Zero Carbon Building – Design Version 2

Energy Modelling Guidelines

March 10, 2020

1. INTRODUCTION

This document provides guidance for the energy modelling required to support Zero Carbon Building – Design Version 2 (ZCB-Design v2) certification. An energy model reflecting the proposed design must be prepared to demonstrate compliance with the requirements of the ZCB-Design Standard v2. A reference building energy model may also be required. The expectation is that energy models used for compliance to the ZCB-Design Standard v2 will be developed to represent the actual anticipated operation of the facility for all energy uses on site. Stipulated conditions such as schedules, occupancy, receptacle loads, and domestic hot water loads shall be based on actual intended operational conditions for the facility in question. It is expected that the energy modelling professional will communicate with the client and facility operations staff to understand building operations as best as possible so that anticipated hours of operation and equipment run times are reflected in the energy model rather than relying on arbitrary defaults from software or applicable code or standards.

2. ENERGY MODELLING

2.1 General

The documentation submitted for ZCB-Design v2 certification must include sufficient detail to demonstrate the simulation process undertaken to arrive at the projected energy model results being claimed, including output files or detailed reports generated by the energy model software along with any calculation spreadsheets for exceptional calculations conducted outside of the main energy model. Further details on documentation requirements can be found in the ZCB-Design v2 Workbook.

Outputs from the proposed building energy model shall be used to calculate TEDI and populate the ZCB-Design v2 Workbook, which will automatically determine EUI, peak demand, and exported renewable energy.

2.1.1 Energy Modelling Software

The energy modelling software or simulation program shall be tested according to ASHRAE Standard 140 (except sections 7 and 8). This includes – but is not limited to – DOE-2 based modelling programs (eQuest, CanQUEST, Energy Pro, Visual DOE), IES, HAP, TRACE, EnergyGauge, and Energy Plus.

Software limitations shall not excuse the limitation of accuracy of energy modelling to show compliance with the standard; consultants are expected to overcome any software limitations with appropriate engineering calculations. All other modelling inputs not discussed in these guidelines shall follow accepted industry best practice.

2.1.2 Process Loads and Tenant Spaces

Process loads and tenant loads must be calculated based on reasonable estimates and included in the energy model. Canada's National Energy Code for Buildings (NECB) 2017 table A.8.4.3.2(2) should be followed where applicable if actual values are not known.

A narrative and calculations with sufficient detail will be required to demonstrate how the tenant and/or process loads are derived.

2.2 Additional Guidance for Option 1 Flexible Approach

Projects pursuing Option 1 Flexible Approach are required to produce a reference building energy model according to NECB 2017, Section 8 Building Energy Performance Compliance Path in addition to the proposed building energy model. The proposed building must demonstrate an EUI improvement when compared to the NECB 2017 reference building with the following additional conditions:

1) Limit vertical fenestration in the reference building. The reference building shall maintain the same vertical fenestration and door area to gross wall area ratio (FDWR) as the proposed building up to the respective maximum prescribed by NECB 2017 Article 3.2.1.4.
If the proposed building exceeds the prescribed maximum FWDR, scale down the vertical fenestration in the reference building to the corresponding NECB 2017 maximum while retaining a distribution proportional to the proposed building on each wall of the reference building.

2) Limit skylight area in the reference building. The reference building shall maintain the same skylight area to roof area ratio as the proposed building up to the respective maximum prescribed by NECB 2017 Article 3.2.1.4.
If the proposed building exceeds the prescribed maximum skylight area to roof area ratio of 2%, scale down the skylight area in the reference building case to 2% while retaining a distribution proportional to the proposed building.

3) Apply supply air temperature reset controlled based on the warmest zone for VAV systems (NECB System 6) consistent with NECB 2017 Sentence 5.2.8.9.(1).

4) The reference building air leakage rate shall be the prescribed default rate stated below in Section 3.2.3 Air Leakage.

3. UNDERSTANDING AND CALCULATING TEDI

The use of a thermal energy demand intensity (TEDI) metric requires building designers to optimize building characteristics related directly to heating. Orientation, solar access, building envelope performance, and other passive design measures must be addressed to ensure a low TEDI. Efficient delivery and heat recovery of ventilation air are also captured by the TEDI metric and are measures that are most easily implemented in new construction and major renovations. Strategies to minimize TEDI should address both architectural and ventilation measures.

The methodology below should be used in all cases to determine or calculate TEDI from energy models to ensure consistency, regardless of HVAC system type used. TEDI is intended to represent the heat delivered to the building, including any extra heat that may be required due to the use of inefficient HVAC systems (e.g., reheat energy in VAV systems). It also includes any heat provided by waste heat sources (e.g., recovered heat from cooling systems, waste heat supply from cogeneration, etc.) as part of the heating requirement of the building. Only heat recovered by exhaust air is exempted.

$$TEDI \left[\frac{kWh}{m^2 year}\right] = \frac{\sum Space \ and \ Ventilation \ Heating \ Output \ \left[\frac{kWh}{year}\right]}{Modelled \ Floor \ Area \ [m^2]}$$

When measured with modelling software, TEDI is the amount of heating energy delivered to the project that is outputted from any and all types of heating equipment, per unit of *Modelled Floor Area*. Heating equipment includes:

- Electric, gas, hot water, or DX heating coils of central air systems (e.g., make-up air units, air handling units, etc.);

- Terminal equipment (e.g., baseboards, fan coils, heat pumps, VRF terminals, reheat coils, etc.), and/or;

- Any other equipment used for the purposes of space conditioning (e.g. humidification) and ventilation.

The heating output of any heating equipment that uses a source of heat that is not directly provided by a utility (electricity, gas or district) must still be counted towards the TEDI.

For example, heating from heating coils of any type that use a heat source derived from waste heat (e.g., from a cooling system or process such as a heat pump or VRF terminal unit, cogeneration waste heat that serves a building hot water loop connected to those heating coils) or a renewable energy source (e.g., solar thermal hot water collectors) must still be counted towards the TEDI. While every type of software has different reporting features, TEDI can be calculated by summing up the heating output of all the heating coils in the building.

Projects that are pursuing an Impact and Innovation strategy related to the heating of the building may need to provide additional details in the TEDI calculations. For example, projects that are aiming to demonstrate that 50% of the heating load is met by heat pumps should provide a breakdown of the heating equipment outputs to demonstrate that the threshold is met.

Specific examples of heating energy that would not be included in the TEDI include but are not limited to:

- Maintaining swimming pool water temperatures

- Outdoor comfort heating (e.g., patio heaters, exterior fireplaces)

- Gas-fired appliances (stoves, dryers)

- Heat tracing

3.1 Internal Heat Gains

Incidental heat gains from lighting, receptacle loads, pumps, fans etc. shall be included in the energy model and reflect the design of the building. Operational schedules should reasonably reflect the expected operations of the building and should be developed in consultation with the building owner and/or operator. This effectively means that these internal heat gains become credits in the TEDI that will automatically be calculated by the energy modelling software.

3.2 Calculating Building Envelope Heat Loss

The ZCB-Design Standard v2 requires buildings to achieve a specific performance limit in TEDI, which is primarily a representation of the annual heating load required to offset envelope heat loss and ventilation loads. Choosing TEDI as a target helps to encourage energy efficient building envelopes. However, building envelope heat loss has historically been simplified due to past difficulties in cost-effectively providing more accuracy. This has generally led to overly optimistic assessments of building envelope performance by way of ignoring or underestimating the impact of thermal bridging.

Building envelope thermal bridging elements that can have a significant impact on heat loss that have historically been underestimated or unaccounted for include:

- Assemblies with thermal bridging elements that are not quantified by codes or standards, such as those with various types of cladding attachments (girts, clips, etc.) and spandrel panels;
- Floor slab thermal bridges, including balcony slabs, window wall slab by-pass and connection details, shelf angles, etc.;
- Window to wall transitions;
- Parapets;
- Corners and interior wall intersection details;
- At-grade transition details; and
- Large structural penetrations.

With the recent addition of industry resources that support more efficient and accurate calculations of building envelope heat loss[1], assemblies and associated thermal bridging elements must be accurately quantified for the purposes of complying with the standard, according the requirements below.

3.2.1 Opaque Assemblies

The overall thermal transmittance of opaque building assemblies shall account for the heat loss of both the Clear Field performance, as well as the heat loss from Interface Details. Additional heat loss from Interface details are to be incorporated in the modelled assembly U-values, according to the provisions below.

Overall opaque assembly U-values can be determined using any of or a combination of the following hierarchy of approaches:

a. Using the performance data for Clear Fields and Interface Details from the Building Envelope Thermal Bridging Guide (BETBG), and the calculation methodology as outlined in 3.4 of the BETBG. A detailed example is provided in Section 5 of the BETBG and a supporting calculation spreadsheet is available from bchydro.com/construction, titled "Enhanced thermal performance spreadsheet";

b. Using the performance data for Clear Field and Interface Details from other reliable resources such as ASHRAE 90.1-2010, Appendix A, ISO 14683 Thermal bridges in building construction – Linear thermal transmittance – Simplified Methods and default values, with the methodology described above in a;

c. Calculations, carried out using the data and procedures described in the ASHRAE Handbook – Fundamentals;

d. Two or three dimensional thermal modelling, or;

e. Laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an average temperature of 24±1°C and a temperature difference of 22±1°C.

Except where it can be proven to be insignificant (see below), the calculation of the overall thermal transmittance of opaque building envelope assemblies shall include the following thermal bridging effect elements:

- Closely spaced repetitive structural members, such as studs and joists, and of ancillary members, such as lintels, sills and plates;

- Major structural penetrations, such as floor slabs, beams, girders, columns, curbs or structural penetrations on roofs and ornamentation or appendages that substantially or completely penetrate the insulation layer;

---

[1] See, for example, the Building Envelope Thermal Bridging Guide (BETBG), Version 1.1.
https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-1.1.pdf

- The interface junctions between building envelope assembles such as: roof to wall junctions and glazing to wall or roof junctions;

- Cladding structural attachments including shelf angles, girts, clips, fasteners and brick ties; and

- The edge of walls or floors that intersect the building enclosure that substantially or completely penetrate the insulation layer.

The following items need not be taken into account in the calculation of the overall thermal transmittance of opaque building envelope assemblies:

- Mechanical penetrations, such as pipes, ducts, equipment with through-the-wall venting, packaged terminal air conditioners or heat pumps;

- The impact of remaining small unaccounted for thermal bridges where the expected cumulative heat transfer though these thermal bridges is so low that the effect does not change the overall thermal transmittance of the above grade opaque building envelope by more than 10%.

3.2.2 Fenestration and Doors

The overall thermal transmittance of fenestration and doors shall be modelled according to their intended actual performance, including the impact of framing for the actual or anticipated window sizes used in the design. The general approach for determining performance shall be in accordance with NFRC 100, "Determining Fenestration Product U-factors", with the following limitations:

- The thermal transmittance for fenestration shall be based on the actual area of the windows and not the standard NRFC 100 size for the applicable product type. It is acceptable to area-weight the modelled fenestration U-value based on the relative proportions of fixed and operable windows and window sizes. It is also acceptable to simplify the calculations by assuming the worst case by using the highest window U-value for all fenestration specified on the project.

- If the fenestration or door product is not covered by NFRC 100, the overall thermal transmittance shall be based on calculations carried out using the procedures described in the ASHRAE Handbook – Fundamentals, or Laboratory tests performed in accordance with ASTM C 1363, "Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an indoor air temperature of 21±1°C and an outdoor air temperature of -18±1°C measured at the mid-height of the fenestration or door.

3.2.3 Air leakage

By default, air leakage shall be modelled based on an assumed field-testing value of I_{75} = 1.5 L/s-m² @ 75 Pa and converted to the modelled air leakage rate using the calculations provided below (from the NECB proposed change 1414).

The use of a value lower than the above default rate - a targeted air leakage rate - is permitted but must be substantiated. The targeted air leakage rate must also be converted to the modelled air leakage rate using the calculations provided below. In this case, two proposed building energy models, one using the default air leakage rate and one using the targeted air leakage rate, are required. Refer to the ZCB-Design v2 Workbook for a list of documentation requirements.

Conversions between air leakage values used in the energy models and the field test air leakage rates should use the methodology from the NECB proposed change 1414. The method published in the proposed change, made available to the public in January 2020, is copied here for convenience. Other conversions are allowable using suitable engineering calculations.

NECB proposed change 1414 section 8.4.2.9. Air Leakage

[1] The energy model calculations shall account for air leakage through the *building envelope*.

[2] The air leakage rate of the *building envelope* shall be adjusted using the following equation:

$$I_{AGW} = C \times I_{75Pa} \times \frac{S}{A_{AGW}}$$

where

I_{AGW} = adjusted air leakage rate of the *building envelope* at a typical pressure differential of 5 Pa and relative to the area of the above-ground walls, in L/(s·m²),

C = (5 Pa / 75 Pa)^n, where n = flow exponent, which shall be 0.60, if no whole *building* test result is available, or the calculated value, if whole *building* testing is carried out in accordance with Article 3.2.4.2. and a series of tests are conducted at different differential pressures,

I_{75Pa} = assumed or measured normalized air leakage rate of the *building envelope* at a pressure differential of 75 Pa, in L/(s·m²),

where the measured air leakage rate at a pressure differential of 75 Pa is calculated as I_{75Pa} = Q/S,

where Q = volume of air flowing through the *building envelope* when subjected to a pressure differential of 75 Pa, determined in accordance with ASTM E 779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization," in L/s, and

S = total area of the *building envelope*, including the lowest floor, below-ground and above-ground walls, and the roof (including vertical *fenestration* and *skylights*), in m², and

A_{AGW} = total area of above-ground walls, in m².

---

4. ADDITIONAL CALCULATION AND REPORTING GUIDANCE

4.1 Energy Use Intensity

This metric shall be based on direct outputs of the energy model, with required adjustments (such as exceptional calculations) clearly demonstrated. Energy use types and amounts must be entered into the ZCB-Design v2 Workbook, which will calculate the EUI of the building using the modelled floor area.

Refer to the Energy Use Intensity Section of the ZCB-Design Standard v2 for additional information.

4.2 Peak Demand

The modelled summer and winter peak demand of the building, including dates and times will be automatically derived in the ZCB-Design v2 Workbook based on the hourly electricity data entered.

Refer to the Peak Demand Section of the ZCB-Design Standard v2 for additional information.

4.3 Renewable Energy

Renewable energy can be determined using one of the following methods:

1. If the building simulation program is capable of modelling the on-site renewable energy, then those systems can be modelled directly within the design building energy model.

2. If the building simulation program is not capable of modelling the renewable systems, or the modeller prefers to use different software, those systems can be modelled using a renewable energy system model that utilizes the same weather file as the design energy model.

3. Hourly renewable electricity generation (green power) must be entered into the ZCB-Design v2 Workbook.

Refer to the Owned Renewable Energy Systems Section of the ZCB-Design Standard v2 for additional information.

4.3.1 Exported Green Power

Exported green power will be automatically calculated in the ZCB-Design v2 Workbook using the hourly electricity use and green power (renewable electricity) generation values entered.

Refer to the Avoided Emissions from Exported Green Power Section of the ZCB-Design Standard v2 for additional information.

GLOSSARY

Clear Field – An opaque wall or roof assembly with uniformly distributed thermal bridges, which are not practical to account for on an individual basis for U-value calculations. Examples of thermal bridging included in the Clear Field are brick ties, girts supporting cladding, and studs. The heat loss associated with a Clear Field assembly is represented by a U-value (heat loss per unit area).

Energy use intensity (EUI): The sum of all **site energy** consumed on site (e.g., electricity, natural gas, district heat), including all process loads, divided by the building **modelled floor area**.

Exported green power: Any **green power** that is generated onsite in excess of the buildings electricity use at a given time-step.

Green power: Electricity generated from renewable resources, such as solar, wind, geothermal, low-impact biomass, and low-impact hydro resources. **Green power** is a subset of renewable energy that does not include renewable energy systems that do not produce electricity, such as solar thermal systems.

Interface Details – Thermal bridging related to the details at the intersection of building envelope assemblies and/or structural components. Interface details interrupt the uniformity of a clear field assembly and the additional heat loss associated with interface details can be accounted for by linear and point thermal transmittances (heat loss per unit length or heat loss per occurrence).

Modelled floor area (MFA): The total enclosed floor area of the building, as reported by the energy simulation software, excluding exterior areas and indoor (including underground) parking areas. All other spaces, including partially-conditioned and unconditioned spaces, are included in the MFA.

Peak demand: The building's highest electrical load requirement on the grid, measured and reported in kW, reflecting any peak shaving impacts from demand management strategies including onsite renewable energy and energy storage.

Site energy: The amount of energy used on the building site.

Thermal energy demand intensity (TEDI): The annual heat loss from a building's envelope and ventilation after accounting for all passive heat gains and losses, per unit of **modelled floor area**.