Team develop 'autotune' software to make it quicker, easier and cheaper to model energy use of buildings

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ORNL buildings researchers Jibonananda Sanyal, left, and Joshua New are developing software that will automatically calibrate models for simulating building energy use.

There are many ways to save energy in residential and commercial buildings. There are products that use less energy for lighting, heating and cooling; materials that better insulate and seal building envelopes; and architectural and engineering designs that lower utility bills through efficient use of space and renewable energy. In fact, experts specify up

to 3,000 parameters when modeling a building's energy use.

Building Energy Modeling (BEM) uses computer simulations to estimate energy use and guide the design of new buildings as well as energy improvements to existing buildings. BEM allows users, such as engineering firms, to adjust a building's features to meet the needs of owners and occupants while reducing energy bills.

"When modeling a building, you might be simulating for total energy saved after implementing new features. Or you may be optimizing for utility cost savings, or limiting electricity use during peak load periods, or other desired results," said Jibonananda Sanyal of the Department of Energy's Oak Ridge National Laboratory's Building Technologies Research and Integration Center, a DOE user facility that develops new building technologies and provides unique capabilities for evaluating products and whole-building systems for market.

In 2010, building owners spent $431 billion on energy. Buildings in the United States consumed 41 percent of the nation's total energy and were responsible for 40 percent of carbon dioxide emissions. Increased building energy efficiency, if widely implemented, could significantly impact energy and environmental sustainability at local to national scales.

ORNL buildings researchers Sanyal and principal investigator Joshua New have developed automated, or "Autotune," calibration software, which reduces the amount of time and expertise needed to optimize building parameters for cost and energy savings.

Over the last 20 years, DOE has invested in EnergyPlus, its flagship whole-building energy simulation tool. The tool estimates energy usage based on weather data and the thousands of input parameters related to heating, ventilation, and air conditioning (HVAC) systems, water

heating, lighting, weather interaction, occupancy schedules, and more.

Use of EnergyPlus or other BEM tools for energy-efficient, large building design is growing. But before using BEM to identify energy improvements to existing buildings, BEM parameters must first be collected, entered into the tool, and adjusted so outputs reasonably match past energy usage. This can be a time consuming chore, but it's often required to receive tax rebates and utility incentives.

"Currently, the biggest barrier is the cost of getting an accurate model of the pre-retrofit building because it requires hiring an expert," Sanyal said.

New and Sanyal's Autotune software will reduce the time and expertise needed to achieve an accurate model, and they're collaborating with universities and industry to make their approach accessible to more building engineers and owners.

"The Autotune methodology uses multiparameter optimization techniques, in combination with big data mining-informed artificial intelligence agents, to automatically modify software inputs so simulation output matches measured data," New said.

"Instead of having a human change the knobs, so to speak, the Autotune methodology does that for you," Sanyal said.

To develop their Autotune software, New and Sanyal used DOE supercomputing and computational resources—including ORNL's 27-petaflop Titan supercomputer and the National Institute for Computational Sciences' Nautilus system—to perform millions of EnergyPlus simulations for a range of standard building types with generated data totaling hundreds of terabytes. On Titan, the team has been able to run annual energy simulations for more than half a million

buildings in less than one hour using over a third of Titan's nearly 300,000 CPU cores in parallel.

Additionally, they worked with building technology experts to identify about 150 of the most important parameters. By focusing on those, they can reduce computational load while still ensuring highly accurate results. The software uses machine learning algorithms to "learn" successful versus unsuccessful paths to optimization. In this way, if similar building input parameters are introduced later, the software optimizes the results more quickly by cutting out what didn't work before.

While programmatic guidelines for tax rebates and utility incentives often require an error rate below 30 percent when calibrating building models to monthly utility bills, Autotune's fully-automated process has routinely calibrated models to an error below 1 percent on all building types tested. With such precision, an overnight Autotune process is far less costly than the time it would take an expert to manually calibrate a model.

The team is currently making Autotune capabilities available to a limited set of beta testers through a web service and anticipates making it publicly available in September 2015.

"We had to use supercomputing resources to create all the metadata used to train the software, but the Autotune software that will be available to the public doesn't require all these high-performance resources," Sanyal said. "We commonly run the software on a laptop."

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