

The Energy Modeling Process

Design & Technology Series #15

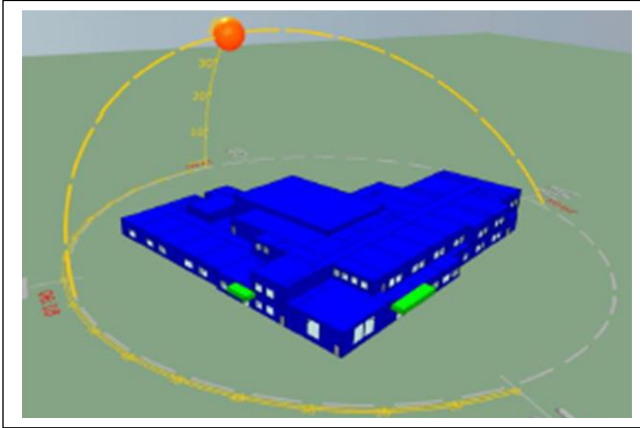


Fig. 1: Example of simplified massing for a school project (used with permission from Oystryk & Team Architecture Ltd.).

What is Building Energy Modeling?

Building Energy Modeling (BEM) is the software simulation of building energy use. Evaluations rely on inputs from the characteristics of design, defined elements of building operation, and local weather data.

As energy codes and sustainability requirements in the construction industry evolve, the role of BEM in the design process is becoming increasingly significant. The importance of BEM is exemplified by the tiered compliance path in the *National Energy Code for Buildings* (NECB).

BEM for Alberta Infrastructure Projects

The Government of Alberta prioritizes energy-efficient building design, as it is the long-term owner and operator of the facilities it constructs. The costs to operate and maintain a building over its life cycle, as well as its environmental and social impacts are heavily influenced by design.

The Technical Design Requirements for Alberta Infrastructure Facilities (TDR) establishes the energy modeling process through ASHRAE Standard 209 and defines the modeling cycles (MC) required in each project phase, as shown in Fig. 4.

Pre-Design: MC #2 - Conceptual Design

At this early stage in the project, the design team must consult with BEM professionals to evaluate early design aspects, including building footprint and massing. This early

collaboration helps to mitigate difficulties in achieving advanced energy targets.

Massing

The General Requirements section in the TDR advises against over-articulation of forms. As seen in Fig. 2, over-articulation significantly increases the amount of building envelope exposed to outdoor conditions, resulting in a greater Thermal Energy Demand Intensity (TEDI) metric. In addition to improved energy performance, massing impacts the project in other ways:

- **Project costs:** A more articulated form results in a larger footprint, requires additional building materials, and increases construction time.
- **Daylighting:** Access to daylight and views benefits the health and well-being of occupants. Compact massing can optimize natural light access through strategic placement of glazing in priority spaces.
- **Thermal bridging:** Simplification of building forms reduces the length of edges or corners where heat can easily escape. This should be recognized early and explored further in MC #3 - Load Reduction.

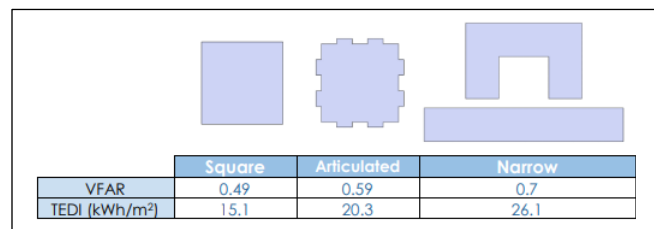


Fig. 2: Impacts of vertical surface area to floor area ratio (VFAR) on envelope heat loss (used with permission from BC Housing).

Schematic Design: MC #3 - Load Reduction

Analysis of reduction of total energy use, including the heating and cooling peak loads, must happen before the final selection of the HVAC system type.

Building Envelope

The NECB requirement for thermal bridging calculations accounts for heat loss occurring in localized areas through the insulated envelope, as seen in Fig. 3. These calculations must include clear fields, linear transmittance around windows, doors, parapets, corners, wall to ground, and single point penetrations through the envelope.

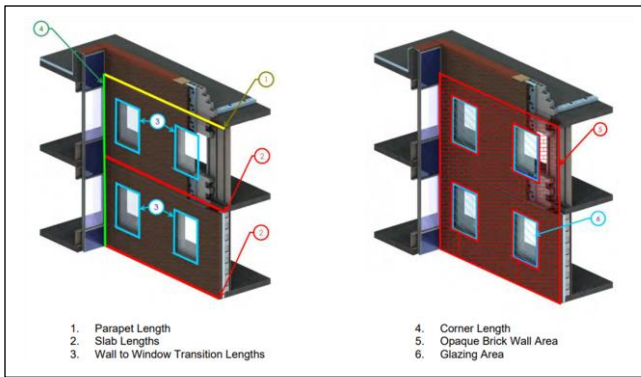


Fig. 3 Impacts of massing on envelope heat loss (used with permission from BC Housing).

Air Tightness

The NECB 2020 permits energy models to use either the prescriptive air leakage rate, or the result of testing achieved at project completion. The results of the air tightness test can only be assumed if a building envelope engineer, as part of the design team, provides signed documents and witnesses the testing.

Design Development: MC #4 - HVAC System Selection

As building energy targets continue towards a net-zero ready future, the selection of HVAC systems must evolve as well. The ASHRAE Zero Energy Advanced Energy Design Guides (AEDG) are a useful resource for reviewing system options.

- **Air Handling Unit (AHU):** The type of system selected, whether mixed-air or 100% outdoor air, should be reassessed. The minimum air change per hour rate identified in the TDR often requires the design of 100% outdoor air systems to over-ventilate, incurring an energy penalty. Additionally, the increased fan sizing designed to optimize for free cooling inadvertently reduces effectiveness of demand control strategies.
- **Energy Recovery Ventilator (ERV):** Energy recovery from both return and exhaust air streams is critical to optimizing energy savings. Dual core recovery systems can achieve up to 90%+ heat recovery efficiency.

Separating the ERV from the AHU allows for the DOAS design intent to be maintained in the ERV while still allowing for free cooling at the AHU.

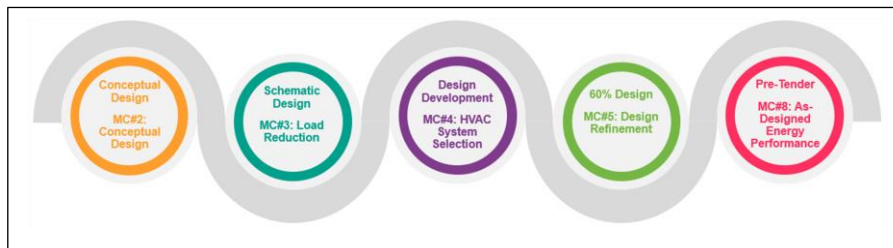


Fig. 4: Building Energy Modeling Process Through Design

It is important to recognize that future versions of the NECB will include requirements for operational emissions. This will encourage the electrification of heating systems through incorporating heat-pump systems into the design.

60% DD: MC #5 - Design Refinement

ASHRAE 209 requires refining at least one building system, though refining all or multiple systems should be considered. The selection of the analysis should be based on maximizing the results.

- **Demand control ventilation:** The use of CO2 sensors and/or occupancy sensors in the spaces to reduce the outdoor air delivered.
- **Reduced lighting power density:** There is the trade-off with further reductions while ensuring health and safe spaces.
- **Automatic receptacle control:** These controls reduce parasitic loads afterhours; however, this is often perceived as impacting the ease of use for occupants.

Pre-Tender: MC #8 - As-Designed Energy Performance

The full energy model documentation that is required for the LEED submission is required in the pre-tender submission to Technical Services. Additional documentation can be requested if questions arise during review.

Reporting Requirements

Reporting during the design process influences decisions and is required to demonstrate compliance with the TDR.

- **Input Data:** At each design phase, the inputs are to reflect the known design parameters at the time. At early stages, assumptions for unknown parameters can be based on past projects that represent realistic inputs.
- **Output Data:** Energy use must be broken out by system type to identify the sub-metering requirements. Systems cannot be further sub-divided to avoid sub-metering.
- **Quality Assurance:** The reports provided must be thoroughly checked by the energy modeler, the architect, and the appropriate design engineers.

For further information contact: Sustainability INFRAS-TSBGreenBuildings@gov.ab.ca

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