Carrier Engineering Newsletter

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Optimizing LEED® 2009 for New Construction: Energy Modeling

There is an emphasis on reducing building energy use in Leadership in Energy and Environmental Design (LEED®) 2009. The number of LEED points currently possible in Energy and Atmosphere Credit 1 (Optimizing Energy Performance) has grown to 19. This is almost double LEED New Construction (NC) 2.2. This first issue of the Carrier Engineering Newsletter discusses ways to approach, streamline and optimize the process of LEED Energy Modeling.

Many projects today set goals that involve high performance building designs often with LEED certification as a requirement. Meeting the intended goals of the new design requirements involve taking the right approach from the very beginning. The first objective of this article defines the importance of the mechanical, electrical and plumbing (MEP) engineer's participation in the early schematic stage of a building design.

A solid foundation results from collaborative design participation during the early stages of a project. However, for LEED Energy Atomsphere Credit 1 (EAc1), a working knowledge of software modeling capabilities is equally important. Therefore, the second objective is to describe the modeling techniques and best practices along with key software features the MEP engineer can use to contribute effectively to the preliminary and ongoing tasks involved in a LEED EAc1 analysis.

Traditional Project Approach

Traditionally, an owner and architect set the building orientation, envelope design, fenestration, massing decisions, and more, long before the MEP engineer gets involved or is even hired. By the time the engineer is on the project, many of the decisions affecting the energy consumption and indoor environmental quality of the building may have already been made. It then becomes an uphill battle to achieve the desired energy results and optimize the points in EAc1. If however, an MEP engineer can contribute to initial decisions on these topics that affect the ongoing energy consumption, the chance of meeting high-performance objectives increases greatly. Software tools that incorporate features designed to assist in early decision-making complement early involvement of the MEP engineer, contributing to high performance design success.

Solution to Problem

A design charrette is a popular and recommended way for the MEP engineer to affect the building design. Charrettes are a relatively quick, intensely focused workshop where architects, engineers, contractors, building owners, equipment suppliers, and other stakeholders convene to develop best solutions. Ideas can flow that may save energy over the life of the building. Preliminary heating, ventilating and air-conditioning (HVAC) system comparison modeling is especially effective and beneficial during these sessions.

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Traditionally, mechanical engineering firms were less likely to do a HVAC system comparison unless required up-front in the design scope. Now however, modeling software may include built-in features that allow up-front comparison work to be considered on just about any project. Even if an engineer inherits the drawings from an architect with little previous knowledge of the building, there are still ways to explore energy savings with a minimum expenditure of time and effort.

Here is an example scenario from a charrette: A one floor building in Denver is being planned. A best practice would be to analyze the building quickly using scoping tools in the modeling software long before final design. The building floor plan can be quickly modeled with thermal blocks as shown in figure 1. Creating thermal blocks typically simplifies the model without sacrificing accuracy but does requires engineering judgment. The key principle is to combine similar zones into a common thermal block.

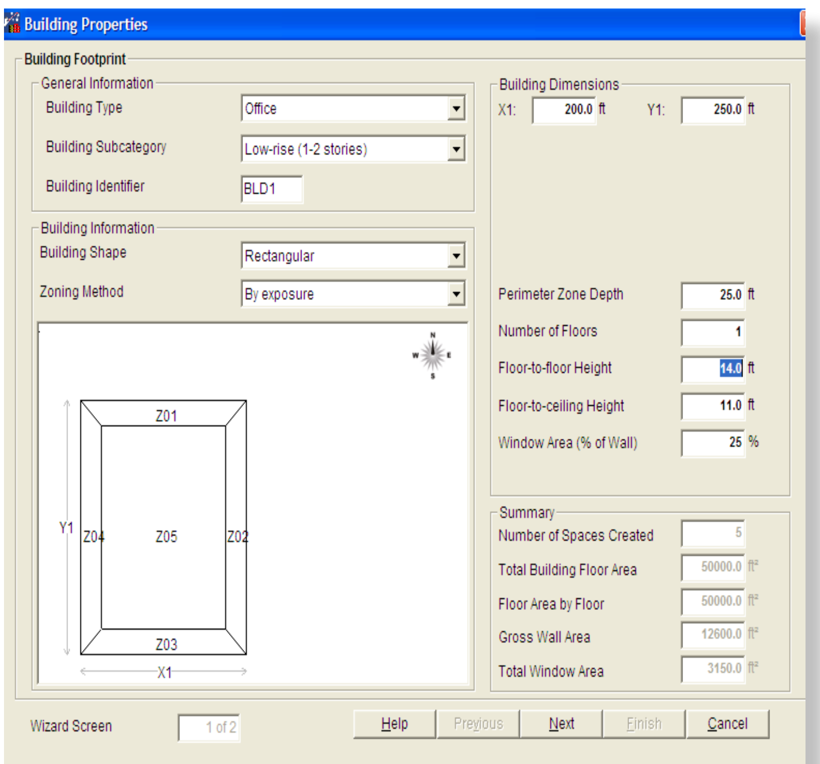

Figure 1 - Wizard Input Screen

This Denver example building initially was to be sited with most of its glass area on the East exposure. However, it was found that rotating the building 90 degrees clockwise, adding overhangs to the windows, and reducing the U value and solar heat gain coefficient of the glass assemblies resulted in a 20 percent cooling cost savings.

Additionally, if the client considers the same building in other geographies, the savings in those climates can be calculated instantly. For example, there is a 13 percent cooling savings if the project were designed for construction in either Philadelphia or St. Louis. The result is a more energy-efficient design, which also translates to energy savings and LEED points in the long run.

Define the Key Issues to Guide the Project During the Early Stages

The MEP engineer should focus on the key issues to help successfully point the project down the correct path from the beginning.Defining the project's energy performance objectives is the goal. To begin, breaking down key elements of the building and comparing them to prescriptive values is a good start. Best practice is to check early to see how the proposed design compares so that high performance can be achieved relative to the baseline on LEED projects.

Since not all building end uses allow trade-offs in a LEED model, the MEP engineer should ensure that their building complies with the minimum performance criteria established in the LEED 2009 for NC Reference Guide and ASHRAE 90.1-2007, Appendix G.

Key Building Elements of a High-Performance Design

ELEMENT	CONTRIBUTION IMPACT
Fenestration	High
HVAC System	High
Interior Lighting	High
On-site Renewable Energy	High
Plug Loads	High
Domestic Hot Water Heater	Medium
Walls	Medium
Exterior Lighting	Low
Roof	Low
Schedules	Low
Slab Floor	Low

The LEED EAc1 analysis uses a performance-based analysis, which compares energy cost of the proposed

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building to a fictitious baseline building that is minimally compliant with ASHRAE 90.1-2007. Early evaluation of key building elements can result in the achievement of a high-performance design that is critical to the optimization of the EAc1 process and subsequent LEED certification. Some of these key elements are described below:

Walls:

How do the proposed wall U-values and overall construction stack up against the baseline? The baseline wall construction is steel-framed and predefined based on jobsite climate zone. The effects of the interrupted insulation by the steel framing members must be taken into account. Wall calculations usually are provided as part of a review for LEED certification. Impact of wall construction can vary from project to project.

Roof:

The baseline roof is prescriptive based on climate zone. However, the roof is not typically a large impact area unless the building has a large roof to floor area ratio, common with large single-story buildings. Roof reflectivity values differ from baseline to proposed.

Slab Floor:

This is a relatively small contributor to building load and operating cost.

Fenestration:

The prescriptive baseline allowable fenestration percentage will max out at 40 percent window-to-wall ratio (WWR) even if the proposed WWR is greater. Compare proposed building areas, U-values and solar heat gain coefficients for possible differentiation against prescriptive baseline. Remember, fenestration U-values and solar heat gain coefficients must represent the entire assembly frame and glass, not just the glass. Fenestration is a potential high-impact area.

Interior Lighting:

The baseline lighting power density (LPD) is prescriptive. Two calculation methods may be used – the "Building Area Method" or the "Space-by-Space Method." The same calculation method must be used in the baseline and proposed case model. In ASHRAE 90.1-2007, for an office building area method the LPD is only 1.0 watts/sq ft. If possible, the allowable baseline lighting power densities should be used as a benchmark or "ceiling" for the proposed design as a general rule of thumb. This will ensure the Proposed design is more energy efficient. This is another high-impact area.

Exterior (Site) Lighting:

Since this analysis is total building energy consumption, exterior lighting should be included. This is typically not an area of high-impact.

Plug Loads (and other process loads):

These loads must be included in the analysis, but they do not provide a great opportunity of differentiation. However, they can have a huge impact on the difference between baseline and proposed operating costs by diluting the savings since plug loads are equal in both models.

Domestic Hot Water Heater:

This is often an area that is overlooked. A high-efficiency domestic hot water (DHW) heater can contribute towards differentiating the proposed building versus the baseline, which uses a minimally compliant model. Preheating of the DHW with rejected heat from other sources such as a heat machine can help differentiate the proposed model.

Schedules:

Since schedules are identical in the proposed versus baseline, this is not an area that offers differentiation.

On-Site Renewable Energy:

If renewable energy is utilized on the proposed building, it is omitted from the baseline model. This makes on-site renewable energy an area of great potential impact. Solar and wind are common examples. Ground coupled heat pump systems are not considered a renewable energy source, however.

Heating Ventilation and Air Conditioning (HVAC) System:

The HVAC system is a major area of possible differentiation in the proposed building. The HVAC system applicable to the baseline building can be quickly defined by referring to page 209 of Appendix G of ASHRAE 90.1 Become familiar with these baseline prescriptive systems, one of which will apply to the LEED project depending on the proposed building total project area, building type, number of floors, and primary source of heat.

Before considering energy saving measures on the proposed building, evaluate where it stand versus the competition.

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The “competition” for an EAc1 computer analysis is the baseline building whose operating cost will be compared to the proposed building. In LEED 2009, the prerequisite mandates beating the baseline by 10 percent on new construction. Earning points towards LEED certification can then begin. The first LEED point will be earned when the operating cost for a proposed new building is 12 percent lower than the baseline.

Committing the project to LEED certification, only to realize later during the submission process the proposed building operating cost is not at least 10 percent lower than the baseline building is to be avoided. Besides earning zero EAc1 points, the entire project’s LEED certification is jeopardized. This is where the right software tools prove invaluable.

Software Tools for LEED EA Credit 1 Analysis

The MEP engineer must ensure that the modeling software used complies with section G2 Simulation General Requirements, paragraph G2.2 in ASHRAE 90.1, Appendix G beginning with page 209.

The software must be a computer-based program with the capability of performing an 8760 hours-per-year analysis. It must model the proposed building and baseline building energy costs and be capable of thermal load modeling which includes modeling hourly variations of internal loads, thermal mass effects, ten or more thermal zones, room set points, and the overall HVAC operation.

The software must have built-in efficiency correction curves for equipment both full- and part-load and simulate the effects of airside economizers with integrated control. It shall perform design load calculations in order to size HVAC equipment capacity, airflow, and water flow.

Lastly, the software vendor should test per ASHRAE Standard 140 (Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs) and make results available.

There are several software packages on the market that are used for LEED EAc1 analysis. Included are Carrier® Hourly Analysis Program (HAP), eQuest, Trane® Trace, and U.S. Department of Energy, Energy Plus. All of these except Energy Plus utilize the Transfer Function Method (TFM) or a version of TFM for the load calculation method.

The TFM is a dynamic means of accounting for heat transfer. Although there are other methods of accounting for heat transfer, TFM extends the analysis to account for specific system behavior to control the air temperature in the thermostat zones. It is popular because of its accuracy and it lends itself to performing an operating cost in addition to calculating loads.

A thorough discussion of the TFM Methodology can be found in HAP e-Help 004 located here.

Until somewhat recently, energy analysis tools in general were very time consuming and not well suited to rapid data entry or screening alternatives in schematic design. That has changed. One example is the ability to quickly enter the proposed building, depending on the nature of the project and whether it is in a preliminary or detailed project stage. Traditionally, building space creation is where most time-consuming data entry has been required.

Modeling software used for LEED EAc1 analysis may provide more than just one option for space creation using rapid evaluation methods.

One option quickly imports spaces from a Computer Aided Design (CAD) or Building Information Modeling (BIM) tool in gbXML format. GbXML stands for green building extensible mark-up language, which is a language for representing information. While the name suggests a use for green building applications, gbXML is usable for any application, green or otherwise. Certain CAD software vendors offer tools to produce gbXML-format files from CAD drawings or BIM data. Importing the gbXML file into the modeling software is easy; the work lies with the creation of the gbXML file in the BIM software tool. Software will import a wide variety of building information from gbXML, but it is ultimately limited by what is written to gbXML in the first place.

A second option for rapid space creation (or whole building data entry) is the use of “Wizards.”

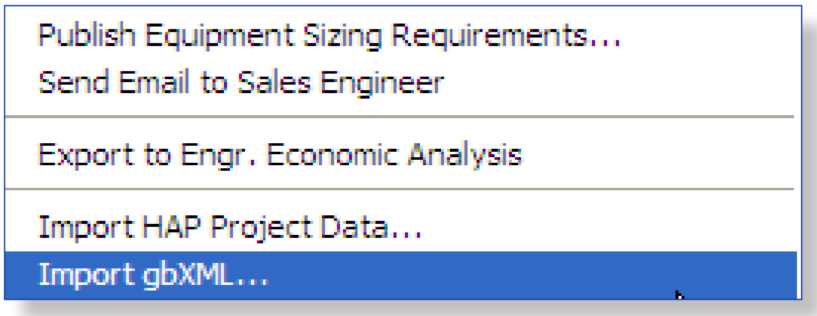

Figure 2 - Import gbXML

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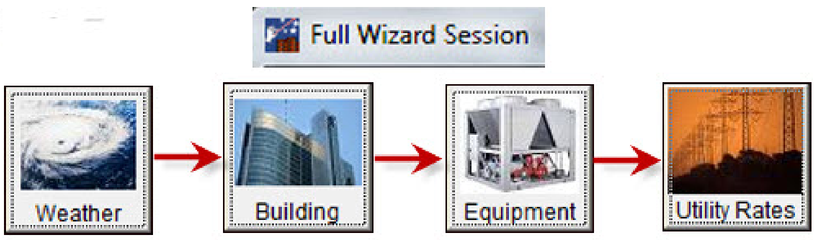
With Wizards, the user answers a relatively small subset of questions about the building location, construction of the building itself, the HVAC system alternatives, and the energy and fuel prices. The Wizards use these inputs with intelligent defaulting assumptions to generate a complete set of detailed input data for the project. This approach is well suited to preliminary or schematic design studies such as evaluating likely HVAC systems for EAc1 where multiple design alternatives may be *quickly* screened to identify the most promising designs for detailed study.

Input data that can be configured in a Wizard session in a matter of minutes could take hours (or days) to create manually in the normal detailed interface. A Wizard interface guides the user through a series of input screens, which ask high level questions about the building location, the building itself, and HVAC equipment and utility rates, then automatically applies intelligent defaulting assumptions to convert the Wizard inputs into a complete set of detailed inputs for the detailed interface. When the user returns to the main program window this data can be edited, if desired, and then the load calculations or energy simulations can be run to compare annual energy costs.



Fugure 3 - Wizards

A good example of the integration of Wizards into simulation software is the Carrier HAP program. A short description of the various Wizard tools is provided:

Weather Wizard is used to quickly set up design and simulation weather for a project.

Building Wizard is used to rapidly create spaces for a building and will later apply HVAC equipment to the spaces.

Equipment Wizard is used to quickly define and apply HVAC equipment to spaces. The spaces to be used with the Equipment Wizard can have been generated by any method (GBXML, manual entry, or Building Wizard).

Utility Rate Wizard is used to rapidly set up utility rates for electricity, gas, oil, and/or propane.

Full Wizard Session is used to compare several alternative HVAC systems. In the Full Wizard, multiple alternate systems can be added one after another.

The use of Wizards has been widespread such that modeling software is now available in a Wizard-only format as shown below.

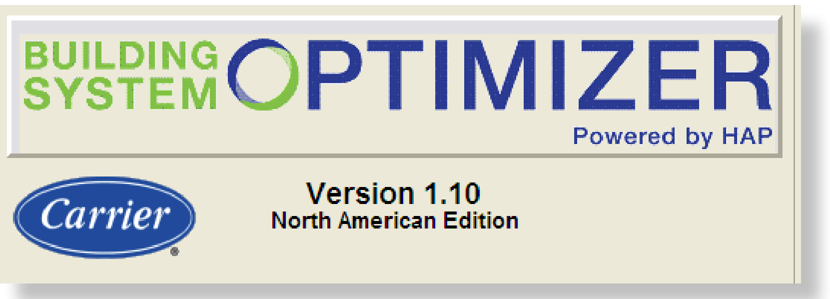


Figure 4 - Building System Optimizer

An example of a Wizard-only tool is Building System Optimizer. It quickly compares energy cost performance of HVAC design alternatives in commercial buildings. It is designed as a screening tool for the schematic design phase of projects or similar situations where multiple HVAC design alternatives need to be evaluated quickly to identify one or a small group of designs with the greatest potential for energy performance.

The Building System Optimizer uses a streamlined user interface that asks for high-level information about the location, building, HVAC equipment and utility prices. Typically a complete analysis of multiple alternatives can be configured in as little as five to 10 minutes. The Building System Optimizer then automatically converts inputs into a complete set of detailed data equivalent to data used in Carrier HAP software. This detailed input data is then used in the HAP simulation engines to run a full hour-by-hour energy analysis for design alternatives.

For detailed information on Carrier Building System Optimizer, CLICK HERE.

The Wizards and Building System Optimizer can quickly evaluate alternate proposed building designs to determine which delivers high-performance versus the baseline. Rapid configuration of these HVAC systems saves time besides

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earning points towards LEED certification. Here is a short list of high performance proposed building systems configurable using Wizards or Building System Optimizer.

- High Energy Efficiency Ratio (EER), Coefficient of Performance (COP) packaged unit systems
- Geothermal heat pump systems
- Air to air energy recovery
- Closed loop water source heat pump systems
- High efficiency chiller systems, variable-flow distribution (VFD)
- Induction beam systems
- Variable Refrigerant Flow (VRF) systems
- Condensing boiler heating systems
- High-efficiency service hot water
- Demand controlled ventilation controls

The second objective of the article is to discuss key software features that assist the MEP engineer with preliminary design for EAc1 analysis. A timesaving feature that pulls-in LEED prescriptive baseline building envelope construction and schedules from built-in resources in the software is discussed.

Use of Preconfigured Libraries to Streamline the LEED Modeling Process

LEED baseline building envelope data can be stored on preconfigured project archive files, one per climate zone. These archives can be retrieved into a LEED project and saved. The data on each one can be imported from project to project via the "Import Project Data" functionality built into modeling software. This is a great time-saver. These archives also contain all the baseline climate zone wall, roof, and glass assemblies plus 48 pre-configured building schedules for use on a variety of commercial buildings. Included in the schedules are completed profiles for these building types:

- Assembly
- Health
- Hotel-Motel
- Light Manufacturing
- Office
- Parking Garage
- Restaurant
- Retail
- School
- Warehouse

For Carrier HAP software, the climate zone archives are automatically installed with the program. They can be opened using the "Retrieve HAP Data" option on the Project Menu. When using this option in HAP v4.7, look for archive files with names like "HAP47_ASHRAE-90-1-2007-Zone-4.E3A". When using an older version of HAP, such as v4.6, climate zone archives can be downloaded from the Carrier web site. Look for the archives in a table titled "HAP v4.6 – LEED 2009 Baseline Building Templates".

There are quite a few additional software features that allow for optimization of the design of high performance buildings while streamlining the LEED EAc1 process such as:

- Built-in auto sizing of cooling and heating equipment capacities including mandatory baseline building oversize (example: peak load + 15 percent for cooling equipment).
- Automatic calculation of baseline fan power allowance per Appendix G
- Modeling of Variable Air Volume (VAV) fan part-load per formance per fan curve in ASHRAE 90.1 Appendix G table G.3.1.3.15.
- Auto-selection of ASHRAE EER/COP for DX cooling and for heating equipment.
- Inclusion of LEED baseline terms like W/CFM, and W/GPM
- Auto-rotation of the baseline 090, 180, 270 building models
- Calculation of LEED Unmet Load Hours
- Generation of LEED 2009 EA Credit 1 Summary Report and display earned EAc1 points.

Lastly, one of the biggest challenges faced by an engineer once comfortable with the modeling process is completing the required LEED tables and forms while documenting required information such as fan power calculations. Ideally, the MEP engineer would start to work on the submission forms early in the process to help inform the design. A best practice is to utilize live support assistance if it is available especially from the software support team. Ideally live support is an integral part of the software renewal process and usually includes unlimited access.

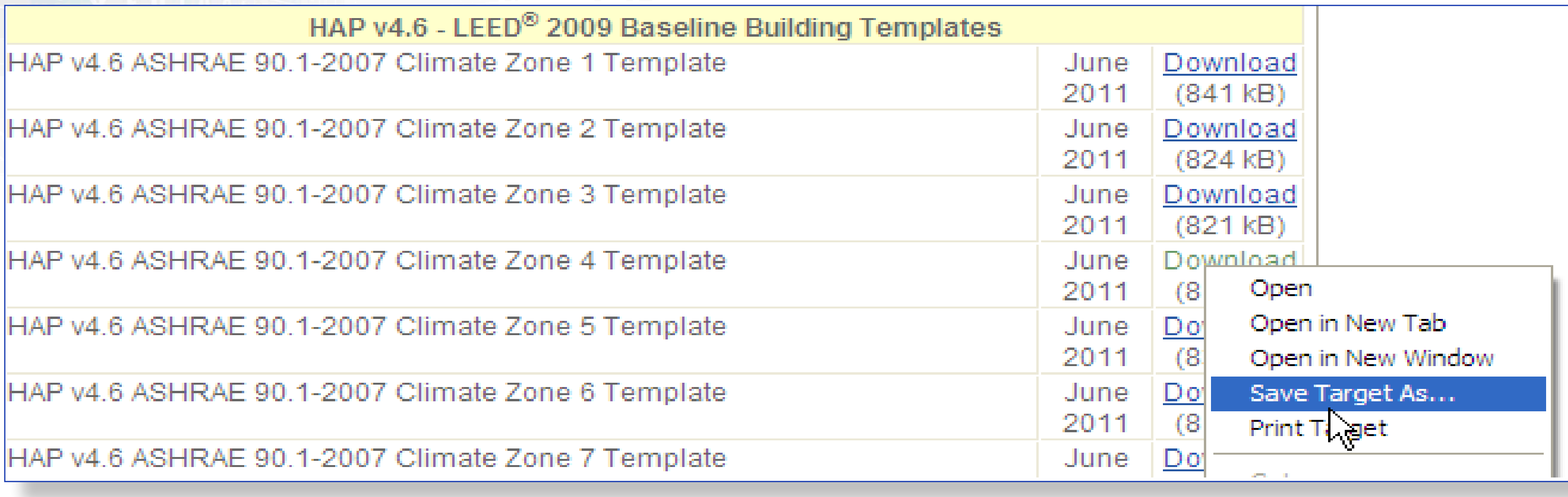

Figure 5 - LEED® 2009 Baseline Building Templates

Conclusion

It is recommended that an MEP engineer establish a solid foundation in the design process for high performance buildings. This includes participation in collaborative design sessions during the early stages of the project. When this is done, there is a much greater chance of meeting the objectives especially in the Energy and Atmosphere Category Credit 1-Optimizing Energy Performance.

The modeling software used for the optimization process plays a very important role, empowering the MEP engineer to influence the technical design in the early stages of the project. For LEED EAc1, a working knowledge of the modeling capabilities of the software is paramount. Lastly, key software features contribute greatly to the optimization of the EAc1 process resulting in a successful and efficient design of a high-performance building.

Click here to contact us for additional information.