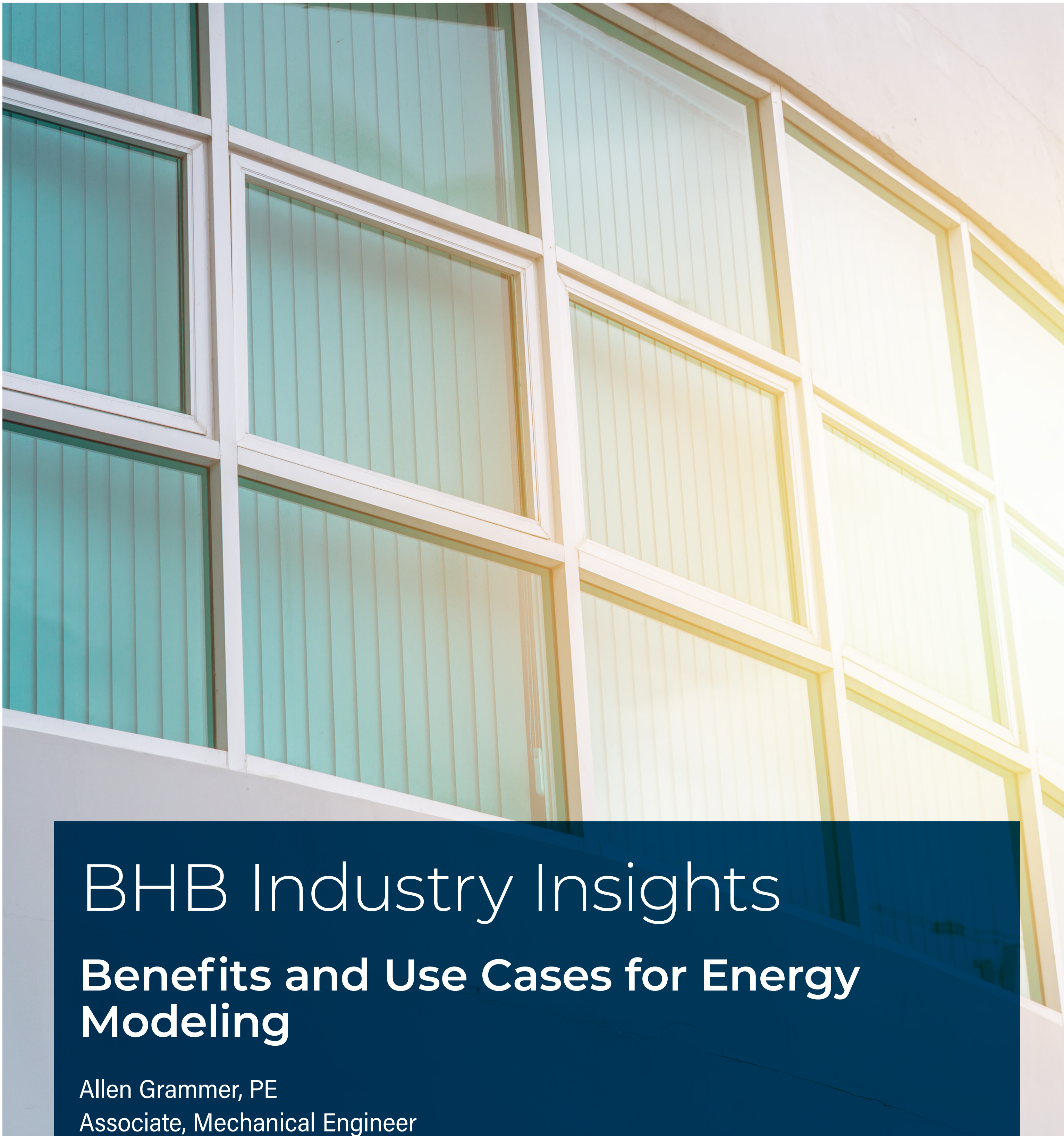

BHB Industry Insights

Benefits and Use Cases for Energy Modeling

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How to Put Energy Modeling Information to Use During Design

Building energy modeling (also known as energy system modeling) is a process used by mechanical and electrical engineers to evaluate energy consumption. It provides a computerized simulation to compare and evaluate the energy consumption, CO2 emissions, peak demands, costs, and renewable energy production for a wide variety of design or facility operation options. This model is used to determine opportunity costs of decisions made during the design process, as well as to inform the design team and the building owner of potential facility operations decisions that could be made throughout the life of the building.

This white paper will provide an overview of the following types of energy modeling and how they can help a design team make quick adjustments to measure the impact on a building's performance:

- Schematic Models
- Detailed Models
- Energy Models
- Calibrated Energy Models

Some may consider energy modeling to be reserved to evaluating energy usage for engineered systems such as HVAC and lighting. However, energy modeling can be applied to evaluate all aspects of building design and usage, from occupancy schedules, to building materials, and even different shading options or negotiated utility rate schedules. There is an assumption that energy models are only provided at the end of a project, to assess the completed design for compliance with the varying types of sustainable design registrations. While that is a common application, energy modeling can be a valuable tool at any stage of the design of a new construction or renovation project.

A common question from architects and owners is whether an energy model is worth the effort. The short answer to that question is yes. While energy modeling for LEED, for example, can be complex and time consuming, many schematic and design energy models can be quick and relatively easy. These high-level energy models are designed to look at a set of design options holistically, to determine the most energy efficient or cost-effective path. For a relatively small initial investment, an architect or owner can move forward with confidence, knowing they are pursing the most efficient design option.

Types of Energy Models

Overview

In a new construction project, the design team can make use of several different types of energy modeling:

Schematic Models

Schematic models are used during the schematic design phase of a project. These models enable the design team to see how simple improvements early in the design process will affect energy use, often providing feedback within hours. These are typically simple comparative models – often focusing on building-level differences in insulation levels, mechanical system options, and building orientation on the site. This is often the most effective type of energy model because informed design decisions can be made early to help focus the team's efforts (and the owner's budget) where it will provide the most benefit.

Detailed Models

Detailed models are used during design development and the construction documents phase of a project. These more complex models help the design team and owner decide on more nuanced topics, such as whether a highly reflective roof will pay back for the owner over a traditional built-up roof, or which window shading configuration is the most effective for a row of south-facing offices.

Energy Models

Energy models used for third-party certification against sustainable design standards (ASHRAE Standard 90.1 and USGBC LEED, for example) are the most complex type of modeling. They require early planning and detailed modeling of the final design. LEED documentation has historically been treated as more of a certification process for a green project after that design is complete, however LEED v4 has added several planning and modeling requirements early in the design. With these changes, the USGBC is working to evolve this perception, and establish LEED as a framework for informing the entire design process. That framework enables the LEED certification to be used as a marketing and recruiting tool for owners – an outward symbol that this building was designed and constructed with sustainability and user-experience in mind.

All the energy models discussed above are typically performed during a new or renovation project design phase. However, some energy models can be extremely useful even before a project has begun. In an existing building, calibrated energy models can provide valuable insight to an owner about options to reduce energy consumption, or strategies to get the most out of every BTU (British thermal unit - a measure of energy content) available at a central plant.

Calibrated Energy Models

Calibrated energy models are done as part of an energy or cost savings effort. This model will help owners, facility managers, and design teams understand their existing systems to make informed decisions about potential renovations. In some cases, this model will show that rather than new systems or equipment, changes to facility operations are a solution to an owner's plant capacity or energy cost savings needs. These models are similar to a detailed model during design, but with the added step of calibrating the model back to match the existing building's energy usage using the owner's utility bills or control system trend data. Once the model matches the real-world building, tweaks to the building systems or operation in the model can show how the real building energy usage could change.

Test Model

Energy modeling at the schematic phase can help the design team make quick adjustments to measure the impact on the building performance. As stated previously, we can rotate the building, change window types, or even try different mechanical systems on a building to see if the additional cost for these upgrades (or investments) has a payback that we are willing to accept. To show this, we have developed the following case study:

The sample project we reviewed was a two-story, 'H'-shaped office building, measuring 200' x 100', with the long side facing north, located in Fort Worth, Texas. Each floor is the same size with similar office functions.

We wanted to explore the impact of the following items on the anticipated annual energy cost of the building:

- What if the building was angled at 45° on the site instead of true north/south?
- What if the building was turned 90° so the long side faced east/west?
- From the best orientation, would window tint be worth the investment?
- Would a chilled water system make sense?
- Should I install a better building control system?

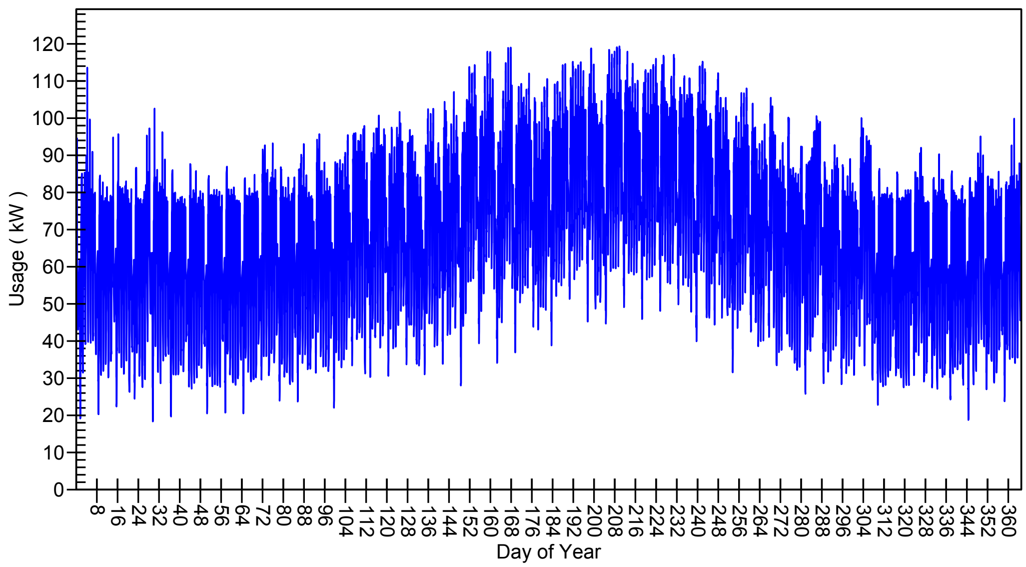
After the base building design was modeled, even with several assumptions to make the model easier to build at the schematic level, the energy simulation software lets us rotate the building and make copies of all systems. For the base building design, we assumed using package rooftop units (one per floor) that operate at variable air volume with downstream VAV boxes using electric heat. The results of the building rotations are presented in Table 1.

Table 1 | Annual energy cost for the same building at different orientations

	Base Building	45° Rotation	90° Rotation
HVAC Sub-Total	$16,207	$16,254	$16,278
Non-HVAC Sub-Total	$32,315	$32,315	$32,315
Total Annual Cost	$48,522	$48,569	$48,593

For the proposed building construction, which matched Energy Code minimums for the Fort Worth area, the orientation of the building did not have a significant impact on energy cost, so we can proceed with the base building design with the long dimension facing north/south.

Figure 1 | Example load profile for base building



We could then duplicate the base building and replace the windows with a double-pane glass that has grey tint on the exterior pane. Running the models again yielded the results in Table 2.

Table 2 | Annual energy cost for the base building with tinted windows

	Base Building	Low-e, Tinted Windows	Additional Insulation
HVAC Sub-Total	$16,207	$14,045	$16,000
Non-HVAC Sub-Total	$32,315	$32,315	$32,315
Total Annual Cost	$48,522	$46,360	$48,315

From the quick analysis, the HVAC energy cost was reduced by an attractive 13.3%. If this is a 30-year building, we can plug that investment cost into a lifecycle cost analysis to determine if the return on investment is worth it. This does show that it is something that should be reviewed further. This also led to a decrease in the size of the mechanical cooling needed for the building, which will decrease the size of the HVAC equipment, the cost of the equipment, and the future replacement costs. This could also decrease the size of the electric service for the HVAC equipment.

The building in our study included metal framed walls with 3 1/2" of batt insulation between the studs. A 3/4" insulation board was then installed prior to the interior gypsum board to provide our continuous layer of insulation. The roof was design as a metal deck with 3" of tapered insulation on top. Adding additional insulation in the wall, to increase the board insulation to 2", and increasing the taper on the roof to 4", did not have as significant of an impact on the energy usage, saving only 1.3% of the HVAC energy cost.

Table 3 | Annual energy cost for the base building and different mechanical system options

	Base Building	Chilled Water	Chilled Water with Building Controls
HVAC Sub-Total	$16,207	$18,817	$15,026
Non-HVAC Sub-Total	$32,315	$32,315	$32,315
Total Annual Cost	$48,522	$51,132	$47,341

From the schematic analysis, we can see that different mechanical systems can offer improvement over the base package rooftop system for this building type and size. It is important to note that economic impacts vary greatly based on the type, shape, and construction of the proposed building. This makes sense when we consider that the chilled water system will have additional components that will benefit from an improved energy management plan. It is worth noting that for the chilled water system, we saw significant improvement in energy cost by implementing an advanced digital building control system that would allow the different components to communicate and make better energy choices, such as temperature setbacks and water-side and air-side economizers. There are up-front costs to consider, but at this point the owner can decide to see what that investment cost might be and see if $3,800 savings per year would make sense.

These numbers are highly schematic and would not be offered to the client as a guaranty of performance, but it does give the design team a relative feel for the impact of different construction options. Schematic models enable us to "what-if" the project in several different ways, but should also be balanced to manage time spent on the study for the potential gain to the project.

Bottom Line

In today's design and construction industry, budgets can be slim and building owners and occupants are becoming increasingly aware of the sustainability of their environment. Clients are looking to get the most bang for their buck, and energy modeling can pinpoint cost-effective energy savings options. Those models can also help create a welcoming, sustainable environment for occupants to enjoy at the same time.

Energy modeling helps create better designs. And they are most effective if brought into the design process as early as possible.

Have a question about energy modeling? Send us an email at mail@bhbinc.com.