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Guideline

Energy Modelling Guidelines

Version ~~2.0~~ 3.0 REDLINE VERSION
Tracked changes from version 2.0 shown in red text

Effective ~~March 17, 2017~~ September 15, 2025

Authority: Chief Building Official

CITY OF VANCOUVER

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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 (the "Policy"), and the Vancouver Building By-law ~~("the Policy",~~ "the VBBL", "By-law", or "code"). These guidelines are applicable to Part 3 new construction. 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 of the applicable version referenced in the VBBL.

~~These guidelines are also referenced in the BC Energy Step Code and are applicable to projects designed to the BC Energy Step Code.~~ Some standards or programs other than City of Vancouver's policies and building by-laws reference these Guidelines (e.g. BC Energy or Zero Carbon Step Code) for modelling compliance. For such projects, use the referenced version of the Guidelines as required by the standard, program, or authority having jurisdiction (AHJ).

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.

The energy modelling professional(s) should adhere to the AIBC & EGBC Joint Professional Practice Guidelines - Whole Building Energy Modelling Services.

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.
b) Components of the building envelope are to be modelled as per Section 3 of these guidelines.
c) In cases where the design ventilation rate exceeds the minimum required by code, ventilation rates shall be modelled as per the design.
d) 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.

e) All building components must be included in the 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 wood studs. The heat loss associated with a clear field assembly is represented by a U-value (heat loss per unit area).

Cooling Energy Demand Intensity (CEDI) – The annual cooling energy demand for space conditioning and conditioning of ventilation air. This is the amount of cooling output, both latent and sensible, from any and all types of cooling equipment per unit of Modelled Floor Area. Cooling equipment may include, but is not limited to, radiant systems, fan coils, air-handler cooling coils, split systems, variable refrigerant flow systems. CEDI does not include mechanical efficiencies of cooling equipment. Cooling output of any cooling equipment whose source is not directly provided by a utility (electricity, gas, or district systems) must still be counted towards the CEDI.

Note: End uses that may be categorized as process loads, such as refrigeration for food storage, would not be included in the CEDI. Cooling of electrical rooms is not a process cooling load.

Equation 1: Cooling Energy Demand Intensity (CEDI)

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

CEDI shall be reported in kWh/m^{2}a, where “a” represents annum (year).

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 1.3.1 ~~2~~ Emissions Factors by Fuel Type	
Fuel Type	Emissions Factor ($kgCO_{2e}/kWh$)
Natural Gas	~~0.185~~ 0.180[3]
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.

[3] Where purchased "renewable" natural gas forms part of the fuel mixture is to be planned, refer to Section 1.4.1.

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

Equation 2: Greenhouse Gas Intensity (GHGI)

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

GHGI shall be reported in kg CO_{2e}/m^2a, where a represents annum (year).

Greenhouse Gas Intensity from Refrigerants (GHGI-R) – The total greenhouse gas emissions associated with the use of refrigerants on site. May be used to calculate and report the life-cycle equivalent annual carbon dioxide emissions of each building, in $kgCO2e/m^2a$, from the emission of refrigerants.

Equation 3: Greenhouse Gas Intensity from Refrigerants (GHGI-R)

$$GHGI-R\left[\frac{kgCO2_e}{m^2a}\right] = \frac{[GWP_r * R_c * (0.02 * L + 0.1)]}{L * MFA}$$

Where:

GWP_r = 100-year Global Warming Potential of the refrigerant [$kgCO2_e/kg_r$]

Rc = Total Refrigerant Charge in the system [kg],

L = Life of the system [years],

MFA = Modelled Floor Area of the building [m^2]

0.02 = Assuming a 2% annual leakage rate

0.1 = Assuming a 10% end-of-life leakage rate

Table 1.3.2: Global Warming Potential of Refrigerants	
Refrigerant	**Global Warming Potential** ($kg\ CO_{2e}/kg_r$)
HFCs	
HFC-23	12,400
HFC-32	677
HFC-134a	1,300
HFC-245fa	858
HFC-404a	3,943
HFC-407c	1,624
HFC-410a	1,924
HFC-507a	3,985
HFC-513A	572
Natural Refrigerants	
Carbon Dioxide (CO_2)	1
Ammonia (NH_3)	0
Propane (R-290)	3

kg_r = kilogram of refrigerant

Note: Reproduced from the Climate Registry 2023 Default Emissions Factors based on GWP-100 values from the Intergovernmental Panel on Climate Change Fifth Assessment (AR5) published in 2013.

Service life should be based on the system in question using Table 2 below. A different service life may be used if supported by documentation acceptable to the AHJ.

~~*Table 2: Default Equipment Lifetime*~~

Table 1.3.3: Default Equipment Lifetime	
Equipment	**Default Equipment Lifetime**
Window air-conditioner, heat pump	10 Years
Unitary, split, packaged air-conditioner, package heat pump	15 years
Reciprocating and scroll compressor, reciprocating chiller	20 years
Absorption chiller	23 years

Water-cooled packaged air-conditioner	24 years
Centrifugal chiller	25 years

Note: Reproduced from the LEED Canada 2009 and v4 Reference Guides, with permission from the CaGBC

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 (in m^2), as reported by the energy simulation software, excluding exterior areas and indoor (~~including underground~~ both above and below grade) parking areas. All other spaces shall be ~~including partially conditioned and unconditioned spaces~~ included in the MFA. This includes unconditioned spaces which are adjacent to vehicle parking areas such as separate bicycle storage rooms, mechanical rooms, and elevator shafts. Horizontal service spaces (e.g. attics and crawl spaces that are concealed and generally inaccessible) are to be excluded from the MFA.

If the MFA differs by more than 5% from the gross floor area reported on the architectural drawings, provide a written explanation for the discrepancy within the energy modelling report, or other compliance documentation as requested by the AHJ. ~~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 (e.g. 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. Energy generated on site may be accounted for in the calculation of the TEUI and GHGI according to their respective definitions. ~~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), humidification, and heat tracing. Space and ventilation heating of vehicle parking areas and horizontal service spaces (e.g. freeze protection of utilities) are to be included in the TEDI unless the heating setpoint is equal to or less than 7°C. This does not affect whether these areas are included in the MFA – refer to the definition of MFA.

Equation 4: Thermal Energy Demand Intensity (TEDI)

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

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

Equation 5: Total Energy Use Intensity (TEUI)

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

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

1.4. Renewable Energy

~~1.4.1~~ Deleted Section ~~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. 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.~~

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

~~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~~

1.4.1~~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 supply for the lifetime of the building 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 a future shifted TMY weather file provided by the National Research Council Canada (NRC) for the RCP 8.5 1.0°C global warming (GW) scenario (the “NRC GW1.0” TMY weather file) to demonstrate compliance to VBBL Section 10.2 Energy Efficiency. The weather files for Vancouver are available here:

LINK TO BE PROVIDED FOR VANCOUVER

Future shifted weather files for the TMY RCP 8.5 2.0°C global warming (GW) scenario (the “NRC GW2.0” TMY weather file) to complete overheating analysis per Section 4 for Vancouver are available here:

LINK TO BE PROVIDED FOR VANCOUVER

For locations outside of Vancouver, NRC weather files for future TMY scenarios can be found on the NRC website, or refer to the requirements of the AHJ:
"Building reference year climate datasets for 564 reference locations in Canada, National Research Council of Canada, 2022-07-22

~~file 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 2020 ~~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 2020 ~~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~~ shall 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 STAR requirements 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 – Suite lighting loads shall be modelled as per the design. For areas within residential suites that are intended for user-supplied lighting (e.g. dining area with ceiling rosette blank, bedroom with switched receptacle for floor lamps, etc.) or where a design is not complete, it is acceptable to model an assumed lighting power density of up to 5 W/m^2~~, unless a complete suite lighting design is provided supporting lower alternative values~~. Modelled lighting power densities may exceed 5 W/m^2 only if supported by the lighting design information.

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~~ Plumbing 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 2020 ~~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 2020 ~~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 3 kW 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, and 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.

2.3.4 Commercial Kitchens

Commercial kitchens and their loads are to be included in the energy model. For the purposes of energy modelling, Commercial kitchens may be represented as a separate 'pseudo major occupancy' for the purposes of establishing performance requirements. This 'pseudo major occupancy' classification is to be used for modelling energy and carbon compliance purposes only. Performance requirements (TEDI, TEUI, GHGI) for these areas are to be determined by a reference building model as per Section 5. Adjacent spaces associated with the kitchen (e.g. dining, storage, back of house, etc.) may be included with this 'pseudo major occupancy' for the purposes of establishing performance requirements to the satisfaction of the AHJ.

2.4. Infiltration

Infiltration rates used in the design phase shall be based on targeted whole building air leakage test rates, using the conversion methodology in section 2.4.1. The targeted whole building air leakage rates may be found in the code requirements (where applicable) or be set by the team. Design teams should consider building geometry, assemblies, air barrier type, details, and construction team experience when considering a whole building air leakage target, to increase the likelihood of meeting the design target at project completion. A tested air leakage rate of 1.5 L/s·m^2 of total enclosure area at 75 Pa is suggested as starting point, representing average airtightness performance. A leakage rate of 1.0 L/s·m^2 is considered a very good level of airtightness, and 0.70 L/s·m^2 is considered exceptional. These are approximate values, intended to provide rough guidelines only.

Projects targeting airtightness levels less than 1.30 L/s·m^2 in modelling compliance to performance limits may be requested to provide a professionally sealed narrative of building envelope products and design & construction strategies that support the target, to the satisfaction of the AHJ. For projects located in the City of Vancouver, refer to the City of Vancouver's Bulletin "Airtightness Testing Process and Requirements for New Buildings"[1] for submittal requirements.

~~Except as permitted in 2.4.1, infiltration shall be modelled as a fixed rate of 0.20 L/s/m^2 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/m^{2}a)~~	~~Minimum Modelled Infiltration Rate Permitted~~
~~> 30~~	~~0.20 L/s/m^2, as per Section 2.4~~

[1] https://vancouver.ca/files/cov/cbo-bulletin-2023-004-ad-bu-airtightness-testing-2023-sept-12.pdf

~~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.~~

2.4.1 Modelling Methodology

Envelope air leakage test results at a pressure of 75 Pa can be converted to typical operating ~~ambient~~ pressures for use in energy modelling software by ~~multiplying the value by 0.112 as~~ applying Equation 6. Conversely, modelled infiltration rates may be converted to an air leakage target by applying Equation 6 ~~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.

Infiltration shall be modelled in all perimeter spaces based on their façade area, at a continuous rate using an "always on, 24 hour a day, 7 days a week" schedule.

Equation 6: Conversion formula for building envelope infiltration

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

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

Where:

I_{AGW} = adjusted air leakage rate of the building envelope at a typical operating pressure differential of 5 Pa and relative to the area of the above-ground walls in [L/s·m^2] ~~infiltration rate [L/s·m²] to be used for energy modelling, and applied to the modelled above-ground wall area~~

I_{75Pa} $\cancel{q_{75Pa}}$ = assumed or measured normalized air leakage rate of the building envelope [L/s·m^2] ~~as tested~~ at a pressure differential of 75 Pa,

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

Where Q = volume of air flowing [L/s] through the building envelope when subjected to a pressure differential of 75 Pa, determined in accordance with ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization"

~~q_{75Pa} = normalized envelope air leakage [L/s·m²] as tested at 75 Pa~~

S = total area of the building envelope [m^2], typically measured at the plane of the building's air barrier assemblies and includes the surface area of doors, windows and the air control layer in the opaque building assemblies ~~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 [m^2] of above-ground walls (including windows)

Example 1 – A six-storey residential building ~~with a TEDI target of 15~~ has:
6,000m^2 of total floor area,
3,600m^2 of above-ground wall area,
1,000m^2 of roof area and,
1,000m^2 of floor slab area.

Combining the above-ground wall, roof, and floor slab areas, this equates to a total envelope surface area of 5,600m^2 to be tested for air leakage. The design team decides to start with a targeted leakage rage (I_{75Pa}) of 1.50 L/s·m^2. The design team converts this value to a modelled infiltration rate of 0.26 L/s·m^2 using Equation 6, to be applied to the façade area in the energy model.

$$I_{AGW} = 0.112 \times I_{75Pa} \times \frac{S}{A_{AGW}} = 0.112 \times 1.50 \times \frac{5{,}600}{3{,}600} = 0.26 \frac{L}{s} \cdot m^2$$

~~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.~~

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

~~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 0.90 ~~0.50~~ L/s·m^2 @ 75 Pa. The design team then converts this to an infiltration rate for use in the final energy model.

$$I_{AGW} = 0.112 \times I_{75Pa} \times \frac{S}{A_{AGW}} = 0.112 \times 0.90 \times \frac{5{,}600}{3{,}600} = 0.16\ L/s \cdot m^2$$

For more information on achieving airtight buildings and appropriate airtightness targets, refer to airtightness and infiltration references listed in section 6.~~, refer to BC Housing's "Illustrated Guide to Achieving Airtight Buildings".~~

~~For more resources on airtightness leakage targets, refer to RDH's paper "Building Enclosure Airtightness Testing in Washington State – Lessons Learned about Air Barrier Systems and Large Building Testing Procedures".~~

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, air distribution effectiveness (as applicable), make-up air for exhaust requirements, corridor pressurization make-up air in residential buildings, among others. Typically, modelled minimum ventilation rates per space must not be less than required as calculated according to the applicable ventilation standard for the project. ~~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 (except addendum n).~~

2.5.2 Corridor Pressurization in MURBs and Hotels/Motels

As the industry moves towards more airtight suites and buildings, direct ventilation in suites, and lower energy use, the quantity and purpose of air delivered into corridors is evolving. Designers are encouraged to consider the purpose and effectiveness of delivering higher than required ventilation volume of air to corridors. 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, and 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, and TEDI ~~and GHGI~~ both pre- and post-adjustment. Note that projects using balanced or unbalanced HRVs or ERVs to supply corridor ventilation may also claim this adjustment based on supply air flow rate.

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

Equation 7: TEDI and TEUI Adjustment for Corridor Pressurization

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

TEUI Adjustment = TEDI Adjustment

~~*GHGI Adjustment=TEUI Adjustment × 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.
Airflow for Pressurization per Door = airflow rate delivered per door via corridor pressurization [L/s/door]
Suites = Number of suites doors provided with corridor pressurization
Corridor Area = area of corridors serving residential suites [m^2] that are pressurized. For example, corridors serving parkades, or a level of retail beneath residential floors should not be included. Similarly, airflow for pressurization per door is calculated only using the air served to applicable corridors to suite doors. For example, if a single make up air unit is providing ventilation to vestibules or corridors in a below-grade parkade, as well as residential corridors, the air volume serving the parkade is not included in the calculation.
MFA = Modelled Floor Area [m^2] - See Section 1.3 Definitions

~~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 10,000m^2 residential building in Vancouver with 125 suites is designed to provide 7 L/s/door of supply air to 1,500m^2 of corridor space, using a gas-fired make-up air unit.

TEDI Adjustment = (~~2825~~ 2925 x ((0.029 x 125 x 7) – (0.0073 x 1,500))) / 10,000 = 4.2~~1~~ kWh/m^2

TEUI Adjustment = 4.2~~1~~ kWh/m^2

~~GHGI Adjustment = 4.1 x 0.185 = 0.8 kgCO2e/m^2~~

After the design is modelled and the as-designed TEUI and 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 when 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 ( ) 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 whose effects are not included in the rated sensible recovery efficiency shall be modelled as designed. If no frost control strategy is specified by the mechanical designer or equipment manufacturer, ~~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~~ model an electric preheat coil ~~shall~~ to 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 referenced in Section 6.

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 Section 2.4.1. No additional intake of outdoor air is required to satisfy the requirements of this section. 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.

All other exhaust fans, including heat recovery units, shall be modelled to reflect the design intent as accurately as possible. For heat recovery units designed to operate at a higher rate on manual occupant control, such as for bathroom exhaust on a timer, this higher rate shall have a runtime of at least 2 hours/day.

2.6.5 Other Fans

All other building fans (e.g. parkade supply and exhaust fans, transfer fans) shall be modelled to reflect the design intent as accurately as possible.

2.7. Small and/or Slim Building Forms Adjustment Factors

Projects with small and/or slim building forms that yield a high Vertical façade to Floor Area Ratio (VFAR) or high Enclosure to Floor Area Ratio (EFAR) may find it difficult to meet absolute floor area-based performance metrics due to the significantly increased infiltration and conduction heat losses per unit floor area, when compared with more conventional Part 3 building forms. A set of adjustment factors has been developed to provide these buildings a reasonable compliance path that results in similar building envelope characteristics as those with conventional building forms.

2.7.1 Eligibility

The adjustment factors described in this section may only be applied to buildings meeting the following criteria to the satisfaction of the AHJ:

1. Small buildings of 1 or 2 storeys (each storey with at least 50% wall area above grade) may claim the Small Building Adjustment described in section 2.7.2.;
2. A building with a VFAR greater than or equal to 0.65 (calculated according to Equation 8) may claim the VFAR Adjustment described in section 2.7.2.; and
    - The high VFAR of the building form must be as a result of site limitations such as, but not limited to: site dimensions, sidewalk setback requirements, neighbouring building setback requirements, infill lot constraints, etc. These limitations should be described in the energy model report to explain the application of this adjustment.

Equation 8: Vertical Façade to Floor Area Ratio

$$VFAR = \frac{A_{AGW}}{MFA}$$

Where:

A_{AGW} = modelled area [m^2] of above-ground wall (including windows) defined in section 2.4.1.
MFA = Modelled Floor Area [m^2] – see section 1.3 Definitions

2.7.2 Adjustment Factors

To allow compliance for small and/or slim buildings required to meet intensity-based performance limits, adjustment factors defined in this section may be applied to the results of the energy model.

Adjustment factors shall be calculated according to the equations below. The Small Building Adjustment is capped at a maximum of 30 and a minimum of 0. The VFAR Adjustment is capped at a maximum of 20 and a minimum of 0. The Form Adjustment may be subtracted from the modelled TEDI and TEUI results when demonstrating compliance with absolute performance limits.

Equation 9: Small Building Adjustment

$$Small\ Building\ Adjustment = 15 \times (3 - \#\ storeys) \times \left(\frac{600}{MFA}\right)$$

Equation 10: VFAR Adjustment

$$VFAR\ Adjustment = 40 \times (VFAR - 0.65)$$

Equation 11: Form Adjustment

$$Form\ Adjustment\ = (Small\ Building\ Adjustment + VFAR\ Adjustment) \times (2 - \frac{3000}{HDD})$$

Where:

# storeys = the number storeys with at least 50% of the exterior wall area (according to the A_{AGW} definition) exposed to outdoor air
HDD = Heating Degree Days (18°C base temperature) for the project location as stated in Division B - Appendix C, Table C-2 Climatic Design Data of the applicable building code.

Example 1 – A small, single storey, standalone convenience store building located in Vancouver has 1000 m^2 modelled floor area and 455 m^2 exterior wall area.

Small Building Adjustment = 15 × (3-1) × (600/1000)
= 18.0 kWh/m^2a

VFAR = 455/1000
= 0.455

The building is not eligible for VFAR adjustment (< 0.65).

Form Adjustment = (18.0 + 0) × (2 – 3000/2925)
= 17.5 kWh/m^2a

Example 2 – A slim 5-storey residential building on an infill lot in Vancouver has 2500 m^2 modelled floor area, and 1900 m^2 exterior wall area.

The Building is not eligible for the Small Building Adjustment (# storeys > 2).

VFAR = 1900/2500
= 0.76

VFAR Adjustment = 40 × (0.76-0.65)
= 4.4 kWh/m^2a

Form Adjustment = (0 + 4.4) × (2 – 3000/2925)
= 4.3 kWh/m^2a

~~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).~~

3 Calculating Envelope Heat Loss

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 according to NECB 2020 Section 3.1.1.5. Performance of spandrel panels may be determined using Section 8.22 of the THERM 7/ WINDOW 7 NFRC Simulation Manual (July 2024), with additional guidance found in ANSI/NFRC 100-2023 Procedure for Determining Fenestration Product U-Values. Thermal bridging elements to include or exclude in the calculation of the overall thermal transmittance of opaque building envelope assemblies shall follow NECB 2020 Section 3.1.1.7. “Calculation of Overall Thermal Transmittance”. ~~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 methods listed in this section shall be used to determine the thermal transmittance and solar heat gain coefficient (SHGC) values of fenestration products to used in building energy model. These methods reference the following industry standards:

- ANSI/NFRC 100-2023 Procedure for Determining Fenestration Product U-Values
- ANSI/NFRC 200-2023 Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence
- CSA A440.2/CSA A440.3 Fenestration energy performance/User guide to CSA A440.2
- Wherever the ANSI/NFRC methods are referenced in this section, CSA A440.2/CSA A440.3 methods also apply

Methods A and B are for fenestration products that fall under the scope of ANSI/NFRC 100 and 200, and thus all products have certified thermal transmittance and SHGC values tested or simulated at ANSI/NFRC 100 Table 4-3 standard sizes from accredited laboratories or professionals.

Method C is for fenestration products that do not have ANSI/NFRC 100 and 200 certification, or products that require additional modelling outside the scope of ANSI/NFRC 100 and 200 (e.g. due to thermal impacts of structural elements, etc).

The thermal performance values used in an energy model may be derived using a combination of these methods as suited to the project's fenestration components and configurations.

Method A: Standardized Size Method

This method allows certified thermal transmittance and SHGC values to be used in the building energy model, regardless of actual product sizes or configurations within the project.

Note: Method A will be phased out over 2 years once industry tools (e.g. tools approved by National Fenestration Rating Council or

Fenestration Canada) enabling Method B are released (expected in mid-2025). Further details on the phase out of Method A will be confirmed once Method B tools are made available.

Method B: Standard Size Scaling Method

This method allows for certified thermal transmittance and SHGC values to be scaled or extrapolated to the actual product size used in a project. The scaled values shall be calculated using the methodology in Appendix A of ANSI/NFRC 100 and 200, specifically "A.1 Determination of SHGC and VT at Non-Standard Sizes" and "A.2 Determination of SHGC and VT at Non-Standard Sizes using Aspect Ratio Calculation" found in ANSI/NFRC 200. Calculated values may be derived using industry approved tools (e.g. tools approved by the National Fenestration Rating Council or Fenestration Canada) to provide thermal values for energy modelling and shall be analyzed using the certified National Fenestration Ratings Council (NRFC) Certified Products Directory (CPD) number based on the standard size values to validate and compare to the installed products.

Note: Good engineering practice shall apply when considering the impacts of structural components that are not included in the NFRC certification scope (which only includes built-in structural elements). Other structural components (e.g. metal reinforcing, couplers, etc.) may impact the overall thermal performance. Thermal modelling or engineering calculations to determine the thermal performance of fenestration configurations that include elements outside of the NFRC certification scope may be requested at the discretion of the Registered Professional of Record (RPR). Such calculations shall be completed according to current NFRC policies and procedures. In such cases, follow Method C for the areas or fenestration configurations under consideration.

Method C: Custom Fenestration Modelling Method

This method allows modelling of the fenestration products' thermal transmittance and SHGC values using the actual sizes and configuration of fenestration products used in the project. Thermal modelling shall be done by an NFRC certified thermal simulator, and include the installed sizes, configurations and all structural elements related to the fenestration system. A thermal simulation report provided by the certified simulator shall include the following information:

- Physical and legal address of building(s)
- A list of each fenestration product type, quantity, size, and area, along with the corresponding U-value and SHGC
- The sizes and configurations of the simulated products as shown by frame elevations and/or shop drawings
- A table of the area-weighting calculations performed to determine the overall average U-values (reported to two decimal places)
- A description of each framing system used, including manufacturer name, series, and model numbers, as well as frame material and any internal reinforcing used
- A complete description of the glazing (e.g. glass type, low-E coatings, air gap size and gas)
- Isotherms for each unique framing member as well as all reinforcing metal in mullions and perimeter frames
- If applicable, the NFRC or CSA A440.2 certified test data for any certified product that was included in the calculation, as a mix of both certified and uncertified product is acceptable.

~~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 NFRC 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 Overheating in Residential ~~Passively Cooled~~Buildings

Overheating is already a concern for ~~non-mechanically cooled~~ many buildings, due to large amounts of glass, minimal exterior shading, ~~and~~ few natural ventilation strategies, urban heat island effect, and warmer future climate. 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. Buildings that incorporate mechanical cooling may risk being overly reliant on mechanical cooling for thermal safety if little consideration is given to passive cooling or solar control strategies. Such buildings may not be resilient in a warming climate and can pose a risk to occupants in the event of cooling equipment failure or power outages, especially as future climate projections indicate higher numbers of summer days >25°C, longer heatwaves and increased extreme temperatures in the Vancouver region.[2] The following building evaluation requirements are intended to mitigate this effect, and complement demonstration of compliance with any code or policy requirements to avoid indoor overheating, 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.~~

To better understand a building's resiliency to future warming and to enable comparison between various complementary active and passive cooling design strategies, buildings must be evaluated for the number of hours where the interior dry bulb or operative temperatures exceed the 80% acceptability limits for naturally conditioned spaces, as adapted from ASHRAE 55-2020 Section 5.4 'Determining Acceptable Thermal Conditions in Occupant-Controlled Naturally Conditioned Spaces (Adaptive Model)', including those spaces provided with active mechanical cooling (full or partial).

4.1 Methodology and Assumptions for Overheating Analysis

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 GW2.0 (global warming +2.0°C scenario) version of the NRC TMY weather file required in Section 1.5, or an alternate weather file accepted by the AHJ. The GW2.0 weather files are available from City of Vancouver or the NRC websites; see also Section 1.5.

[2] Climate Data, Annual Values for Vancouver; https://climatedata.ca/

Table 3: Monthly Acceptability Limits for Vancouver based on NRC TMY GW 2.0 weather file	
Month	80% Acceptability Limit for Vancouver based on NRC TMY GW 2.0 weather file
April	N/A (Mean temperature too low)
May	25.5 ~~25.2~~ ˚C
June	26.5 ~~26.1~~ ˚C
July	27.5 ~~26.9~~ ˚C
August	28.4 ~~26.9~~ ˚C
September	26.5 ~~25.2~~ ˚C
October	25.2 ˚C ~~N/A (Mean temperature too low)~~
November	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 limits (if applicable) 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 (e.g. west-facing suites on upper floors).

The temperature limits in Table 4 apply only to projects located in the City of Vancouver. Temperature limits for other locations may be derived from the weather files for that location as specified by the AHJ, and may be determined using the following equation from ASHRAE 55-2020 Section 5.4.2.2:

Equation 12: ASHRAE 55 Upper 80% Acceptability Limit

$$Upper\ 80\%\ acceptability\ limit\ (°C) = 0.31\,\overline{t_{pma(out)}} + 21.3$$

Where:

$\overline{t_{pma(out)}}$ = the average air temperature for the month [˚C]

To perform the overheating analysis, model the building design with any mechanical cooling systems disabled (e.g. cooling coils, chilled beams, radiant cooling systems, or any other terminal system using chilled water or refrigerant to remove heat from the space). The overheating hours evaluated using this methodology are referred to as “Passive Overheating Hours”. This number of passive overheating hours in the critical spaces in a building must be reported with energy modelling results.

For any requirements or limits on Passive Overheating Hours and which spaces they apply to, refer to the AHJ and applicable codes and policies.

For residential suites where cooling is only provided to a selected room(s) within the suite, it is acceptable to model the suite as one zone with the installed cooling capacity serving the entire zone.

Note that this analysis of hours exceeding the 80% acceptability limits has been adapted from ASHRAE 55's Section 5.4 Adaptive Model and deviates from it by being applied to buildings with full or partial mechanical cooling, such as systems designed with supply of cooled ventilation air, residential suites with cooling provided to only one room, or where cooling systems are not designed to maintain space temperatures according to NECB space types. Furthermore, the ASHRAE 55 Adaptive Model specifies the use of operative temperatures. However, for the purposes of this overheating analysis, dry bulb temperatures may be used in lieu of operative temperatures, to accommodate commonly used modeling software that are not capable of producing operative temperatures.

4.1.1 Operable Window Effective Opening Area

When modelling natural ventilation as a passive cooling strategy, the effective operable window area must be calculated based on the dimensions of the opening, insect screens, opening operation type, and any limitations to degree of opening, such as window limiters. For example, effective operable area of a top hung window is calculated as the hatched areas in Figure 1. Effective operable area can not exceed 100% of the operable window area. Insect screens are to be accounted for in the effective operable area. Unless otherwise known, insect screens are assumed to be present for all operable windows and have a free-area of 70%, reducing the effective operable area by 30%.

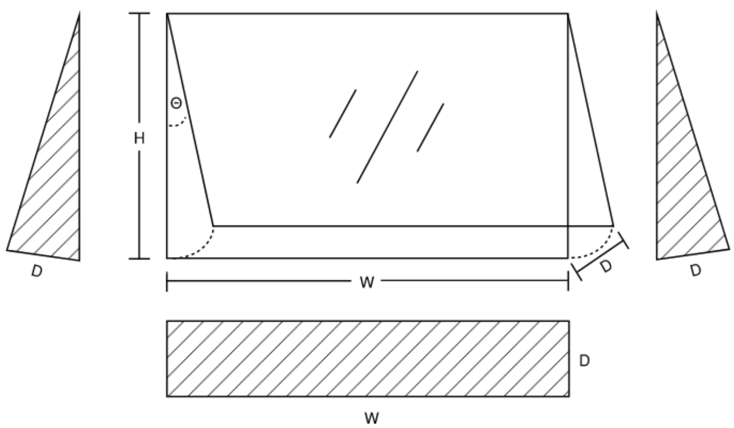

Figure 1: Operable Window Effective Opening Area

4.1.2 Standard Occupant Behaviour Assumptions

Where manual cooling measures such as exterior shading and operable windows are modelled for overheating analysis, use the following standardized occupant behaviour assumptions. Temperatures noted below should be operative temperatures, unless operative temperatures are not available in the modelling software, in which case dry bulb temperatures are acceptable.

1. Operable windows are opened when indoor air temperature is >24°C.
2. Operable windows are closed when outdoor air temperature > indoor air temperature.
3. Patio doors are not used for passive cooling.
4. Interior blinds/shades are not to be modelled.
5. Operable exterior shades are deployed when indoor air temperature is >24°C.
6. Operation of bathroom exhausts, and boost modes for ventilation systems for the purpose of reducing space temperature is only permitted when there is a documented plan to educate occupants on how to use these features for this purpose. The use of range hoods for passive cooling is not permitted.

The above standard behavioural assumptions are provided as a baseline for consistency in overheating analysis. The project team should consider other factors that may affect occupant behaviour and yield a more conservative result, such as exposure to a busy street that may reduce the likelihood that an occupant may open windows due to noise and air quality concerns.

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 with or without TEUI and/or GHGI reduction requirements), 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.
If the reference building envelope performance values already account for the effects of building envelope thermal bridging (e.g. NECB 2017 or 2020), the reference envelope values may not be further derated. If the reference building envelope performance values do not include the effects of building envelope thermal bridging (e.g. NECB 2011 or 2015), 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 2017 or 2018 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. Similarly, the portions of the building that have an absolute GHGI target must still meet their combined GHGI 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. Where the reference building envelope performance values already include the effects of the Building Envelope Thermal Bridging Guide (e.g. NECB 2017, 2020), no de-rating is applied.

5.3 GHGI Targets Compared to a Fossil Fuel Baseline

This section only applies to projects with Groups A, B, or F major occupancies which are subject to VBBL compliance requirements with either an ASHRAE 90.1 or NECB Part 8 reference model. Where the “reference building modelled using only fossil-fuel systems” (the “GHGI Reference”) described in VBBL Table 10.2.2.5.A1 differs from the ASHRAE 90.1 or NECB reference model (used to determine TEUI and TEDI requirements) the approach described in this section may be used as an alternative to an hourly simulation of the “GHGI reference” model to determine the GHGI requirement.

The GHGI described in VBBL Table 10.2.2.5.A1 for “all other occupancies”, prior to the % reduction requirement, may be calculated from the ASHRAE 90.1 or NECB reference building results with the natural gas emissions factor used for all space heating, ventilation heating, and domestic hot water end uses as a simplified alternative to requiring additional energy modelling. A full energy GHGI reference model may still be used if desired.

Example – A warehouse building subject to VBBL table 10.2.2.5.A1 with 2000 m^2 modelled floor area uses a rooftop heat pump system to provide space heating and gas-fired boiler to provide domestic hot water heating. The building’s NECB Part 8 reference design therefore uses a packaged unitary rooftop heat pump conditioning system.
The reference model space heating use is 65,000 kWh electricity, DHW is 11,000 kWh natural gas and other end uses in the building account for 120,000 kWh electricity total.

As an alternative to modelling the same reference building, but requiring a change in system configuration and efficiencies to the equivalent NECB gas-fired rooftop system for the purposes of VBBL table 10.2.2.5.A1, the same NECB reference building results are used with the space heating emissions factors changed to calculate the project’s GHGI requirement.

Under this methodology the project GHGI requirement per table 10.2.2.5.A1, including the 50% reduction, is the following:

$$\begin{aligned} \text{GHGI} &= 0.50 \times ((65000 + 11000) \times 0.180 + 120000 \times 0.011) / 2000 \\ &= 3.7 \text{ kg CO2e/ m}^2\text{a} \end{aligned}$$

5.4 Infiltration for other building types

Infiltration rates for NECB or ASHRAE 90.1 reference buildings shall be calculated using the methodology of that code/standard to convert from tested whole building leakage rate to model infiltration rate.

Portions of proposed models comparing to NECB or ASHRAE 90.1 reference models shall use the same infiltration calculation methodology as the reference. An example is shown below, where the NECB conversion rate is the using the default exponent.

Table 4. Infiltration Example for a Building with Mixed Requirements

Building Area	Basis of Requirements	Whole Building Tested or Targeted Air Leakage ($L/s{\cdot}m^2$ of total enclosure at 75 Pa)	Total Enclosure Area (m^2)	Façade Area (m^2)	Conversion Factor from Tested to Operating	Conversion Reference	Modelled Infiltration ($L/s{\cdot}m^2$ façade)
Office	VBBL TEDI/TEUI	1.50	5000	3000	0.112	CoV EMG	0.28
School	NECB 2020		5000	3000	0.197	NECB 2020	0.49

6 Additional 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 90.1-2019 ~~2010~~ – Energy Standard for Buildings Except Low-Rise Residential Buildings
e) ASHRAE Standard 55-2020 Thermal Environmental Conditions for Human Occupancy
f) Commercial Buildings Building Envelope Thermal Bridging Guide, Version 1.1, BC Hydro, 2016
g) Energy Modelling Guidelines and Procedures, CONMET, 2014
h) ENERGY STAR Multifamily High Rise Program, Simulation Guidelines, Version 1.0, Revision 03, January 2015
i) Infiltration Modelling Guidelines for Commercial Building Energy Analysis, PNNL, 2009
j) National Energy Code of Canada for Buildings (NECB), NRC, 2020 ~~2011~~
k) New Construction Program's Energy Modelling Guideline, BC Hydro, March 2016
l) TM54 – Evaluating Operational Energy Performance of Buildings at the Design Stage, CIBSE, 2014
m) Guide to Low Thermal Energy Demand in Large Buildings, BC Housing, March 2018
n) ~~Reference Procedure for Simulating Spandrel U-Values, Fenestration BC, September 2017~~ THERM 7/ WINDOW 7 NFRC Simulation Manual (July 2024)
o) Illustrated Guide to Achieving Airtight Buildings, BC Housing, September 2017
p) Passive Cooling Study for Multi-Unit Residential Buildings, City of Vancouver, April 2017
q) Joint Professional Practice Guidelines – Whole Building Energy Modelling Services, version 1.0, Architectural Institute of British Columbia and Engineers & Geoscientists British Columbia, 2018
r) The Climate Registry - 2023 Default Emissions Factors, June 2023
s) City of Vancouver Guidelines – Airtightness Testing – Process and Requirements for New Buildings, City of Vancouver, September 2023
t) "Building Enclosure Airtightness Testing in Washington State – Lessons Learned about Air Barrier Systems and Large Building Testing Procedures", RDH Building Science, 2014
u) Guide to Low Thermal Energy Demand in Large Buildings, BC Housing, 2018
v) ANSI/NFRC 100-2023 Procedure for Determining Fenestration Product U-Values
w) ANSI/NFRC 200-2023 Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence
x) CSA A440.2/CSA A440.3 Fenestration energy performance/User guide to CSA A440.2