City of Vancouver *Land Use and Development Policies and Guidelines*

Planning, Urban Design and Sustainability Department

453 West 12th Avenue, Vancouver, BC V5Y 1V4 | tel: 3-1-1, outside Vancouver 604.873.7000 | fax: 604.873.7100
website: vancouver.ca | email: planning@vancouver.ca

ENERGY MODELLING GUIDELINES

Version 2.0

Effective March 17, 2017
Amended July 11, 2018

(These guidelines are referenced in the Green Buildings Policy for Rezonings, amended by Council on November 29, 2016)

July 2018

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1 Introduction and Intent

The City of Vancouver Energy Modelling Guidelines (the “CoV Modelling Guidelines”, or “the guidelines”) provide clarity on energy modelling inputs for the purposes of showing compliance with absolute performance limits, as established in the City of Vancouver Green Buildings Policy for Rezonings, and the Vancouver Building Bylaw (“the Policy”, “the VBBL”, or “code”). This document is not intended to be an exhaustive set of technical and administrative requirements or best practices for energy modelling, and these guidelines are to be used in addition to the applicable requirements for energy performance modelling as written in the National Energy Code of Canada for Buildings (NECB), Part 8.

These guidelines are also referenced in the BC Energy Step Code and are applicable to projects designed to the BC Energy Step Code.

The objectives of the Modelling Guidelines are to:

(a) Standardize and clarify inputs to ensure that modelled building performance is comparable between projects and with fixed performance limits; and,

(b) Reduce the potential performance gap between energy models and actual operating performance of buildings.

This document standardizes energy modelling inputs that may have a large impact on performance targets but are not integral to building system performance (for example, schedules). It also clarifies inputs where current industry practice for those inputs does not support intended outcomes or leads to performance gaps (for example, not fully accounting for total envelope heat loss through thermal bridges).

Design-related modelling inputs not specified in this document shall represent the actual design. Software limitations shall not limit the accuracy of energy modelling to show compliance with the Policy; consultants are expected to overcome software limitations with appropriate engineering calculations. All other modelling inputs not discussed in these guidelines shall be based on good engineering practice.

1.1 Guidelines are Additional to NECB Modelling Requirements

As stated above, these guidelines are intended to be used in addition to the applicable requirements for energy performance modelling as written in the NECB, Part 8. In the event of overlap between these guidelines and the modelling requirements of Part 8, the following conditions shall apply:

(a) Semi-conditioned and unconditioned spaces shall be modelled as per the design. These spaces do not need to be modelled as fully-conditioned and do not contribute to annual unmet hours.

(b) Infiltration shall be modelled as per Section 2.4 of these guidelines.

(c) Components of the building envelope are to be modelled as per Section 3 of these guidelines.

(d) In cases where the design ventilation rate exceeds the minimum required by code, ventilation rates shall be modelled as per the design.

(e) For buildings or portions of buildings with absolute performance limits, a reference model is not required. For buildings or portions of buildings that do not have an absolute performance limit, refer to section 5.

(f) All building components must be included energy model as required by these guidelines, and may not be excluded by meeting the prescriptive requirements of the NECB.

1.2 Modelled vs Actual Results

The results of models created to meet these guidelines are intended for regulatory purposes only, to enable the Authority Having Jurisdiction (AHJ) to determine whether a building complies with the applicable policy or code. Much like an emissions test on a car, test results are used for standardized comparison, and are not necessarily predictive of actual performance. The energy and thermal comfort performance of actual buildings will depend on many factors that can vary from these standardized assumptions, including: intensity and hours of use, weather, occupant behavior, as-built vs as-designed parameters, among many others. This applies to performance in both actively and passively cooled buildings.

In addition to varying from actual energy use, the standardized assumptions used may vary from those used in other ratings systems or modelling guidelines developed for their respective programs, which will cause differences in modelled performance. As noted above, the standardized inputs in these guidelines were developed to facilitate easy comparison with fixed limits and between projects, with better prediction of actual performance as a secondary goal. For this reason, some assumptions may be higher or lower than other references.

1.3 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 steel or woodstuds. 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 the use of all energy utilities on site, using the following emissions factors:

Table 1.2 Emissions Factors by Fuel Type

Fuel Type	Emissions Factor ($kgCO_{2e}$/kWh)
Natural Gas	0.185
Electricity	0.011
District Energy System	as provided by utility[1,2]

[1] The emissions factor of a district energy system shall be as provided by the utility (and as agreed by the utility and the AHJ).

[2] Where a district energy utility agrees to provide a development with energy at a carbon intensity that varies from that of the overall system, documentation of that agreement (or intent to enter an agreement), and any other measures or agreements required to secure the supply of low-carbon energy (such as those required by the CoV LCES Policy), shall be provided to the authority having jurisdiction.

Refer to Section 1.3 for details on how these emissions factors may be reduced through renewable energy.

$$GHGI\ \left[\frac{kgCO_{2e}}{m^2a}\right] = \frac{\sum\left(Site\ Energy\ Use\ \left[\frac{kWh}{a}\right] \times\ Emissions\ Factor\ \left[\frac{kgCO_{2e}}{kWh}\right]\right)}{Modelled\ Floor\ Area\ [m^2]}$$

GHGI shall be reported in kg eCO_{2e}/m^2a, where *a* represents *year*.

***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. The MFA must be within 5% of the gross floor area from the architectural drawings, unless justification is provided demonstrating where the discrepancy arises and why the MFA should differ from the gross floor area by greater than 5%.

Other Building Types – Building types that do not have absolute performance limits established for energy use, heat loss, or greenhouse gases, and instead use a reference model to set targets specific to the proposed building. For these building types, please refer to Section 5.

Performance Limits – Absolute limits on TEUI, TEDI, and GHGI established in policy or code.

Site – The building(s) and all associated area where energy is used or generated. A site may include one or more buildings, either as independent structures or interconnected. For the purposes of these guidelines, sites containing multiple buildings may be divided into separate sites where desirable (ex. where one building must register for LEED), and larger sites may be required to divide sites by block or parcel.

Site Energy Use – All energy used on site including all end-uses, such as heating, cooling, domestic hot water, fans, pumps, elevators, parkade lighting and fans, plug and process energy, interior and exterior lighting, among others. It incorporates all site efficiencies, including the use of heat pumps or re-use of waste heat, but does not include energy generated on site.

Note: For systems connecting to a district energy system, the modeller may choose to include the district system within the scope of the building systems – refer to section 1.6 District Energy Systems for more information.

Site Renewable Energy Generation – Energy generated on site from renewable sources, such as solar or wind. Where a site is not able to send energy off-site (for example, not connected to the electricity grid), only energy that can be consumed (or stored and then consumed) on site shall be counted as Site Renewable Energy Generation.

Thermal Energy Demand Intensity (TEDI) – The annual heating energy demand for space conditioning and conditioning of ventilation air. This is the amount of heating energy that is output 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 (for example, make-up air units, air handling units, etc.), terminal equipment (for example, baseboards, fan coils, heat pumps, reheat coils, etc.), or any other equipment used for the purposes of space and ventilation conditioning. TEDI does not include mechanical efficiencies of heating equipment, and hot water or heat pump heating sources that are derived from a waste heat source, or a renewable energy source, do not contribute to a reduction in TEDI. Heating output of any heating equipment whose source of heat is not directly provided by a utility (electricity, gas or district) must still be counted towards the TEDI.

Note: Specific examples of heating energy that are not for space conditioning and ventilation, and would not be included in the TEDI, include domestic hot water, maintaining swimming pool water temperatures, outdoor comfort heating (for example, patio heaters, exterior fireplaces), and heat tracing.

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

TEDI shall be reported in kWh/m^{2}a, where *a* represents *year*.

Total Energy Use Intensity (TEUI) – The sum of all energy used on site (i.e. electricity, natural gas, district heat), minus all renewable energy generated on site, divided by the *Modelled Floor Area*.

$$TEUI\left[\frac{kWh}{m^2a}\right]=\frac{\sum Site\ Energy\ Use\ \left[\frac{kWh}{a}\right]-\sum Site\ Renewable\ Energy\ Generation\ \left[\frac{kWh}{a}\right]}{Modelled\ Floor\ Area\ [m^2]}$$

TEUI shall be reported in kWh/m^{2}a, where *a* represents *year*.

1.4 Renewable Energy

1.4.1 Site-Generated Renewable Energy

As stated in the definition of TEUI, renewable energy generated on site may reduce the TEUI. Additionally, the City of Vancouver Zero Emissions Building Plan states that if grid electricity is not 100% renewable, a building may achieve zero emissions by installing on site renewable energy generation to offset the portion of grid electricity that is non-renewable. As electricity in BC is legislated to be a minimum of 93% renewable, an all-electric building can achieve zero emissions by installing renewable electricity generation equal to 7% of site electricity use, and in this case the electricity emissions factor is considered to be zero. For sites installing renewable electricity generation totaling less than 7% of site electricity use, the electricity emissions factor is reduced proportionally, to a minimum of zero. For the purposes of these guidelines, this may be read from Table 2 below or calculated as follows.

$$Emissions\ Factor_{elec}\left[\frac{kgCO_{2e}}{kWh}\right]=-0.157\times\left(\frac{Site\ Generated\ Renewable\ Energy_{elec}}{Site\ Energy\ Use_{elec}}\right)+0.011$$

Table 1.3.1 Reduced Electrical Emissions Factors

Percent of Electrical Site Energy Use Generated On Site	Reduced Electrical Emissions Factor (kgCO_{2e}/kWh)
0%	0.0110
1%	0.0094
2%	0.0079
3%	0.0063
4%	0.0047
5%	0.0032
6%	0.0016
7%	0.0000

1.4.2 Purchased Renewable Energy

Where renewable energy is purchased directly from utilities or renewable energy providers, and guarantees of long-term supply are provided to the satisfaction of the AHJ, an emissions factor of zero may be applied to the portion of the utility that is renewable.

Note: Guarantees of long-term supply must be provided for at least the portion of renewable energy used to demonstrate compliance with the limits.

1.5 Weather File

Projects shall use the Canadian Weather year for Energy Calculation (CWEC) 2016 weather file. The weather files for BC are available online from Environment Canada here: ftp://client_climate@ftp.tor.ec.gc.ca/Pub/Engineering_Climate_Dataset/Canadian_Weather_year_for_Energy_Calculation_CWEC/ENGLISH/CWEC_v_2016/BC_CWEC.zip

An additional source for download is available here: http://climate.onebuilding.org/

1.6 District Energy

For buildings connecting to a district energy utility, the modeller may choose two options:

1. Model heat energy as delivered to site with 100% efficiency; or,

2. Model the building systems as including the total district energy system, and use the system efficiency as provided by the utility (and as agreed on by the utility and the AHJ) when calculating site energy use. Where district systems make use of biomass/biofuels to achieve low carbon supply yet are limited in maximum efficiencies, consideration may be given in the system efficiency agreed on with the AHJ.

2 Standardized Assumptions

2.1 Schedules

Occupancy, temperature setpoints, lighting, plug load, domestic hot water (DHW), and ventilation fan schedules shall generally be as per NECB 2011 for the corresponding building type or building function with the clarifications, additions and exceptions listed below. Where actual operating hours are expected to exceed the applicable NECB schedule, use of an alternate and more intensive schedule is permitted.

Table 2.1 Schedules	
Building or Space Type	NECB 2011 Schedule
Residential	Table A-8.4.3.2(1)G
Office	Table A-8.4.3.2(1)A
Retail	Table A-8.4.3.2(1)C
Hotel	Table A-8.4.3.2(1)F
Other Building Types	To be selected by the modeller according to good engineering practice
Residential Corridors	Lighting at 24 hours per day
Enclosed Parking Garages	Lighting at 24 hours per day, Fans at 4 hours per day
Lighting Schedules only for spaces whose functions are not directly tied to the main building function (ex. stairways, mechanical and electrical rooms, etc.)	Use recommended lighting annual hours as guidance, provided in Appendix B of BC Hydro's New Construction Program's Energy Modelling Guideline
Exterior Lighting	Schedule on at night, using Astronomical data for location

2.2 Internal Gains and Domestic Hot Water

Occupancy, plug loads, lighting power and DHW shall be modelled according to the following:

2.2.1 Residential Suites

For Suites in residential buildings, use the following:

Occupancy – 2 people for the 1st bedroom, 1 additional person for each bedroom thereafter. Studios and Single Room Occupancies (SROs) may assume one person per unit.

Plug Loads – 5 W/m^2. If there are gas-fired cooking appliances, then 1 W/m^2 shall be assigned to gas and 4 W/m^2 shall be assigned to electricity. Credit for use of energy efficient appliances (for example, refrigerator, stove/range/oven, dishwasher, washer, dryer) may be applied, provided that the appliances use less energy than current ENERGY STARrequirements for that appliance. Savings are to be determined based on the relative savings using the appliance kWh ratings, applied to the plug value of 5 W/m^2. If the appliance type in question does not have an ENERGY STAR rating available, then no credit is to be applied for that appliance.

Example – Total ENERGY STAR minimum kWh ratings for suite appliances,1,000 kWh.
Total project kWh use for selected suite appliances, 900 kWh.
Reduction in plug load = 5 W/m^2 x 900/1000 = 4.5 W/m^2

Lighting – 5 W/m^2, unless a complete suite lighting design is provided supporting lower alternative values.

Domestic Hot Water (DHW) – 0.0016 L/s/person (0.025 gpm/person), modelled as the peak hourly flow and modified by the schedule noted in Section 2.1. Reduction to this peak hourly flow is allowed and shall be determined using industry standard methods for hot water use estimates (for example, LEED Canada NC 2009, Water Efficiency Prerequisite 1) with savings calculated relative to BC Building Code requirements for maximum fixture flow rates. Reductions are also permitted for installations of passive drain water heat recovery systems to a maximum of 15%, and for heat pump systems, which shall be modelled as per the design. Savings shall be determined using good engineering practice and relative to the areas in which the system is installed (i.e. the 15% reduction is only allowed if drain water heat recovery was installed on all DHW fixtures).

Models shall assume an average domestic cold water inlet temperature of 5°C.

2.2.2 All Other Spaces

Except in residential suites, all occupancy, plug, and DHW loads shall be based on Table A-8.4.3.3.(1)B of NECB 2011. Lighting loads shall be modelled as per the design. Credit for lighting occupancy sensors may be applied as a reduction to the schedule or modelled lighting power density as per the methodology in NECB 2011, Section 4.3.2.10. Daylight sensors shall be modelled directly in the software, where credit will be as per actual modelled results. Credit for DHW savings is permitted using the methodology described for Residential Suites in Section 2.2.1.

2.3 Other Loads

2.3.1 Elevators

Elevators shall be modelled using an electrical load of 3kW per elevator and the equipment schedule of the building type.

2.3.2 Other Process Loads

All process loads expected on the project site are to be included in the energy model. This includes but is not limited to: IT/data loads, exterior lighting, swimming pool heating, patio heaters, exterior fireplaces, heat tracing, etc. All loads are to be estimated to reflect the actual design and using good engineering practice.

Note: electric car charging is not included in building process loads, as this is a growing load that is associated with transportation rather than buildings, and may include sub-metering and/or re-sale of electricity.

For other building types that have a target based on a percentage improvement over a reference building, process loads savings may be applied for the use of ENERGY STAR equipment provided it is documented to the satisfaction of the AHJ.

2.3.3 Fireplaces

Where fireplaces are used as the primary means of space heating, they shall be modelled as any other zone heater. All other fireplaces (indoor and outdoor) shall be modelled using the capacity and schedule consistent with the design and intended use. At a minimum,fireplaces for individual homes shall assume that each fireplace has a capacity of 10 kW each and runs 2 hours per week. Fireplaces intended for communal use shall assume 10 hours per week to reflect greater usage. The energy and emissions shall be captured in the overall TEUI and GHGI results.

2.4 Infiltration

Except as permitted in 2.4.1, infiltration shall be modelled as a fixed rate of 0.20 L/s/m² at operating pressure, and is to be applied to the modelled above-ground wall area (i.e. walls and windows). For Part 9 residential buildings, infiltration is to be modelled using 9.36.6.4, Sentence 4.

2.4.1 Reduced Infiltration Rates

Projects pursuing a TEDI target of 30 or lower may model reduced infiltration rates. The level of reduction depends on the TEDI target, as indicated in Table 2.4.1.

Table 2.4.1: Minimum Infiltration Rates for Energy Modelling	
TEDI Target (kWh/m²a)	Minimum Modelled Infiltration Rate Permitted
> 30	0.20 L/s/m², as per Section 2.4
30 ≥ x > 15	≥ 0.10 L/s/m²
≤ 15	≥ 0.05 L/s/m²

If choosing to model a reduced infiltration rate, the project must commit to achieving the corresponding airtightness target, to be confirmed by mandatory air tightness testing.

Note: projects must provide all airtightness documentation required by the AHJ at each phase of project approval, and projects using reduced infiltration rates may have additional documentation requirements.

Envelope air leakage test results at a pressure of 75 Pa can be converted to ambient pressures for use in energy modelling software by multiplying the value by 0.112. Conversely, modelled infiltration rates may be converted to an air leakage target by dividing by 0.112. Note that air leakage test results are often normalized by the total envelope surface area, which is different than the above ground wall area, due to the inclusion of floors and roofs. When converting from an air leakage test to modelled infiltration or vice-versa, the difference in surface areas must be accounted for.

$$I_{AGW} = 0.112 \times q_{75Pa} \times \frac{S}{A_{AGW}}$$

Where:

I_{AGW}	=	infiltration rate [L/s·m²] to be used for energy modelling, and applied to the modelled above-ground wall area
q_{75Pa}	=	normalized envelope air leakage [L/s·m²] as tested at 75 Pa
S	=	total surface area [m²] of the building envelope included in the air leakage test (i.e. the pressure boundary), including ground floors and roofs, and possibly below-grade walls.
A_{AGW}	=	modelled area [m²] of above-ground wall (including windows)

Example 1 – A six-storey residential building with a TEDI target of 15 has:
6,000m² of total floor area;
3,600m² of above-ground wall area;
1,000m² of roof area; and,
1,000m² of floor slab area.

Combining the above-ground wall, roof, and floor slab areas, this equates to a total envelope surface area of 5,600m² to be tested for air leakage. As this project has a TEDI target of 15, it is permitted to model an infiltration rate lower than stipulated in Section 2.4, and as low as 0.05 L/s/m², as per Table 2.4.1. During schematic design, the project chooses advanced airtightness as an energy savings measure, and chooses to model an infiltration rate of 0.10 L/s/m². The design team then converts this infiltration rate to an airtightness target, so the project can be designed and constructed to achieve the predicted level of performance.

$$q_{75Pa} = \frac{I_{AGW} \times A_{AGW}}{0.112 \times S} = \frac{0.10 \times 3,600}{0.112 \times 5,600} = 0.58\, L/s \cdot m^2 @75Pa$$

Note: The above is an example of modelling a reduced infiltration rate as permitted by this section, and the above calculation shows this represents an exceptional level of airtightness to be achieved. Projects modelling a reduced infiltration rate must consider the achievability of the corresponding airtightness target when deciding on the infiltration rate to be modelled.

Example 2 – The same six-storey residential building from Example 1 is tested for airtightness after construction and achieves a result of 0.50 L/s·m² @ 75 Pa. The design team then converts this to an infiltration rate for use in the final energy model.

$$I_{AGW} = 0.112 \times q_{75Pa} \times \frac{S}{A_{AGW}} = 0.112 \times 0.50 \times \frac{5,600}{3,600} = 0.087 L/s \cdot m^2$$

For more information on achieving airtight buildings, refer to BC Housing’s Illustrated Guide to Achieving Airtight Buildings.

2.5 Ventilation

2.5.1 Ventilation Rates

Ventilation rates are to be modelled as per design, including but not limited to ventilation for occupants according to building code requirements, make-up air for exhaust requirements, corridor pressurization make-up air in residential buildings, among others. Note that for residential projects designing to ASHRAE 62-2001, make-up air quantities for the suites are typically not permitted to be lower than that required by Table 2: Outdoor Air Requirements for Ventilation - 2.3 Residential Facilities, of ASHRAE 62-2001.

2.5.2 Corridor Pressurization in MURBs

As the industry moves towards more airtight suites and buildings, and lower energy use, the quantity and purpose of air delivered into corridors is evolving. During this transition period, projects that provide additional airflow to corridors above the minimum required by code may subtract an adjustment value from the modelled TEUI, TEDI, and GHGI when demonstrating compliance with the performance limits. These adjustment values are to be implemented as a post-processing exercise, using the modelled outputs that are reflective of the actual ventilation design. Adjustments shall not be made to the simulation files themselves, and modellers will be required to report the TEUI, TEDI and GHGI both pre- and post-adjustment.

Adjustment values shall be calculated according to the equations below, to a maximum TEDI adjustment of 10, and a minimum of 0.

$$TEDI\ Adjustment = \frac{HDD \times \left((0.029 \times \#Suites\ \times (L/s/door)) - (0.0073 \times Corridor\ Area)\right)}{MFA}$$

$$TEUI\ Adjustment = TEDI\ Adjustment$$

$$GHGI\ Adjustment = TEUI\ Adjustment \times Emissions\ Factor$$

Where HDD is Heating Degree Days (18°C base temperature) for the site as stated in the building code in Division B, Appendix C, Table C-2.

The GHGI Adjustment shall use the emissions factor of the fuel used to heat air supplied to the corridors. Systems using heat pumps to heat corridor supply air, including heat pump make-up air units with natural gas backup, shall be considered electric.

Example – A 10,000m² residential building in Vancouver with 125 suites is designed to provide 7 L/s/door of supply air to 1,500m² of corridor space, using a gas-fired make-up air unit.

TEDI Adjustment = (2825 x ((0.029 x 125 x 7) – (0.0073 x 1,500))) / 10,000 = 4.1 kWh/m²

TEUI Adjustment = 4.1 kWh/m²

GHGI Adjustment = 4.1 x 0.185 = 0.8 kgCO_{2e}/m²

After the design is modelled and the as-designed TEUI, TEDI, and GHGI have been documented, the calculated adjustment factors may be subtracted, and both the pre- and post-adjustment values reported when demonstrating compliance.

2.5.3 Demand Control Ventilation

Credit may be taken for demand control ventilation systems that monitor CO_2 levels by zone and that have the ability to modulate ventilation at either the zone or system level in response to CO_2 levels. Reductions in outdoor air shall be modelled as closely as possible to reflect the actual operation of the designed ventilation system and controls. The occupancy schedule from Section 2.1 can be used as a surrogate for CO_2 control in the model. For example, if a zone has the ability to decrease ventilation in response to CO_2 levels in that zone, the ventilation for that zone at each time step shall be determined by multiplying the zone’s design ventilation rate with the scheduled occupancy fraction.

2.6 Other Considerations

Depending on the stage of the project that the energy model is developed, there may be the need to make a number of assumptions, of which many can have a significant impact on the performance of the building. While it is up to the design team and energy modeller to make reasonable assumptions based on past experience or engineering judgement, the items noted below are explicitly listed as they are often misrepresented in energy models.

2.6.1 Heat or Energy Recovery Ventilators

Heat or energy recovery ventilators shall be modelled according to design, even in instances where there exists software limitations. Appropriate workarounds or external engineering calculations are expected to be performed to accurately assess the performance of the as-designed systems. This includes the use of preheat coils and/or other frost control strategies.

When modelling a heat recovery system, the energy modeller must use Sensible Recovery Efficiency (SRE), and determine if an adjustment to efficiency is required to properly account for fan heat in the system. The modeller must do one of the following:

(a) Use SRE of the specified product and model fan location and power as per the Heat Recovery Ventilator (HRV) design directly in the software; or,

(b) If the software cannot model exact fan placement and/or fan power as per the HRV’s design, adjust the SRE efficiency so that it incorporates the benefit of fan heat directly in the SRE value for any fans that contribute heat to the supply air stream. Model the fans without power and account for their energy use elsewhere in the software or externally to the software.

Note: SRE is a measure of the heat exchanger's efficiency, i.e. removing the impact of case heat loss, air leakage, fan heat, etc., and is defined in CAN-CSA C439-2014. While the impact of such items do improve the heat exchanged to the supply air of the HRV, they do so at the expense of indoor air quality or heat from the space in which the HRV is located, with the exception of fans.

Heat or energy recovery ventilators that use frost control strategies which limit the amount of ventilation supplied to the space (i.e. exhaust only defrost) shall be modelled to include an electric preheat coil before the heat or energy recovery ventilator that heats the air to the minimum temperature before frost control is employed, as indicated by the manufacturer. For example, if the minimum temperature prior to frost control being deployed is -5°C, then an electric preheat coil shall heat the incoming air to -5°C prior to it entering into the heat or energy recovery ventilator. The purpose of this approach is to not reward designs that reduce ventilation to the space due to their lack of efficiency.

For more detail on these requirements, refer to Chapter 3 of BC Housing's Guide to Low Thermal Energy Demand in Large Buildings.

2.6.2 Terminal Equipment Fans

Terminal equipment fans shall be modelled according to design. Specifically, ensure that fan power and fan control (i.e. cycling, always on, multi or variable speed) of terminal equipment represent the design and design intent as accurately as possible.

2.6.3 Variable Air Volume (VAV) and Fan-Powered Boxes

Modellers must ensure that minimum flow rates and control sequences of VAV terminals and Fan Powered Boxes are modelled according to the design, and if not available at the time of modelling, according to expected operation based on maintaining ventilation and other air change requirements as appropriate. Note that default values for minimum flows of VAV terminals are often unreasonably low in most energy modelling software.

2.6.4 Exhaust Fans

Suite exhaust fans that are not part of the ventilation system (for example, kitchen exhaust or bathroom exhaust not connected to an HRV or similar), shall have a runtime of 2 hours/day. All other exhaust fans, including heat recovery units, shall be modelled to reflect the design intent as accurately as possible.

Note: make-up air for suite exhaust fan use under this section is considered to be accounted for as part of the overall infiltration of the building, as per 2.4.1. No additional intake of outdoor air is required to satisfy the requirements of this section.

2.7 Projects Not Sub-Metering Hot Water for Space Heating

Research indicates that multi-unit residential projects that do not sub-meter hot water for space heating at the suite level typically use 15% additional heating energy or more when compared to sub-metered suites. To account for this increase in heating energy use, projects where suite hot water for space heating is not sub-metered must add 15% to their modelled residential heating energy end-use. This increase would be reflected in the TEUI only (i.e. TEDI results would remain as a direct output from the model, with no additional 15% added).

Typical building envelope thermal bridging elements that can have a significant impact on heat loss that have historically been underestimated include: balcony slabs, cladding attachments, window wall slab by-pass and slab connection details, interior insulated assemblies with significant lateral heat flow paths such as interior insulated poured-in-place concrete or interior insulation inside of window wall or curtain wall systems, and others. With the recent addition of industry resources that support more efficient and accurate calculations of building envelope heat loss, assemblies and associated thermal bridging elements must be accurately quantified, according to the requirements below.

3.1 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 losses from interface details are to be incorporated in the modelled assembly U-values, according to the provisions below.

3.1.1 Acceptable Approaches

Overall opaque assembly U-values must be determined using the Enhanced Thermal Performance Spreadsheet (available from BC Hydro New Construction Program), 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.

If clear fields or interface details matching the proposed opaque assemblies are not available in the BETBG, overall U-values may be determined using any of the following approaches:

(a) 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 in the BETBG;

(b) Performance of spandrel panels may be determined using the Reference Procedure for Simulating Spandrel U-Factors, developed for Fenestration BC;

(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.

3.1.2 Thermal Bridges to be Included

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:

(a) Closely spaced repetitive structural members, such as studs and joists, and of ancillary members, such as lintels, headers, sills and plates,

(b) 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,

(c) The interface junctions between building envelope assembles such as: roof to wall junctions and glazing to wall or roof junctions,

(d) Cladding structural attachments including shelf angles, girts, channels, clips, fasteners and brick ties,

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

3.1.3 Thermal Bridges that may be Excluded

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

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

(b) The impact of remaining small unaccounted for thermal bridges can be ignored if the expected cumulative heat transfer through 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 Fenestration and Doors

The overall thermal transmittance of fenestration and doors shall be determined in accordance with NFRC 100, “Determining Fenestration Product U-factors”, with the following limitations:

(a) 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.

(b) 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.

4 Passively Cooled Buildings

Overheating is already a concern for non-mechanically cooled buildings, due to large amounts of glass, minimal shading, and few natural ventilation strategies. Improving the building envelope to meet the applicable performance requirements may lead to increasing overheating if they are not addressed through design strategies that limit heat gain and promote passive cooling. The following requirements are intended to mitigate this effect, as well as ensure any benefit a project might seek from passive solar gains is balanced with considerations of summertime overheating. As noted in Section 1.1, the actual thermal performance of the building will depend on many factors, and these requirements are not intended as a guarantee of thermal comfort.

For buildings that do not incorporate mechanical cooling, it must be demonstrated that interior dry bulb temperatures of occupied spaces do not exceed the 80% acceptability limits for naturally conditioned spaces, as outlined in ASHRAE 55-2010 Section 5.3, for more than 200 hours per year for any zone (for Vancouver, refer to Table 4 below).

For buildings or spaces with vulnerable groups (for example, seniors housing, shelter and supportive housing, daycares, schools, healthcare facilities, etc.), it is recommended that projects work with owners and user groups to determine if mechanical cooling may be required to achieve their thermal comfort needs. Where pursuing passive cooling, it is recommended that projects target a more strigent threshold of not exceeding the 80% acceptability limits for more than 20 hours per year.

Measures such as solar shading, minimizing internal gains, dynamic glass, effective methods of natural ventilation, etc. shall be validated through engineering calculations (i.e. computer modelling or similar). Calculations must be based on hourly weather data using the weather file required in Section 1.5, or a warmer alternate weather file accepted by the AHJ.

Table 4 Acceptability Limits for Naturally Conditioned Spaces in Vancouver[1]

Month	80% Acceptability Limit
April	N/A (Mean temperature too low)
May	25.2 ˚C
June	26.1 ˚C
July	26.9 ˚C
August	26.9 ˚C
September	25.2 ˚C
October	N/A (Mean temperature too low)

Notes:
[1] Acceptability limits for other locations must be derived from the weather file for that location.

Note: Compliance with the limits must be demonstrated to the satisfaction of the AHJ. This could be achieved by submitting a summary of the modelled temperatures in each zone, or by summarizing the results in select zones, chosen to create a representative picture of the building, and including any areas of high concern (for example, west-facing suites on upper floors).

5 Mixed Use and Other Building Types

5.1 Mixed-Use Buildings

Buildings consisting of different occupancies with different absolute TEUI, TEDI, and GHGI targets shall create whole-building targets by area-weighting the TEUI, TEDI, and GHGI requirements accordingly.

For buildings consisting of different occupancies that have different fundamental requirements (i.e. part of the building has absolute TEUI, TEDI, and GHGI target and part of the building has a reference building target), the following methodology shall be used to determine the overall building requirements:

(a) Develop a reference building only for the portion(s) of the building that do not have an absolute performance target. Note that the reference building may be based on either ASHRAE 90.1 or NECB as permitted by the applicable policy or code requirements. The reference building may also use a de-rated R-value according to the methodology outlined in the white paper “Accounting for thermal bridging at interface details – a methodology for de-rating prescriptive opaque envelope requirements in energy codes”, available from the BC Hydro New Construction Program.

(b) Extract the TEUI, TEDI, and GHGI for that reference building.

(c) If required (such as projects subject to Vancouver’s Green Buildings Policy for Rezonings), reduce the TEUI according to the percentage savings required.

(d) The total building TEUI, TEDI, and GHGI requirement shall be based on an area-weighted average between the resulting targets for the reference building, and the requirements for the rest of the building.

(e) In addition to the total building targets, the portions of the building that have a TEDI target must still meet their combined TEDI target.

5.2 Other Building Types

For other building types that do not have absolute performance limits and instead have a reference building target, follow the modelling requirements and methodologies laid out in ASHRAE 90.1, or NECB Part 8. The proposed building must account for overall thermal performance as described in Section 3 of these guidelines, and as a result the reference building may use a de-rated R-value according to the methodology outlined in the white paper “Accounting for thermal bridging at interface details – a methodology for de-rating prescriptive opaque envelope requirements in energy codes” available from the BC Hydro New Construction Program.

6 Resources

(a) 2014 Building America House Simulation Protocols, NREL, 2014

(b) Accounting for thermal bridging at interface details – a methodology for de-rating prescriptive opaque envelope requirements in energy codes, BC Hydro, 2015

(c) ASHRAE Handbook of Fundamentals, ASHRAE, 2013

(d) ASHRAE Standard 90.1-2010 – Energy Standard for Buildings Except Low-Rise Residential Buildings, ASHRAE 2010

(e) Commercial Buildings Building Envelope Thermal Bridging Guide, Version 1.1, BC Hydro, 2016

(f) Energy Modelling Guidelines and Procedures, CONMET, 2014

(g) EnergyStar Multifamily High Rise Program, Simulation Guidelines, Version 1.0, Revision 03, January 2015

(h) Infiltration Modelling Guidelines for Commercial Building Energy Analysis, PNNL, 2009

(i) National Energy Code of Canada for Buildings, NRC, 2011

(j) New Construction Program's Energy Modelling Guideline, BC Hydro, March 2016

(k) TM54 – Evaluating Operational Energy Performance of Buildings at the Design Stage, CIBSE, 2014

(l) Guide to Low Thermal Energy Demand in Large Buildings, BC Housing, March 2018

(m) Reference Procedure for Simulating Spandrel U-Values, Fenestration BC, September 2017

(n) Illustrated Guide to Achieving Airtight Buildings, BC Housing, September 2017

(o) Passive Cooling Study for Multi-Unit Residential Buildings, City of Vancouver, April 2017