

DESIGNING BUILDINGS FOR REAL PERFORMANCE



Energy modelling must deliver the goods

The next great leap in the design of sustainable buildings is measuring and reporting the operational building performance. Traditionally design teams have ensured buildings are built as designed but have had limited involvement in the operation of a building. New rating systems, building codes and client contracts are dramatically changing this. Design [and construction] teams are being asked to specify and guarantee the maximum annual energy use of their buildings as estimated using energy models. This creates complex new relationships between designers, energy modellers, contractors and owners. This article explores what is driving the market toward actual energy performance, tools that are used to accurately estimate energy usage, guidelines on how to achieve accurate energy modelling results, and methods to verify performance.

By David Mead

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WEST FACADE OF THE FEDERAL SOUTH BUILDING 1202, THE REDEVELOPMENT AND EXPANSION OF AN A EXISTING WAREHOUSE INTO A FLEXIBLE, HIGH-PERFORMANCE HEADQUARTERS FOR THE US ARMY CORPS OF ENGINEERS [1]

What is driving the market toward actual energy performance?

The building market has been transformed by LEED in the past 10 years. Recent criticism of LEED mostly relates to how a number of LEED buildings have not performed as expected in regard to their actual energy usage. Critics have focused almost exclusively on actual energy performance, showing how scandalous it is that LEED certified buildings aren't as energy efficient as similar non-certified projects of the same era. This is a great example of critics misrepresenting a rating system which was never exclusively about energy performance. Energy performance is part of the rating system but a building that is net zero may not be LEED Platinum, since site, indoor air quality and innovation are also evaluated for LEED certification.

Critics use energy as an easy target to compare buildings. But criticism is valid when looking at how some LEED buildings have not been performing anywhere close to their expected energy usage. Clients, building codes and rating systems are starting to demand more from design teams so that buildings perform as predicted.

Many other green building rating systems are calling for actual energy performance. The Passive House system is a great example where maximum energy usage thresholds must be met in the first year of building occupancy. The Architecture 2030 challenge, Living Building Challenge, Net Zero Energy Certification and Energy Star all look at actual energy performance. By comparison, LEED has a design energy model that it compares to a hypothetical baseline building defined in ASHRAE/IES/ANSI 90.1. There are advantages to the LEED method in that it helps manage the liability to the design team to guarantee performance of a building that they won't occupy. Building owners often run buildings in very inefficient ways and design teams have no control over this.

One would be hard pressed to find many people interested in guaranteeing performance that is greatly out of their control. It can be compared to agreeing that your neighbour will stay on a weight loss program. You design the diet plan and give it to your neighbour for them to implement. They have an entire year to stick to the plan and you have to guarantee they will lose a certain amount of weight. The plan may be a brilliant design that could get anyone to their target weight but it is up to them to implement it.

The flip-side to this is that the diet plan might be too aggressive to actually be implemented by anyone. LEED energy modelling reviews are meant to identify projects like this and keep them from getting many energy points. But the LEED energy models are based on design and much can happen in the construction process that can change the performance. In addition to this, ASHRAE/IES/ANSI 90.1 also has a number of loop holes that allow certain building and system types to get higher savings out of projects than would be expected because the baseline building results shift higher.

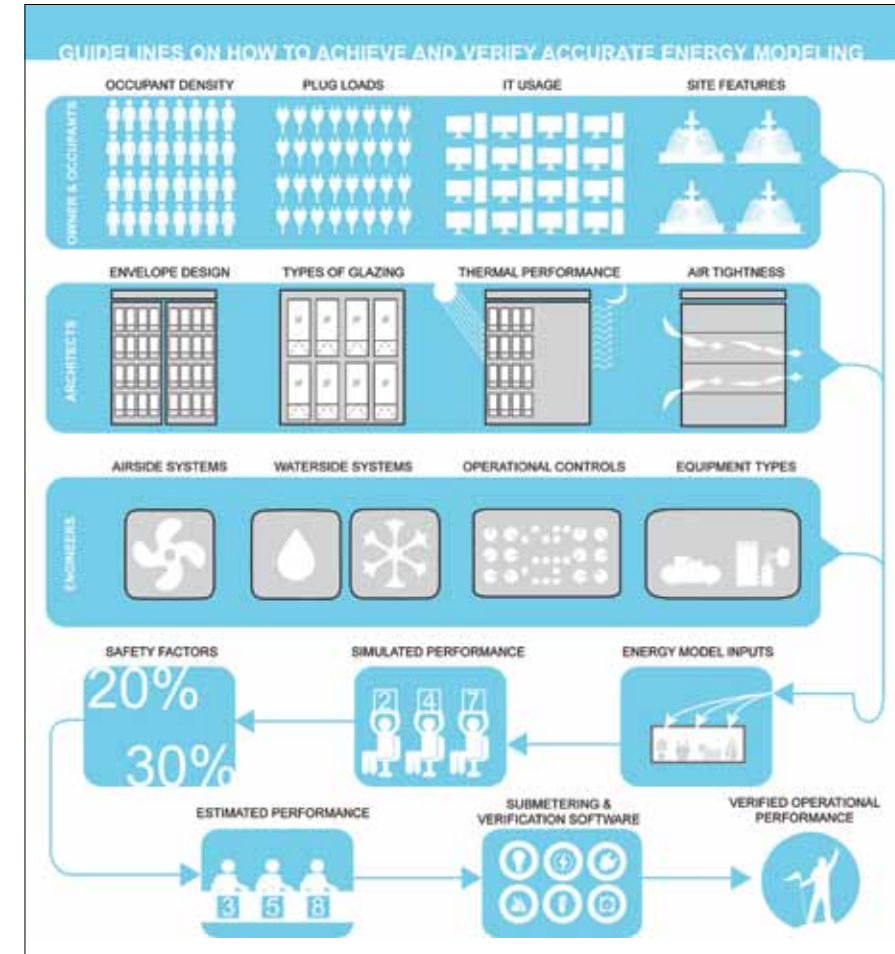
Rating systems that look at the actual energy performance of a building can avoid the complexities of design versus baseline energy model and begins to silence the critics. This is attractive to owners but creates a challenge for the design team, owner and operator to work together to achieve a common energy goal.

Energy modelling is as easy as clicking a button!

There are many energy modeling tools available that can estimate energy usage. Until recently most of them have been quite complex and hard to learn. Many required writing code, interacting with complex scripting and significant amounts of exporting for post processing in spreadsheets. A number of newer software tools claim to simplify the process and allow users to get results out very quickly with very few inputs. Though the idea is intriguing, in practice these tools are actually very dangerous for design teams that do not have the knowledge to weed out bad data.

One excellent example of software like this being marketed heavily to the industry at the moment is Sefaira. This software uses cloud computing to get virtually instantaneous results, including whole building energy use intensity [EUI] numbers. With almost no inputs a designer can know how a building is performing. But how can this be? How can design teams trust a number that makes hundreds of assumptions on building occupancy, operations, system design and building detailing. Tools like this create significant liability for a design team if they promise a certain level of energy performance [like an EUI of 22] without understanding what they are promising. Future lawsuits could be on the horizon if tools claim to show energy performance and design teams blindly use them.

Sefaira can be used for comparative analysis early in the design process but care should be taken with software like this as many of the variables it assumes can make comparisons almost useless. An example of this is comparing the façade loads on a building with a VAV system versus one with passive chilled beams. The need for solar control is very different for each of these system options as VAV needs very little solar control compared to chilled beams in most climates. If a design team shows the benefits of the solar control on a façade for a VAV system it will be wildly off from what is needed for chilled beams. To a designer who is unfamiliar with the complex relationship between the building envelope and the building systems, tools like Sefaira can easily become little more than random number generators, wasting a design team's time with inputs that have nothing to do with their project. This has been acceptable in the industry when buildings don't have to operate as designed but care must be taken as clients are demanding better estimates for building energy performance.



Tools that are used to accurately estimate energy usage

The first priority is choosing the right tool for the job. There are a number of energy modelling programs available that have enough inputs to accurately model building performance. The programs used the most in North America are eQuest, IESVE and programs that use EnergyPlus as an engine. For instance eQuest does not accurately model radiant systems like chilled beams. IESVE has limitations on its output reports and is known to be quite buggy at times. Programs that have EnergyPlus as an engine often only use portions of the software. DesignBuilder for instance uses EnergyPlus in the background but many of the HVAC systems in EnergyPlus still aren't available in DesignBuilder.

It is best to work with professionals with experience with these programs to ensure the right tool is selected for a job and reasonable results are generated. All of the programs have nuances that can take years to understand properly to generate sound results. Good consultants can work with a design team to get energy estimates out early and quickly to inform the design process. They can then use the same models refining inputs from the owner and design team as the design evolves.

Guidelines on how to achieve and verify accurate energy modelling results

Getting the best, most realistic assumptions on how a building will be used is of paramount importance to achieve accurate energy modelling results. This includes diligently working to get good estimates of expected plug loads, occupancy schedules, occupant densities, IT computer schedules, the scope of servers and additional site features. Each of these items could take an entire article to cover properly but the key point is that design teams need to get realistic inputs for all of them as they can have dramatic impacts on actual energy usage. One example from a recently completed project was a water feature in the site. It was a design build water feature that wasn't part of the design team's documents. The pumps for the feature were an open loop with 12 ft. of head which uses large amounts of energy. For this specific project the water feature was using up to 10% of the total site energy. Items like this are considered "process loads" in LEED energy submissions but they have to be properly accounted for when teams are asked to accurately predict energy usage.

When guaranteeing energy performance it is wise to add safety factors to cover items that can be unexpected. It is common for a 20% safety factor to be applied to energy modelling results when having to guarantee performance. This is especially wise when occupancy schedules, densities and plug loads aren't explicitly defined for the design team.

Methods to verify performance

As actual energy usage is becoming the industry standard, better methods to measure and analyze energy performance are needed. Most buildings have only had utility meters on them with little ability to understand what is actually using the energy in the building. Even when submeters have been installed it is often hard to collect this data and convert it in a usable format.

Case Study

LEED has included a measurement and verification credit until the release of LEED v4. The new version is calling for a minimum level of sub-metering as a prerequisite and an advanced metering credit has been added. The point of these credits is to ensure buildings can properly measure what is using energy. Once all of these systems are measured, buildings still need intelligent communication networks that can collect the data and make it accessible to owners, operators and design teams.

A number of newer software programs have created an interface to this data while also adding automatic fault detection. One example of this software is SkySpark which is a flexible program that can open up data to show what is actually happening in a building. In the past this data was often only available as data dumps out of a BMS with massive amounts of spreadsheet work to make it usable. If teams have a complex building where actual performance matters it is critical to sub-meter the major energy users and have a platform that can reveal what is happening in the operation of the building.

In order to illustrate how actual energy performance matters, the following case study provides an example of a building where an energy performance guarantee was required. A second case study of a building with a net zero design can be found in the online version of this article at www.sabmagazine.com. Both buildings had to estimate performance, and the actual energy usage has been scrutinized by the design team and owner.

Federal Center South

Federal Center South is the district headquarters of the U.S. Army Corps of Engineers located in Seattle. The project is an excellent example of a high-performance building that was built with a design-build guaranteed performance contract. The guaranteed energy performance target required the design build team to meet an energy goal 30% better than the ASHRAE/IESNA Standard 90.1-2007 baseline model, or an effective EUI of 27 kBtu/ft²/yr.

THE DESIGN SOLUTION INCLUDES OPTIMIZED BUILDING ORIENTATION AND INTEGRATES ACTIVE AND PASSIVE SYSTEMS, MATERIALS, AND STRATEGIES THAT PLACE THE 1202 BUILDING WITHIN THE TOP 1% OF ENERGY-EFFICIENT OFFICE BUILDINGS IN THE U.S [2].

A portion of the overall contract award was retained until the first year of operation was verified. The retained fee was nearly \$400,000 which gave the design-build team significant incentive to ensure the building operated as planned.

Measuring the performance of the building started about three months after substantial completion of the project. During the first quarter of operation a number of items were identified that were causing energy usage to be higher than expected. These items were identified and modifications were made to get the building back on target. After the first quarter the building was on track to meet its guaranteed performance and succeeded at the end of the first year of operation through the combined efforts of the M&V team. The adjustments to the building operation from M&V save the USACE up to \$40,000 a year. For more information a detailed case study article for this project can be found in the Fall 2014 issue of High Performance Buildings.

RECLAIMED TIMBER BRIDGES AND STAIRS THROUGHOUT THE COMMON ATRIUM CONNECT PEOPLE ACROSS THE BUILDING, AND ARE STRATEGICALLY LOCATED AROUND INFORMAL SEATING AND TOUCHDOWN WORK SURFACES [3]. ALL PHOTOS BY BENJAMIN BENSCHNEIDER, COURTESY ZGF ARCHITECTS LLP.

This example, together with the Conrad Hilton Foundation featured in the web version of this article, show how actual energy performance is really starting to be a priority for clients. Performance guarantees are even starting to be part of building codes in some jurisdictions. Seattle is currently experimenting with actual performance as part of the building permitting process. Whether through a permit, rating system or for information, it is great that the industry is learning how buildings actually perform. This will help design teams make decisions to improve building performance and reduce global emissions. ◀

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