as Computational Fluid Dynamics (CFD) and detailed hydraulic system analysis should be used instead of, or supplement to, comprehensive energy simulation models.

Most importantly, as we delve ever deeper into the intricacies of modeling, we should never leave wisdom, common sense and good judgment behind. Modeling is just one of many tools that will guide us to buildings that use fewer resources more productively and provide fundamentally better environments.

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