Building Innovation Hub

Developed in partnership with

Module 2: Energy Modeling

Energy Target Setting and Modeling by Project Phase

Introduction

As discussed in Module 1a: Pre-Design Stage. Owner-Architect Contract Language and Scope Development and Module 1b: Contracting for Energy Modeling Services, architects and the larger design community want to set expectations, establish clear guardrails to keep projects on track for successful compliance with the District's codes and policies, and to manage optimal project outcomes.

Projects that set performance targets early and use simulation to validate design decisions throughout the process consistently show 15-30% greater energy savings than projects that wait until the end of design for a compliance model, according to the American Institute of Architects. Furthermore, it is challenging to advocate for high performance design or protect it in the Value Engineering (VE) process without metrics to inform decisions. Studies have shown that fees for Energy Modeling services typically are paid back in a 1-3 months of operational savings, and buildings

25,000 sq. ft. and larger almost universally can pay back in under a year. Payback for modeling on buildings under 25,000 sq. ft. vary based on complexity of design and level of performance targeted, but can pay back in under a year as well. Once the case for Energy Modeling is made, the project team must define what Energy Modeling in the context of the project; this facilitates clear communication about expected scope and outcomes. The ASHRAE 209 Standard for Energy Simulation Aided Design for Buildings was developed by both architects and engineers to clarify the types of modeling and simulation may be performed on a project at each stage of design and construction, as well as type of information or output the exercise is intended to generate.

Most projects only utilize an energy model that would fall under, Section 7.1 Modeling Cycle 8 – As-Designed Energy Performance. This is used as a close-out of design modeling in order to obtain a permit or LEED points. Unfortunately, for too many projects this is the first and only fully executed energy model contracted in the design process, and this model is not intended to provide design feedback, assist with value engineering (VE) exercises or improve the project in any way. This is too late to improve the design or identify savings in construction costs or annual operating expenses. By this point, the majority of the value in energy modeling has been left on the table.

If the owner declines to utilize energy models to provide a feedback loop during the design or construction process, or if they direct approval of a change despite the model output indicating negative performance impacts, it is highly recommended that the architect document the issue, their recommendations, and the perceived impact that changes may have. They can do so in a letter, a memo, or meeting minutes, and then distribute to the owner and the team. This creates a clear record of communication about the effects of decisions made before occupancy.

ASHRAE 209 Standard Recommendations

Contract sections, and recommendations as to when and how they should be used, are as follows.

The ASHRAE 209 Standard requires minimum compliance with:

- **Section 5 General Requirements**
- **Section 6 Design Modeling Cycles**
    - o Required: Section 6.3 Modeling Cycle 3 – Load Reduction Modeling
    - o And select at least one (1):
        - Section 6.1 Modeling Cycle 1 – Simple Box Modeling
        - Section 6.2 Modeling Cycle 2 – Conceptual Design Modeling
        - Section 6.4 Modeling Cycle 4 – HVAC System Selection Modeling
        - Section 6.5 Modeling Cycle 5 – Design Refinement
        - Section 6.6 Modeling Cycle 6 – Design Integration and Optimization
        - Section 6.7 Modeling Cycle 7 – Energy Simulation Aided Value Engineering

Optional, but encouraged, modeling cycles during construction and occupancy include:

- **Section 7: Construction and Operations Modeling**
  - Section 7.1 Modeling Cycle 8 – As-Designed Energy Performance
  - Section 7.2 Modeling Cycle 9 – Change Orders
  - Section 7.3 Modeling Cycle 10 – As-Built Energy Performance
- **Section 8: Postoccupancy Modeling**
  - Section 8.1 Modeling Cycle 11 – Post-Occupancy Energy Performance Comparison

While all of these cycles are important, only Modeling Cycles 1, 2, 3, 5, and 8 are essential for Building Performance Compliance and are strongly recommended to be included as a basic service.

The ASHRAE 209 Standard requires minimum compliance with:

Section 5 General Requirements

This section includes:

5.1 Simulation software requirements, which are consistent with ASHRAE 90.1, Section G2.2. The DC Energy Code is based on ASHRAE 90.1.

5.2 Energy modeler credentials, which include a) certified Building Energy Modeling Professional (BEMP), b) certified Building Energy Simulation Analyst (BESA), c) or equivalent credential established by the Department of Consumer and Regulatory Affairs (DCRA).

5.3 Climate and site analysis parameters are established to support relevant simulation exercises, including: a) dry bulb temperatures, b) relative humidity, c) wind speed and direction, d) insolation, e) cloud cover, f) ground temperature, g) precipitation, h) heating and cooling degree days.

5.4 Benchmarking is used in the standard as a term to describe target setting and performance validation during the design process, rather than the annual post-occupancy performance disclosure required in the District under the 2008 Clean and Affordable Energy Act. The requirement is to create a data set of peer buildings with similar occupancy, climate and other characteristics to inform energy targets and against which to compare the project's measured energy assumptions during design.

5.5 Energy charrette describes the requirement of at least one workshop that includes owner, architect, design engineer, energy modeler, certification consultant, contractor or cost estimator if applicable, and other relevant parties. The purpose is to mutually agree upon project goal(s), metrics, energy efficiency measures (EEMs) to study, important financial criteria for decision making, follow- up tasks, and a general timeline.

5.6 Energy performance goals in owner's project requirements (OPR) include:

- Building performance rating systems (e.g. LEED, Green Communities, Passive House, etc.)
- Financial criteria for Life Cycle Cost Analysis (LCCA)
- Overall energy goals (which may include a target Energy Star score)
- Site or source EUI for BEPS compliance
- Individual subsystem goals (e.g. Lighting power density)
- Green building goals (e.g. indoor air quality, daylight optimization, glare control, local material selection, etc.)

ASHRAE 209 requires early coordination of the owner's project requirements, thus supporting commissioning requirements in both LEED and the DC Energy Code.

5.7 General modeling cycle requirements include baseline and goals, input data, output data reporting, quality assurance, reviews, and quality assurance.

Required: Section 6.3 Modeling Cycle 3 - Load Reduction Modeling

Required: This cycle is mandatory in the ASHRAE 209 standard and therefore should be a basic service.

Description: This cycle is focused on reducing both return on investment (ROI) heating and cooling loads. The former reduces operating expenses and is generally includes in 'payback' or ROI calculations. For example, if the owner spends more money on more efficient HVAC equipment, but it saves energy every year, that increased first cost will be paid for through annual energy savings. Peak loads, on the other hand, are used to determine system sizing. Peak load reduction strategies may include but are not limited to: a) building envelope, b) lighting and daylighting, c) internal equipment loads, d) outside air, and e) passive conditioning and natural ventilation.

For example, if the team designs a better thermal envelope, specifies better glazing, reduces the Window to Wall Ratio (WWR) or uses exterior sun shades to control solar heat gain, the overall net effect may be lower peak heating and cooling loads, thereby reducing the tons of cooling or BTUs of heating necessary for maintaining building comfort. The construction budget may be able to carry fewer or smaller chillers, or be able to reduce or eliminate perimeter heat systems, for example. These are called 'trade-offs' and the net effect may be cost neutral in terms of first costs (construction costs) or even a cost savings. These trade-offs are identified and validated through energy modeling and load calculations.

Peak load reduction may impact HVAC system selection or design; understanding how tradeoffs balance the costs of high-performance design elements helps to retain those elements in the design instead of rejecting them out of a gut VE instinct.

Note: This model is self-referencing, rather than a comparison to a baseline. It is an exercise in optimizing the design for its own sake.

When: Because of the potential impacts on the design, this modeling cycle must be performed before HVAC system selection and no later than the end of Schematic Design.

Required: At least one of following cycles:

Section 6.1 Modeling Cycle 1 - Simple Box Modeling

Encouraged: This cycle is strongly recommended as a basic service due to its alignment with the DC Energy Code and DC Green Building Act, in addition to support of BEPS compliance.

Description: This is an orientation-neutral model, often conducted before building geometry is set. It is also known as shoebox model. It allows the team to apply early ideas to the project to keep on the table or reject based on high-level impacts. Sometimes this is used for an early look at systems options, to validate certain design ideas, or to benchmark against a performance goal or target. The box model identifies which design characteristics will have the most impact on building performance, such as orientation, massing, WWR, high performance thermal envelope, daylighting, or HVAC system efficiency. For example, in a climate with predominantly overcast skies it might become evident that building orientation has very little impact on performance. On an office building or academic building where loads are externally driven, a high-performance envelope might have a meaningful impact, but there may be a point of diminishing returns. For a more complex building like a laboratory, hospital or data center where loads are internally driven, building form and enclosure may be less impactful, but energy recovery ventilation, low friction ducts, or cascading air may lead to a significant reduction in energy use.

This modeling cycle aligns with the LEED credit for integrative process. This requires a “simple box” energy model to explore how to reduce energy loads, analyzing any two of the following: a) site conditions, b) massing and orientation, c) building envelope, d) lighting levels, e) thermal comfort ranges, f) plug and process loads, g) program and operational parameters.

Note: This model is typically self-referencing, as opposed to being compared to an external baseline requirement. It is an exercise in optimizing the design against its own possibilities.

When: This cycle is typically performed in Concept or early Schematic Design, but for LEED Integrative Process compliance must be conducted no later than the end of Schematic Design. ASHRAE 209 requires that it is conducted before or during the energy charrette, which should be held in Concept or early Schematic design as well.

Section 6.2 Modeling Cycle 2 - Conceptual Design Modeling

Encouraged: This cycle of modeling is relevant if the form of the building is still subject to change before the onset of Schematic Design. This cycle is strongly recommended as a basic service, unless the building form and orientation are already determined.

Description: This cycle includes analysis and refinement of the architectural form to fine-tune building performance before systems design begins. This cycle may involve rapid iteration of analysis of building form, orientation, natural or mixed mode ventilation, passive solar heating, daylighting and other passive design strategies. This cycle is often conducted in Sketchup, Rhino or Revit using analysis tools that are supported in each design software platform. For details, see the Hub article "BEPS Targets for New Construction," which includes a section on box models and illustrations.

Note: This model is typically self-referencing, as opposed to being compared to an external baseline requirement. It is an exercise in optimizing the design against its own possibilities.

When: This cycle must be conducted in Concept Design.

Section 6.4 Modeling Cycle 4 - HVAC System Selection Modeling

If applicable: This cycle of modeling is useful if more than one HVAC system is under consideration, for example radiant systems vs. forced air systems. This cycle is recommended as an additional service unless it is known to be relevant and critical to the design process from the outset.

Description: This cycle can be used to evaluate the annual energy demand impacts of various system options and the resulting impacts on building operating expenses. Modeling system options supports LCCA, which includes first costs, operating costs, maintenance costs, replacement costs, decommissioning costs and anticipated annual energy savings. This is often a good time to engage building operations personnel to discuss experience with existing systems, problems and challenges with occupant comfort, operations and maintenance (O&M) protocols, as well as any concerns about new proposed systems. Education or training for new systems can begin at this stage if modeling shows compelling reason to pursue certain types of systems.

Note: This modeling cycle begins to compare the design case to a baseline standard. There may be variations in the energy standards cited for code and certifications like LEED, so there may be one or more variations to the baseline model.

When: This cycle must be conducted after Cycle 3 – Load Reduction Modeling and before the HVAC system is selected. This typically occurs in late Schematic Design or early Design Development, and no later than 50% Design Development.

Section 6.5 Modeling Cycle 5 - Design Refinement

Encouraged: This cycle is strongly recommended as a basic service.

Description: To ensure accuracy, models should be updated as the building design becomes more detailed, space use and partitioning become more defined, preliminary lighting layout is developed, AV and plug loads are provided, and other inputs are generated. The model can be used as a tool to validate the direction of the design or highlight areas that are off course and need more attention. This cycle should be iterative, and the number of iterations depends on the size and complexity of the project as well as the design schedule. At a minimum, modeling should include updates on a) HVAC systems, b) lighting systems, c) envelope systems, d) service water heating systems, e) process and plug-load systems. After each iteration, a model review meeting or discussion would be helpful to discuss EEM and design opportunities. These meetings should be coordinated with commissioning activities once commissioning commences.

Note: There may be variations in the energy standards cited for code and certifications like LEED, so while the 'design case' may consistently reference the same standard, there may be one or more variations to the baseline model.
When: This cycle should be iterative and may include check-ins at 50% and 100% Schematic Design, and 50% Design Development, to be defined in the architect-consultant scope agreement.

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Section 6.6 Modeling Cycle 6 - Design Integration and Optimization

Encouraged: This cycle is strongly recommended as a basic service.

Description: The model becomes more detailed and more accurate as: a) the building design becomes more detailed, b) enclosure materials and glazing systems are selected, c) systems and sub-systems more detailed and complex, and d) HVAC system components, sensors and controls, scheduling, etc. are determined. If a couple of options are under consideration, the model can be used to evaluate merits (energy savings) of those options. The model can be updated and iterated for multi-variable optimization. This allows the team to identify when two or more design elements have a compounding impact on energy performance. This cycle should be iterative, and the number of iterations depends on the size and complexity of the project as well as the design schedule. After each iteration, a model review meeting or discussion would be helpful to discuss EEM and design opportunities. These meetings should be coordinated with commissioning activities.

Note: There may be variations in the energy standards cited for code and certifications like LEED, so while the 'design case' may consistently reference the same standard, there may be one or more variations to the baseline model.

When: This cycle should be iterative and may include check-ins at 100% Design Development, 50% and 95% Construction Documents, to be defined in the architect-consultant scope agreement.

Section 6.7 Modeling Cycle 7 - Energy Simulation Aided Value Engineering

If applicable: This cycle is recommended as an additional service if needed to support VE discussions and to inform decisions.

Description: This cycle of simulation can support VE decisions, for example,

- A reduction in WWR ratio or improvement to higher performance glazing (or combination of both strategies) that reduces peak cooling loads sufficiently to eliminate a chiller while also maintaining performance expectations;
- A reduction in perimeter glazing or improvement in glazing characteristics to eliminate the perimeter heat system while maintaining performance and occupant comfort.

Both examples show how to reduce budget while maintaining performance targets, even with changes to the original design. Energy simulation in this cycle is intended to confirm that performance expectations are maintained despite taking the VE option, or else the option may be discarded.

Each time an energy model is run during the VE process, a follow-up meeting or discussion to review the results with the entire project team is helpful to discuss outcomes and opportunities, as well as to make decisions and give direction for design changes. These meetings should be coordinated with commissioning activities.

Note: There may be variations in the energy standards cited for code and certifications like LEED, so while the 'design case' may consistently reference the same standard, there may be one or more variations to the baseline model.

When: This cycle should be conducted as needed, typically in Design Development and Construction Documents VE exercises.

Optional, but encouraged, modeling cycles during construction and occupancy include:

Section 7.1 Modeling Cycle 8 – As-Designed Energy Performance

Encouraged/Required: This cycle of modeling is typically necessary to demonstrate code compliance. This cycle is strongly recommended as a basic service.

Unless the project intends to comply with DC Energy Code under the Prescriptive Path, and falls under the Green Code rather than the Green Building Act (which would require LEED or Green Communities certification), it is likely that this cycle should be considered required.

Description: This cycle is often referred to as a 'compliance model' or 'documentation model' as it is a model reflective of the completed design, intended to demonstrate compliance with the energy code and/or LEED criteria (or other certification program). There may be variations in the energy standards cited for code and certifications like LEED, so while the 'design case' may consistently reference the same standard, there may be one or more variations to the baseline model.

When: This cycle is conducted at the end of construction documents for permit application, and often overlaps with the beginning of Construction Administration for LEED documentation.

Section 7.2 Modeling Cycle 9 – Change Orders

Encouraged: This cycle of modeling is relevant if change orders are made in the field during Construction Administration that could affect building performance. This cycle is recommended as an additional service if needed to validate performance will be maintained and to inform decisions.

Description: During construction, changes to the design necessitated by the unavailability of materials or products, long lead times, contractor submitted substitution requests (that lead to change orders), client-led changes, cost overruns, and VE exercises may affect anticipated building performance. It is highly recommended that the energy model be updated to reflect the impact of any suggested change orders and validate that the energy code compliance is maintained and that anticipated BEPS compliance has not changed.

DCRA may actually require an updated model if they see differences on site from the design described in the energy model that was submitted at the time of permit.

The owner-contractor agreement could include language that the contractor is responsible for any updates to the design and the energy model required to validate energy code and BEPS compliance if such changes are triggered by contractor-initiated change orders or substitution requests.

The architect should review and approve an updated energy model before approving any such changes. After each change order model is run, a model review meeting or discussion would be helpful to discuss outcomes, make decisions and give direction for design changes. These meetings should be coordinated with commissioning activities.

If the owner declines an updated model or directs approval of a change despite the model output indicating negative performance impacts, it is highly recommended that the architect document the issue, their recommendations, and the perceived impact that changes may have. They could do so in a letter, a memo, or meeting minutes, and then distribute to the owner and the team. It is important to create a clear record of communication about performance targets and the impacts of late-stage changes.

When: This cycle is typically performed as needed in the Construction Administration phase.

Section 7.3 Modeling Cycle 10 – As-Built Energy Performance

Encouraged: This cycle of modeling is relevant to reflect: 1) changes in design that occur during Construction Administration and, 2) updates to assumptions about use, and 3) building O&M. This cycle is recommended as an additional service to improve the accuracy of the energy model.

Description: This cycle of modeling is critical to adapting the design model into a valuable tool for use in ongoing performance optimization and BEPS compliance. The model is often updated to reflect:

- intentional changes in design
- changes in use
- identified tenant spaces
- new meter and submeter information
- change orders or substitutions made in the field that could impact building performance
- newly onboarded O&M personnel
- updates to building operations, scheduling, maintenance protocols

After the As-Built model is run, a model review meeting or discussion would be helpful to discuss updates and lessons learned with the owner, design team, operations team and Commissioning team.

When: This cycle of modeling is typically performed as needed, at the end of Construction Administration, or early Post-Occupancy.

Section 8.1 Modeling Cycle 11 – Post-Occupancy Energy Performance Comparison

Encouraged: This cycle of modeling is relevant to recalibrate the energy model for real-life conditions. This cycle is recommended as an additional service to improve the accuracy of the energy model.

Description: A building owner may be interested in this last cycle when they want to: 1) understand why a new building is not performing as anticipated, 2) reduce operating expenses, 3) improve metrics for benchmarking purposes, or 4) maintain long-term/multi-cycle BEPS compliance.

Design-stage energy modeling normalizes the unknown, which includes weather, occupant behavior, plug loads, hours of operation, and many other key factors that influence building energy performance. During the first 12-18 months of occupancy, the building may be used, operated, or maintained in ways that are different than anticipated in the model. Updating the As-Designed or As-Built model to reflect real-life conditions will calibrate the model to more accurately reflect how the building performs, which in turn makes it easier to understand when something is out of alignment or performing outside of expectations, and provide clues or indications why.

This cycle can be very helpful as a foundation for long-term BEPS compliance. It can also be coordinated with LEED Enhanced Commissioning, monitoring-based commissioning, occupant comfort survey credits for LEED, or general post-occupancy evaluation exercises.

When: This cycle is typically performed as needed, in the first 12-18 months of Post-Occupancy.