ZERO CARBON BUILDING STANDARD
Canada Green Building Council

Zero Carbon Building

Energy Modelling Guidelines

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Contents

1. INTRODUCTION

This document has been created to provide clarity for energy modelling performed in support of Zero Carbon Building – Design certification, primarily in regards to the determination of Thermal Energy Demand Intensity. It also provides additional information on how to account for exported, onsite renewable energy and peak demand.

The expectation is that energy models used for compliance with the CaGBC's Zero Carbon Building Standard ("the standard") 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 DHW 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 hours of operation and equipment run times are understood rather than relying on arbitrary defaults from software or applicable code or standards.

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.

As the standard relies heavily on Energy Star® Portfolio Manager to calculate building energy and emissions performance, applicants to the standard should consult the technical guidelines on the Portfolio Manager access page for clarity on any other definitions and methodology. Clarity on all requirements of the Zero Carbon Building Standard can be found on the CaGBC website.

1.1 DEFINITIONS

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).

Greenhouse Gas Intensity (GHGI) – The total greenhouse gas emissions associated with all energy use on the *building site*. GHGI shall be reported in kg CO_2e/m^2/year. See the [Portfolio Manager Technical Reference on GHG Emissions]() for more details on how to calculate building GHGI.

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).

Gross Floor Area (GFA) – The total property floor area, measured between the outside surface of the exterior walls of the building(s). This includes all areas inside the building(s), including supporting areas.

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

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.

2. CALCULATING TEDI

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.

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

Understanding TEDI

The use of a thermal energy 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. The efficient delivery and waste heat recovery of ventilation air are also captured by the TEDI metric, and are measures that are best implemented in new construction and major renovations (rather than existing buildings). Performance limits have been developed such that both architectural and ventilation measures must both be addressed to minimum levels of best practice. The methodology presented in Section 2 should be used in all cases to determine or calculate TEDI from energy models to ensure consistency, regardless of HVAC system type used. Note that in the event that building design involves situations that are not specifically accounted for in Section 2, the definition noted in Section 1.1 should be used to guide calculations and energy model inputs.

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 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.

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

2.1 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.

2.2 CALCULATING BUILDING ENVELOPE HEAT LOSS

The ZCB-Design standard 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.

2.2.1 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;
- ✓ The interface junctions between building envelope assembles such as: roof to wall junctions and glazing to wall or roof junctions;

[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

- ✓ 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:

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

2.2.2 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 pro 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.

2.2.3 INFILTRATION

- Infiltration shall be modelled at 0.00025 $m^3/s/m^2$ or 0.05 cfm/ft^2 of total (at 5 Pa), above grade gross wall area (i.e. walls and windows), unless air leakage testing will be conducted to verify alternate values.
- Air leakage testing values determined at 75 Pa can be approximately converted for use in the energy model using a constant value by multiplying the tested value at 75 Pa by 0.112 (as per formula below). For example, a tested value of 0.0015 $m^3/s/m^2$ at 75 Pa would

equate to 0.000168 $m^3/s/m^2$, which can then be used in the energy model, instead of the 0.00025 $m^3/s/m^2$ indicated. Other conversions are allowable using suitable engineering calculations.

$$(Model\ Input\ Air\ Leakage\ @5\ Pa\ [\frac{\frac{m^3}{s}}{m^2}]) = (Measured\ Air\ Leakage\ @75\ Pa\ [\frac{\frac{m^3}{s}}{m^2}]) * (0.112)$$

3. ADDITIONAL CALCULATION GUIDANCE

3.1 CALCULATING ENERGY USE INTENSITY

Applicants to the ZCB program shall report their Energy Use Intensity (EUI). EUI refers to the sum of all site (not source) energy consumed on site (e.g., electricity, natural gas, district heat), including all process energy, divided by the building gross floor area. This metric shall be a direct output of the energy model.

3.2 CALCULATING PEAK DEMAND

Applicants to the ZCB program shall report their Peak Demand. This metric shall be a direct output of the energy model, averaged over a one hour time-step. For models that use sub-hourly time-steps, an average hourly value shall be used.

3.3 CALCULATING RENEWABLE ENERGY

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

- 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.
- If the building simulation program is not capable of modelling the on-site 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. The energy displaced by these systems can be subtracted from the building energy model results.

3.3.1 CALCULTING EXPORTED RENEWABLE ENERGY

Applicants must provide calculations for the avoided emissions from onsite renewable energy that is exported, using the marginal provincial CO_2e factors. Exported renewable energy is defined as any renewable energy that is generated onsite in excess of the buildings requirement at a given time-step (i.e., hourly or sub-hourly). The sum of the exported renewable energy over a year can only be calculated using an hourly or sub-hourly energy model that includes both the building energy consumption and renewable energy generation or separate hourly or sub-hourly energy models for the building and renewable energy system that utilize the same weather file as input. It is not sufficient to provide an annual balance of renewable energy generation since the emissions factors are different whether the site is using the onsite renewable energy (i.e., uses average emissions factors) or whether it is being exported to the grid (i.e, uses marginal emissions factors).

3.4 GENERAL MODELLING NOTES

The expectation is that energy models used for compliance with the standard will be developed to represent the actual anticipated operation of the facility for all energy uses on site. This will require the modelling professional to communicate with the client and facility operations staff to understand the building rather than relying on arbitrary defaults from software, or applicable codes and standards.

4. REPORTING GUIDANCE

4.1 REPORTING TEDI

The modelled TEDI performance of the building shall be reported in kWh/m2/year.

4.2 REPORTING ENERGY USE INTENSITY

The modelled site EUI of the building shall be reported in kWh/m2/year, calculated based on the total predicted annual energy consumption from the whole building energy simulation divided by the gross floor area.

4.3 REPORTING PEAK DEMAND

The modelled Peak Demand of the building must be reported in kW, including the date and time when the peak is modelled to occur.

4.4 REPORTING EXPORTED RENEWABLE ENERGY

The modelled exported renewable energy for the building must be reported in kWh.