Leveraging BIM for Energy Efficiency

By Sarah Hodges, Autodesk AEC Solutions

It's out there. The need to create more environmentally conscious, sustainable buildings is no longer a noble desire, but a dire necessity. Within this historical and industrial context, it has never been more important to precisely understand the progressive process of designing for sustainability and energy efficiency. Buildings in the US are accountable for consuming 38.9% of the US's total energy, including 72% of all electricity usage , and 13.6% of total potable water . According to the American Institute of Architects (AIA), buildings are the leading source of greenhouse gas emissions in the United States, yet in a new Harris Interactive poll, a paltry 4% of American adults are aware of this fact.

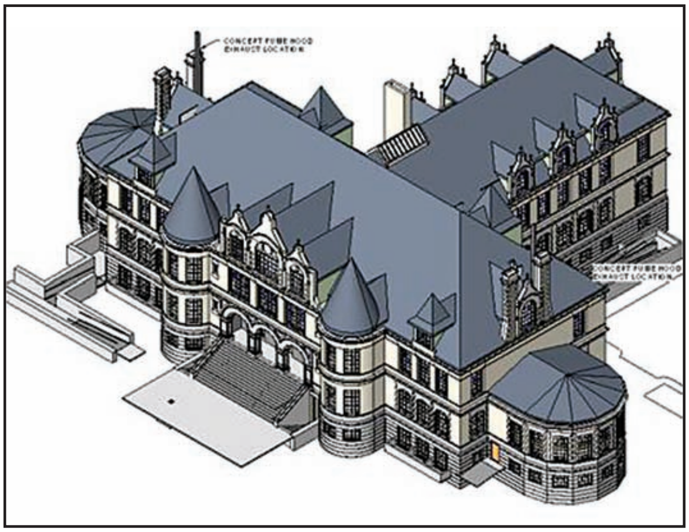
As industry professionals continue to adapt to new market forces such as rampant globalization and ever-increasing client expectations, they are being forced to design projects in more innovative, more sustainable ways. Building information modeling (BIM) is helping them to deliver on those expectations.

Simply put, BIM is an integrated process built upon coordinated, reliable information about a project from design through construction and operation. A BIM-based building design process involves the use of a digital building model created from coordinated, consistent design information—leveraged value that can be vital for green decision-making and analysis. Many industry professionals—from architects and engineers, to builders and fabricators—are using BIM methods and BIM software on green projects. To better understand how BIM can be used in sustainable design projects, let's look at how one firm is using BIM and BIM software to deliver sustainable designs to its clients.

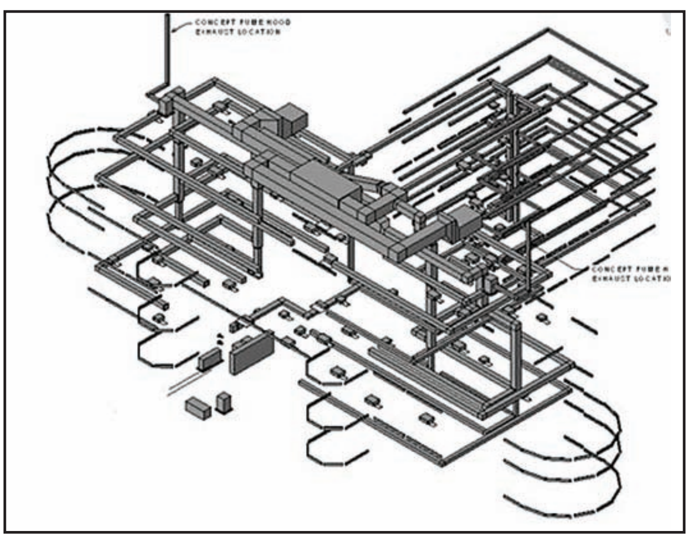
Glumac is a mechanical, electrical and plumbing (MEP) consulting engineering firm with over 250 people in 8 offices up and down the west coast of the United States. Founded in 1971, Glumac provides MEP engineering services to its clients in the commercial, healthcare, institutional, and advanced technology market sectors. The firm currently employs almost 80 LEED-accredited professionals and all of the firm's principals and associate principals are LEED-accredited as well. So every project it undertakes is staffed with sustainable design experts.

One of Glumac's current projects is the 1100 Broadway building—a new 20-story LEED Silver office building to be built in Oakland, California. The high-rise glass tower is prominently located in the downtown area and will connect to the newly renovated Key System Building façade, a National Historic Landmark. The real estate glossy brochure about the project is a testament to the growing importance of sustainability. As expected, the brochure highlights the building's amenities; prominent downtown location, panoramic views, easy access to public transportation, on site parking, etc. In addition, the brochure gives equal billing to the project's green features: photovoltaic solar panels; high efficiency HVAC system with under floor air distribution; high performance glass façade; and green roof and rainwater collection, filtration and reuse systems.

“Like all of our sustainable designs, our goal on this project is to save as much energy as possible without sacrificing the quality of the design,” says Skander Spies, an energy analyst in Glumac’s Portland office. “Energy modeling is essential to achieving that goal.” Glumac used the BIM-based design model in conjunction with a building energy use analysis tool to analyze the potential savings of various green design features: daylighting shelves; different types of window glazing on different building façades; and the efficiency of assorted equipment needed for the under floor air distribution system. Glumac used the 3D geometry inherent in the BIM design model as the basis for its energy modeling, creating a simplified version of the architectural model suitable for energy analysis. “By leveraging the architect’s digital design data, we’ve been able to significantly cut down the amount of time it takes for us to do our analysis,” reports Spies. “On average, we experience a 50% time savings just for the geometry creation.”



“With BIM software, we’re getting a lot more value out of a centralized model that we can all leverage for our own needs. The mechanical design team, the CFD analysis team, and the energy modeling team can all share the same model,” says Skander Spies, Energy Analyst at Glumac.



On the 1100 Broadway project, the Glumac team used their BIM-based design model to quickly perform “what-if” analyses for an under floor air system versus a traditional overhead system—quantifying for both the architect and the building owner the energy and cost savings.

Although the time savings itself it beneficial, Glumac feels that the real value of BIM in this situation is their ability to provide feedback to the architect earlier in the design process. “A key success factor for getting sustainable measures incorporated into a project is providing high-quality feedback to the extended project team throughout the entire project,” remarks Spies. “It starts by introducing sustainable concepts to them that they may not have experience with, and then continually revising the design and giving them feedback and analysis results throughout the entire design process.”

Continual, informed design revisions based on constructive feedback and analysis benefits the entire design process. Being able to explore multiple scenarios, gain rapid feedback, and—both visually and analytically—communicate concepts and results helps mechanical engineers optimize their designs and push the design envelope beyond traditional capabilities. “For example,” says Aryn Bergman, a mechanical engineer and energy analyst in Glumac’s San Francisco office, “On the 1100 Broadway project, we used a BIM-based design model to quickly perform ‘what-if’ analyses for an under floor air system versus a traditional overhead system—quantifying for both the architect and the building owner the energy and cost savings. The integration of the BIM-based design model with energy analysis software and computational fluid dynamics packages is essential for that kind of timely feedback."

Once the decision was made to use an under floor air system, Glumac engineers used that same BIM-based architectural design model as the basis for their own MEP design model, beginning with load calculations—exporting the geometry to a neutral gbXML format and then importing that into Trane's TRACE software. In addition, airflow and load calculations for each room were then posted back to the design model as room attributes—for specific equipment and ductwork sizing.

As the MEP design progressed, Glumac could leverage their partner's BIM-based models for design coordination. "This project is a complete building approach that needs to be treated holistically," says Bergman. For example, integrating under floor air distribution in a building design affects the entire building; the floor-to-floor height, the structural design, the electrical distribution, etc. By coordinating its MEP design with the architectural and structural building information models, Glumac could identify issues early in the design phase that under normal circumstances might not be caught until construction. Bergman cites this example, "We were supplying the air coming out to the floor from the core and there was an issue where one the beams coming down was cutting off the area that we needed for our air supply." The structural engineer moved the beam, but that new location restricted the area near a door that was needed to bring furniture onto the floors. By "seeing" the design in the BIM-based modeling environment, the design team was able to detect that problem and develop a solution immediately—averting a much more serious problem if the beam was installed.

The robustness and quality of a BIM design model is they key to its value for multipurpose design and analysis, embodying the wealth of information necessary for sustainable design. "Before using BIM, we had unconnected design instruments—a set of drawings for the design, an energy model that we had to built from scratch for our energy analysis and load calculations, another model built from scratch for CFD analysis, and so on," remarks Spies. "But with BIM software, we're getting a lot more value out of a centralized model that we can all leverage for our own needs. The mechanical design team, the CFD analysis team, and the energy modeling team can all share the same model." In addition to design and analysis functions, the model is used to obtain material quantities—to determine percentages of material reuse, recycling, or salvage. Standard orthogonal drawing views are created directly from the model (which the BIM software automatically coordinates with the model)—improving the efficiency and accuracy of green certification. And the model can be used to produce advanced visualizations such as solar studies or 3D views and renderings—for better understanding and collaboration between all the stakeholders in a project.

Below is a snapshot of Glumac's energy metric table created for the project—BRE's Villa Granada, a large high residential apartment complex currently being built in Santa Clara. Note: To calculate the estimated savings, Glumac leveraged their BIM design and performed an energy analysis in eQuest (DOE 2.2) and then contrasted those results to a Title 24 baseline design (Title-24 is California's energy efficiency standards for non-residential and high rise residential buildings) to get comparisons for electricity and natural gas consumption. They then took an average electrical cost ($/kWh) and thermal cost, and multiplied the differences in the baseline

Electricity Savings	Natural Gas Savings	Estimated Utility Savings	Est. % Utility Savings	Estimated Initial Costs	Simple Payback Period	Int. Rate of Return (IRR)
kWh/yr	therms/yr	$/yr	%	$	years	%
1,135,668	18,437	$144,039	39.1%		0.0	N/A

and design models to get the estimated annual utility savings.

Summary

Achieving optimal sustainable design—with an ultimate goal of carbon neutrality—requires innovative and collaborative methodologies for design and analysis that extend beyond traditional 2D and schedule-based analysis. Even the most insightful and informed mechanical engineers cannot perform the analysis necessary within their design budgets without appropriately leveraging the architectural information and efforts of other design team members. BIM provides a rich repository of intelligent data for immediate use during early conceptual design and analysis phases.

Source: Energy Information Administration - http://www.eia.doe.gov/
Source: Environmental Information Administration (2008). EIA Annual Energy Outlook.
Source: U.S. Geological Survey (2000), 2000 data.