Appendix II: Embodied Carbon Assessment Guide for Low-rise Residential Buildings (Part 9)

Appendix to the City of Vancouver Addendum v1.1 to the National wbLCA Practitioner's Guide[1]

Last amended January 26, 2025

Effective January 1, 2025

[1] This document is intended to serve as a standalone guide. References to the National whole-building Life Cycle Assessment Practitioner's Guide or the City of Vancouver Addendum are for additional information.

II.1. Application

The primary application of this appendix is for demonstrating compliance with the embodied carbon requirements in the City of Vancouver "Zero Emission Buildings in R1, RT and RA Districts Bulletin"[2] (Zero Emission Buildings Bulletin).

While this is not currently required in Vancouver Building Bylaw (VBBL), the guidance provided here can also be used to assess embodied carbon emissions for the following building types:

- Part 9 residential buildings: residential buildings that fall under Part 9 of the VBBL,
- Part 3 low-rise residential buildings: Residential buildings that fall under Part 3 and are currently exempt from the VBBL embodied carbon requirements (Division B, Section 10.4).

Where uncertainty exists, applicants should consult with the Authority Having Jurisdiction's building officials to confirm the applicability of embodied carbon requirements.

II.2. Compliance

A project can comply by following the Intensity Limit or the Baseline path. The embodied carbon reduction requirement is stipulated in the applicable policy or program.

For compliance with the Zero Emission Buildings Bulletin, a 40% reduction from the benchmark is required as follows.

a. Intensity Limit

To comply via the Intensity Limit path, the project's embodied carbon is reduced compared to an absolute Embodied Carbon Intensity (ECI) benchmark. This path is simplest and suitable for typical projects.

Table viii shows the cradle-to-grave, as well as the equivalent cradle-to-gate (upfront) Embodied Carbon Intensity (ECI) benchmarks and limits. See Section II.4(c) for more details on the scope of whole-building Life Cycle Assessment (wbLCA) for compliance with the Zero Emission Buildings Bulletin.

[2] https://guidelines.vancouver.ca/bulletins/bulletin-sustainability-zero-emissions-r1-rt-ra.pdf

Table viii: Embodied Carbon Intensity (ECI) benchmark and limit for the City of Vancouver's Zero Emission Buildings Bulletin

Scope	Life Cycle Stages*	Life Cycle Modules*	ECI Benchmark ($kgCO_2e/m^2$)	ECI Limit ($kgCO_2e/m^2$)
Cradle-to-Gate (Upfront)**	Product	A1-A3	200	120
Cradle-to-Grave	Product, Construction Process, Use (including replacement), End-of-life	A1-A3, A4-A5, B1-B5, C1-C4	250	150

* See Appendix B.1 in the National wbLCA Practitioner's Guide for more details on the life cycle stages and modules.

** Equivalent cradle-to-gate ECIs in this table are calculated using the methodology in Section 4.3(c)(viii) of the National wbLCA Practitioner's Guide, assuming a default building lifespan of 60 years.

b. Baseline

To comply via the Baseline path, the project shall:

1. Create a functionally equivalent baseline following Section II.5.
2. Demonstrate that the project has achieved the required embodied carbon reduction compared to the baseline, i.e. 40% for compliance with the Zero Emission Buildings Bulletin requirements.

This path is suitable for more unique projects that cannot meet absolute ECI limit in Table viii.

II.3. Proposed Design Representation in Model

This section specifies the scope and assumptions to be used for calculating embodied carbon emissions through a whole-building life cycle assessment (wbLCA).

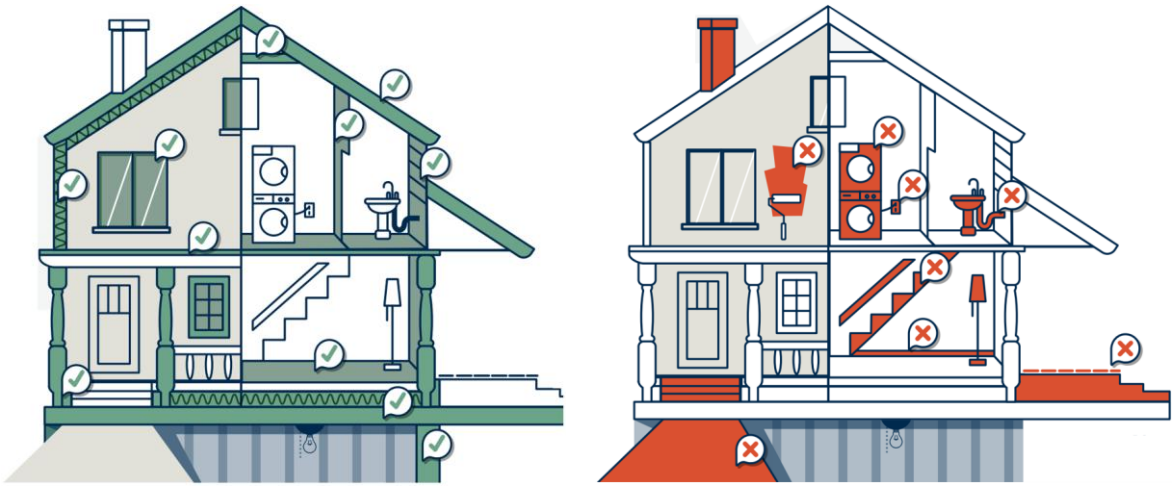
a. Multiple Buildings

If the project consists of multiple buildings on the same site, they may be combined in one calculation.

If a building consists of multiple units, separated by a party wall, the embodied carbon emissions must be reported in one calculation.

b. Scope of Building Elements

Building elements shall be included or excluded as shown in Figure 2.



Included Building Elements

- Footings and Slabs
- Foundation Walls
- Structural Elements (posts and beams)
- Exterior Walls
- Party Walls (where applicable)
- Exterior Cladding
- Windows
- Interior Walls
- Floors
- Ceilings
- Roofs
- Garages (attached and detached)

Excluded Building Elements

- Mechanical, electrical, and plumbing (MEP)
- Solar photovoltaic (PV) panels
- Paints and surface finishes
- Fixtures and appliances
- Millwork, stairs, cabinetry and trim
- Driveways, earth moving, excavations, and all site works
- Decks, balconies, and porches

Figure 2: Building Elements Included and Excluded in the Embodied Carbon Assessment
(Source: Emissions of Materials Benchmark Assessment for Residential Construction Report[3])

c. Gross Floor Area

Gross Floor Area (GFA) used to assess Embodied Carbon Intensity (ECI) shall be based on the internal heated floor area, as defined by the EnerGuide Rating System Technical Procedure[4]. This method includes all heated areas and excludes garage areas and unheated crawl spaces (see Figure 3).

For buildings with multiple units, the floor area occupied by party walls should be included in the building's GFA.

[3] Magwood, C., Bowden, E., Trottier, M. Emissions of Materials Benchmark Assessment for Residential Construction Report (2022). Passive Buildings Canada and Builders for Climate Action. https://www.buildersforclimateaction.org/uploads/1/5/9/3/15931000/bfca_pbc-embarc_report-web.pdf

[4] Natural Resources Canada, EnerGuide Rating System: Technical Procedures (Version 15.13), 2024

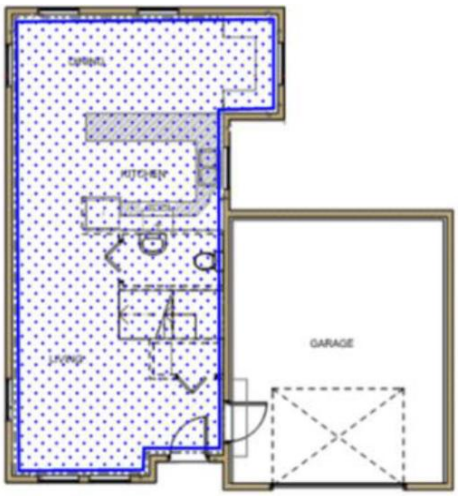


Figure 3: Gross Floor Area Measurement Methodology Sample

d. Material Takeoffs

Material takeoffs shall represent the project geometry and design documents submitted for the relevant policy or permit.

e. Completeness

All major materials and products used in the required elements shall be included. The user may use their professional judgement to identify cut-off points for minor materials and products, especially those that are challenging to quantify, such as fasteners, nails, and clips. As a general guidance, the total mass of the excluded materials shall not be greater than 1% of the total mass of materials used in the required elements. However, there is no need to quantify the masses to show compliance.

f. Materials and Product Types

Project documents shall be used to identify building elements, assemblies, material types, and dimensions. If details are missing, project team shall primarily use their professional judgement to determine common local practice for their specific building archetype and design requirements. Table ix (Section II.5(b)) can be used as a guide for common-practice assemblies and materials in Vancouver.

II.4. Embodied Carbon Quantification

a. Qualified Practitioner

The wbLCA shall be undertaken by a Qualified Practitioner (user), defined as someone who:

- Is an Energy Advisor registered by National Resources Canada (NRCan) and affiliated with a Service Organization located in the province of the project (i.e. BC for Vancouver), and
- Has completed BEAM[5] or MCE2 training.

[5] https://www.buildersforclimateaction.org/beam-training-course.html

b. Software Tools

To quantify the embodied carbon emissions of low-rise residential buildings, the user shall enter the material takeoffs for the included building elements in the latest version of the BEAM[6] tool or the MCE2[7] tool. BEAM[8] and MCE2[9] each have user guides which should be followed.

If the user wishes to use any tool other than BEAM or MCE2 for compliance with the Zero Emission Buildings Bulletin, they must first confirm that the tool is acceptable with the Authority Having Jurisdiction's building officials.

c. Life Cycle Stages

A cradle-to-grave scope wbLCA and a default building lifespan of 60 years must be used for compliance with the Zero Emission Buildings Bulletin.

Since the BEAM and MCE2 tools, currently, only report upfront (cradle-to-gate) emissions, the user can use the upfront benchmark and limit in Table viii to assess compliance in these tools. They can then report upfront emissions in the Embodied Carbon Design Report (ECDR), which automatically calculates and shows the cradle-to-grave emissions, based on up-front (A1-A3) emissions, using the interim solution provided in Section 4.3(c)(viii) of the National wbLCA Practitioner's Guide. See Section II.6 for more information on ECDR.

d. EPDs

An Environmental Product Declaration (EPD) is a third-party verified document that complies with regional or international standards and reports the environmental impacts of a product, including its Global Warming Potential (GWP), commonly referred to as embodied carbon, using life cycle assessment (LCA) methodology.

In BEAM and MCE2, Industry Average EPDs should be selected whenever possible; if these are unavailable, the tool average (such as the BEAM Average) should be used. When referencing industry-wide EPDs, the most regionally specific option should be used, meaning a regional or provincial industry-wide EPD takes precedence over a Canadian industry-wide EPD, which in turn takes precedence over a North American industry-wide EPD.

If it is certain that a specific product will be used, which has a representative EPD included in the tool, that product-specific EPD may be selected. For products that have EPDs, but are not currently included in the tool, the tool's user guide should be followed to add values from the missing EPDs.

When neither an industry average nor a tool average value is available, and the specific product is unknown or lacks a product-specific EPD, the product-specific EPD for a similar product in the tool with the highest net emissions must be chosen.

[6] https://www.buildersforclimateaction.org/beam-estimator.html
[7] https://natural-resources.canada.ca/maps-tools-publications/tools-applications/material-carbon-emissions-estimator-mce2
[8] https://docs.google.com/document/d/1f6i0EPMUFeuzfX6umioyQNEn2vxttPWKhysfrn1r2cU/edit?pli=1#heading=h.oc1by5ovpwwl
[9] https://natural-resources.canada.ca/sites/nrcan/files/canmetenergy/files/MCE2_USER_GUIDE.pdf

e. Carbon Storage

Short-cycle biogenic carbon may be counted toward compliance. The City of Vancouver Addendum to the National wbLCA Practitioner's Guide defines short-cycle biogenic carbon as carbon stored in agricultural or forestry crops with a natural growing life cycle of 10 years or less, as well as carbon stored in biomass from waste streams, forestry residues, or reused wood products.

Short-cycle carbon storage reported by BEAM or MCE2 may be included in compliance assessments. Long-cycle carbon storage reported by these tools shall not be included.

For reused wood products, exclude associated emissions. However, their carbon storage value can be accounted for in the "Carbon Storage" sheet of the Embodied Carbon Design Report (ECDR), consistent with Section II.4(f). Carbon stored in reused wood may be counted toward compliance only when the material is reused on the project site of the proposed design.

f. Material Reuse

If, in the proposed design, a portion or components of the existing building on site are reused – or if a salvaged component from another site is reused – the embodied carbon emissions of those reused materials and components shall be excluded from the embodied carbon assessment. Biogenic carbon stored in salvaged material may be counted only when the material is reused on the same project site (see Section II.4(e)).

When calculating GFA for ECI, include the reused portion in the floor area, except for the area of attached garages.

Do not include embodied carbon from the demolition of the portion of the existing building that is removed from the site.

II.5. Determining the Baseline

If following the Baseline path to show compliance (see Section II.2(b)), the user shall undertake two wbLCAs. One for the proposed design and another for the baseline. For low-rise residential buildings, the methodology provided in this section must be followed for determining the baseline. The user can refer to Section 5 of the National wbLCA Practitioner's Guide for additional guidance.

a. Functional equivalency

To create the baseline wbLCA, a functionally equivalent design for the baseline must be created. Functional equivalency must be ensured in the following areas:

i. **Thermal Equivalence:** The proposed design and the baseline shall have functionally equivalent thermal performance. Approximate equivalency of clear-wall assembly R-value is acceptable for the embodied carbon modelling of the baseline. Detailed calculations of thermal bridging and equivalency are not required. The glazing ratio and number of panes shall be the same in the baseline and the proposed design.

ii. **Structural Equivalence:** The proposed design and the baseline shall have functionally equivalent structural performance.

iii. **Geometrical Equivalence:** The proposed design and the baseline shall have a functionally equivalent building geometry and program (i.e., services and function of the spaces, building shape and orientation, and number of residential units and occupants for multiplexes).

b. Baseline Materials

Baseline materials and products shall represent common practices to build a functionally equivalent project. The user should primarily rely on the project team's professional judgment to identify if any of materials and assemblies used in the project vary from typical practices for their building archetype and design requirements. Note that element assemblies, materials, and dimensions in the baseline model should not change, unless they vary from common practice.

For any details that the project team may not be able to provide, the user may refer to Table ix as a guide. If there are discrepancies between the assumptions listed in Table ix and the proposed design, but the project team advises the user that the assembly is common practice, the baseline model should match the project documents rather than Table ix.

Table ix: Default Common-Practice Assemblies and Materials for Key Part 9 Building Elements

Element	Sub-element (if applicable)	Default Material and Product Assumption
Footings and Slabs	Foundations	• Concrete per structural drawings with steel reinforcing bars*
	Slab on Grade	• Slab on Grade: concrete with steel mesh reinforcing - 4" • Sub-slab Insulation: extruded polystyrene (XPS) • Vapour Barrier: 6 mil polyethylene
Foundation Walls		• Concrete per structural drawings with steel reinforcing bars* - 8" • Framing (Interior): 2" x 4" wood studs @ 24" on-center (O.C.) • Exterior Continuous Insulation: XPS • Damp Proofing: liquid applied • Interior Cavity Insulation: mineral wool batt • Drywall: ½" gypsum wall board**
Structural Elements	Posts (Columns)	• Solid or engineered wood columns (when required)
	Beams	• Typical Span: engineered wood I-joist at 16" O.C. • Long Span: steel beams
Exterior Walls		• Framing: 2" x 6" wood stud @16" O.C. • Sheathing: ½" plywood • Sheathing Membrane: vapour permeable self-adhesive • Thermal Insulation (Cavity): mineral wool batt insulation • Thermal Insulation (Continuous): rigid mineral wool • Garage Thermal Insulation: none • Drywall: ½" gypsum wall board**
Party Walls (when required)		• Framing: 2" x 4" wood stud @ 16" O.C. • Thermal Insulation (Cavity): mineral wool batt insulation

Element	Sub-element (if applicable)	Default Material and Product Assumption
		• Sheathing: 5/8" Type X gypsum wall board**
Exterior Wall Cladding		• Exterior Cladding: fiber cement siding • Strapping: ¾" x 3" pressure treated wood @ 16" O.C. • Drywall: ½" gypsum board**
Windows		• Window Frame: Vinyl • Insulated Glass Unit: As required to meet the thermal performance • Window-to-wall Ratio: As Required to meet the thermal performance
Interior Walls	Interior Wall Construction	• Framing: 2" x 4" wood stud @ 16" O.C. • Sheathing: ½" gypsum wall board** • Acoustic Insulation (where required): fiberglass batt insulation
	Finishes (Excluded)	• Skim Coat and Paint
Floors (Including Heated Basement Flooring)	Floor Construction	• Framing: engineered wood I-joists @ 16" O.C. • Topping: 1 ½" lightweight concrete • Sub-flooring: ⅝" plywood • Insulation (Cavity): mineral wool batt insulation
	Flooring	• Typical Interior Finish: engineered wood • Bathrooms: ceramic tile • Garage: exposed concrete
Ceilings		• ½" gypsum wall board**

Roofs	Roof Construction	• Framing: wood trusses @ 24" O.C.
		• Sheathing (Exterior): ¾" plywood
		• Ceiling: ½" gypsum wall board**
		• Insulation:
		  ○ Open Attic Roof (Vented, insulation on floor): Loose-fill cellulose
		  ○ Cathedral Roof (Vented or not, insulation in rafters): mineral batt in cavity, mineral board if continuous layer.

	Roofing	• Asphalt shingles

* Compressive strengths in the baseline should be the same as the proposed design. If no information is available on project documents or from the project team, 25 MPa can be assumed.

If no detailed steel reinforcement (rebar) quantities are available, embodied carbon calculations may use One Click LCA's recommended average concrete reinforcement quantities[10] (in kg rebar/m^3 concrete) as a guideline for typical ranges in rebar for different building elements. This is suitable in earlier design phases; however, if actual rebar quantities are available in later design stages, it is best to use those quantities instead. When quantifying the concrete volume of reinforced concrete elements for construction document stage assessments, it is recommended to account for the volume of reinforcement within these elements (i.e., volume CONCRETE = $volume_{FORMWORK} - volume_{REINFORCEMENT}$).

** Type X gypsum board shall be assumed for fire-rated walls.

[10] https://help.oneclicklca.com/en/articles/275888-average-quantities-of-reinforcement-in-concrete

c. Creating A Baseline

The user can use the proposed design wbLCA model to create the baseline model. To do so, the user makes a copy of the proposed design wbLCA and replaces the type and EPD of the materials that are different from common practices with the common-practice materials and the industry-average or tool-average EPDs. Section II.5(b) shall be followed to identify common practice materials.

The baseline parking and below grade areas shall be the same as the proposed design, unless the team has changed those to reduce embodied carbon emissions.

II.6. Required Reporting Materials

The following documents are required to be provided at each of the following project stages to show compliance with embodied carbon requirements of the Zero Emission Buildings Bulletin.

a. Design Stage: Development Permit or Development and Building Permit

i. **Application Drawings** with:
- A prominent label identifying the project as Low Embodied Carbon, and
- A list of the key embodied carbon reduction strategies from the Embodied Carbon Design Report (ECDR) to achieve the proposed design embodied carbon[11].

ii. **The Embodied Carbon Design Report[12],** in Excel format, completed by the Qualified Practitioner showing the project meets the embodied carbon reduction requirement Specified in Section II.2
- If Industry Leadership Credits (ILCs), listed in Section II.7, are pursued, the "ILCs - Design" sheet of the ECDR must be completed.

iii. **The raw data**, in Excel format, from the embodied carbon software tool[13].
- One raw data file is required (Proposed) if the Intensity Limit Path is used for compliance.
- Two raw data files are required (Proposed and Baseline) if the Baseline Path is used for compliance.

b. Construction Stage: Mid-construction (if optional Industry Leadership Credits are pursued)

i. **Updated Embodied Carbon Design Report (ECDR),** in Excel format, completed by the Qualified Practitioner with the "ILCs - Construction" sheet completed for ILCs indicated to be pursued in the "ILCs - Design" sheet in the Development Permit or Development and Building Permit submission.

ii. **Supporting Industry Leadership Credit Documentation,** as specified in Table x and in the "ILCs - Construction" sheet of the ECDR, in one combined PDF file.

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[11] Sheet '3. EC Modelling Info' in the ECDR has a list of key embodied carbon reduction strategies. Only strategies included in the design shall be listed on the application drawings.

[12] Available here: https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx#embodied-carbon (under "Embodied Carbon in Zero Emission Buildings in R1, RT and RA Zoning Districts")

[13] Follow instructions on how to prepare the raw data from BEAM and MCE2 on this webpage: COV Embodied Carbon Design Report Raw Data Submission Instructions (https://priopta.notion.site/COV-Embodied-Carbon-Design-Report-Raw-Data-Submission-Instructions-44469d8b2adf4d21bf835d7a77f49a6d).

II.7. Optional Industry Leadership Credit

Appendix I[14] introduces Industry Leadership Credits (ILCs) for large buildings. These are optional credits that incentivize industry-leading practices that enhance embodied carbon reduction capacity. Table x lists the ILCs available to low-rise residential buildings for compliance with the Zero Emission Buildings Bulletin.

These ILCs relax the reduction requirements by up to 10%, i.e. if a project achieves 10% ILCs, the embodied carbon reduction requirements of the Zero Emission Buildings Bulletin can be met by reducing the project's embodied carbon by 30% instead of 40%. These credits can be used for both the Intensity Limit and the Baseline compliance pathways in Section II.2. A maximum of 10% credit can be claimed for any combination of Industry Leadership Credits.

[14] https://vancouver.ca/files/cov/embodied-carbon-vancouver-addendum-appendic-industry-leadership-credits.pdf

Table x: Industry Leadership Credits Available and Submission Requirements

Industry Leadership Credit	Criteria	Available Credit % *(Max 10%)*	Submission Requirements		
			Design Stage (Development Permit or Development & Building Permit)	Construction Stage (Mid-construction)	
				Updated ECDR	Additional Documents
Report Additional Information			Commit, within the "ILCs - Design" sheet of the ECDR, to demonstrate compliance with ILC requirements at mid-construction.	Update ECDR with the "ILCs - Construction" sheet completed.	
a.ii Report As-Built Concrete Data	Track the as-built concrete data and compare against the proposed design submitted at the design stage. • As-built concrete should be per contractor tracking or signed by the Qualified Practitioner. • The total volume of the excluded materials shall not be greater than 5% of the total volume of concrete materials.	• **2%** for reporting the volume of as-built concrete mixes. • Additional **3%** for reporting the as-built concrete GWP substantiated from mix-specific EPDs.			N/A
Implement Reuse Practices					
b.i Relocate Existing Building	Relocate an existing *building* on the project site for *reuse* as a *building* in another site. Ancillary *buildings*, such as detached garages or storage sheds, are excluded from this credit.	**10%**			Provide proof of building relocation such as photos.
b.ii Salvage Materials from Project Site	*Salvage* materials from an existing *building* on the project site and demonstrate they are *reused* in the new *building*[15], stored for the purpose of future *reuse,* or sold or donated for *reuse*. • **Path 1:** *Salvage* at least 3.5 kg or 2.6 board feet of lumber per square foot of finished floor space of the existing *building*. Finished floor space is the gross floor area shown on the BC Assessment property assessment, including basement finish area. • **Path 2:** Quantify *salvaged* materials and estimate their embodied carbon value by using the embodied carbon of equivalent new materials in a wbLCA or embodied carbon assessment tool.	• **Path 1: 2%** • **Path 2:** Project can claim credit **equal to the embodied carbon value of the *salvaged* materials**.			Provide proof of *salvaged* materials claimed in the ECDR, such as photos and receipts from facilities receiving the materials for *reuse*.

[15] Material reuse in the new building, regardless of the source, can follow the methodology in Section II.4 (f).