An Occupancy Model for Energy Efficient Design

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Summary
Building designers want to design energy efficient facilities. However, today's buildings are not achieving optimal performance. This, in part, is because current energy models in the design stage are failing to accurately predict energy performance. Industry consensus is that today's models are only sufficiently accurate to enable order-of-magnitude approximations and relative comparisons between design alternatives. Without more fidelity in predictions, design of energy efficient buildings will remain more of an art than a science.

Many factors contribute to the inability of energy models to accurately predict actual energy performance. One is the underlying complexity of the calculation needed to simulate the intricate control strategies and dynamic thermal conditions of today's building and HVAC systems. Serious research is ongoing to increase the capabilities of available thermal calculation engines[1]. Another factor may be the disconnect between as-built conditions (field installation, construction quality, uncommissioned systems etc.) and design intent. Rigorous research is also being performed to improve the use energy models in verifying and validating building performance in the field[2]. However another reason often given, yet one that is less researched, is that energy modelers do not have control over how occupants use or operate the building. Modelers typically use gross assumptions about occupant usage patterns during design and analysis and little follow-up work is done to see how the occupants actually occupy the building after construction.

Our preliminary research has demonstrated that actual occupant-based building usage patterns (e.g., occupant count, lighting usage, plug loads, ventilation etc.) differ significantly from modeling assumptions in magnitude, variability and distribution. Shown here are representations of occupant densities over a single day for the Global Ecology Building, Stanford, California. Observed data is shown in the first two figures and professionally assumed data is shown in the following two figures. Note the vast discrepancy, both in magnitude, and variability.

In order to more closely reconcile predicted performance with actual, more work is needed to characterize occupant-influenced usage patterns of the built environment, and the role of this behavior in predicted energy performance. Additionally, more work is needed to develop processes for enabling energy modelers to gather, use and visualize this occupancy information in their simulations.

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1 EnergyPlus is a new-generation building energy simulation program being developed and researched by Lawrence Berkeley National Laboratory and others, with support from the U.S. Department of Energy, Office of Building Technology, State and Community Programs.
2 *Improving and Verifying Building Energy Performance,* Maile, T., Fisher, M., Bazjanac, V.

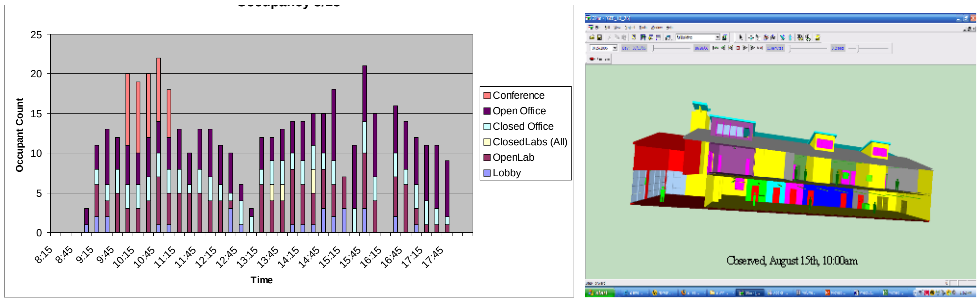


Figure 1: Global Ecology Building Occupancy as observed, Weekday, August 15th, 2006

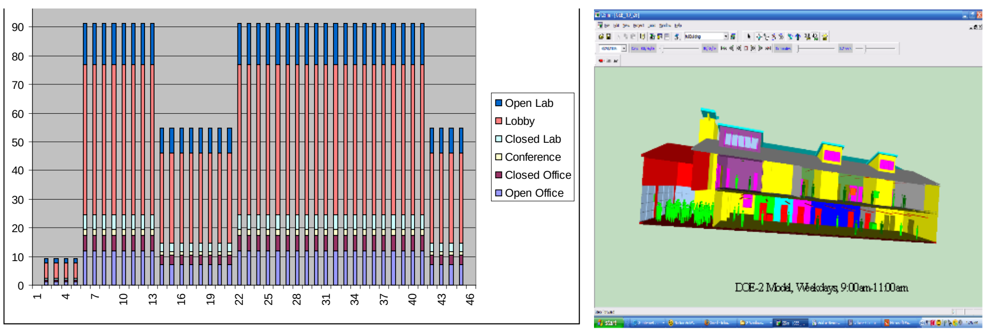
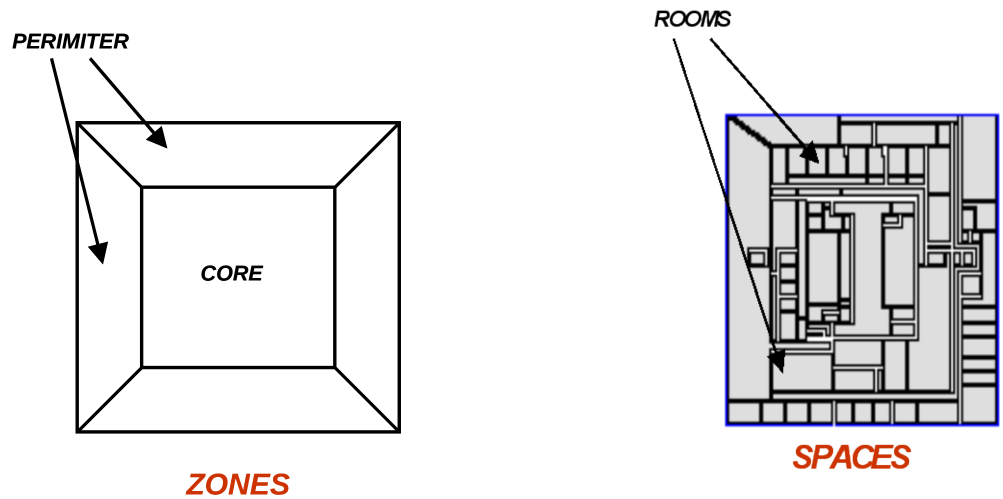


Figure 2: Global Ecology Building Occupancy as modeled, Weekday throughout the year

An emerging technology, Building Information Modeling (BIM) provides an opportunity to address some of the current modeling shortcomings as they relate to building occupancy. Traditional energy modeling practice relies on cumbersome, error-prone manual modeling and data input procedures and quality control is mostly limited to detailed review of text-based files. In order to remain manageable, traditional practice is primarily limited to zoned-based modeling using gross and homogeneous assumptions. BIM-base energy modeling allows for more automated and precise space-based assumptions to be modeled on a room-by-room basis and remain manageable. While using the same underlying calculation engines, BIM-based energy models are better equipped to handle more comprehensive and representative (custom and functionally specific) inputs. In addition, they provide greater opportunity for transparency of assumptions through the development of visualization tools which could be applied early in the modeling process.

The ability to achieve greater specificity and transparency of inputs may be keys to improving modelers' ability to better predict actual energy performance. While it is commonly understood that greater accuracy of inputs leads to greater accuracy of outputs, BIM-based energy modeling provides a fundamentally more robust and flexible framework from which to accurately represent and analyze highly variable and complex (realistic) occupant-based building usage patterns.



Traditional Energy Modeling Partitioning   BIM-Based Energy Modeling Partitioning

Figure 3: BIM enables finer grained modeling and analysis.

This research seeks to develop a more complete understanding and model of building occupancy to serve as more accurate input to BIM-based energy simulation software. Our work will develop:

- ontology and process for documenting occupant behavior.
- database of actual building occupant patterns.
- process for using this data to analyze and visualize more realistic models of occupancy
- visualizations and analyses of occupant behavior and impact on energy performance
- validation of the extent to which these improved occupant models and energy modeling processes can improve energy modeling performance.

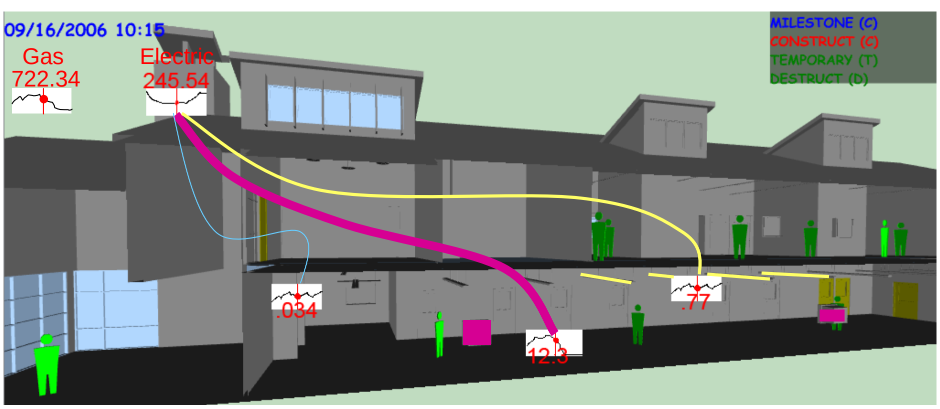


Figure 4: A visualization of occupancy and energy consumption over time, showing occupants current use of computers is responsible for most energy consumption.