# Guidelines

## Embodied Carbon Guidelines

*Version 1.0*
*Approved by Chief Building Official on October, 2023*
*Last amended October 18, 2023*

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## Background and Context

Vancouver's Climate Emergency Action Plan, approved by City Council in November 2020, sets a goal of reducing embodied carbon in construction by 40% by 2030. In May 2022, City Council approved changes to the Vancouver Building By-law[1] (VBBL) to require designers to calculate, limit, and later reduce, embodied carbon in new Part 3 buildings.

These guidelines are referenced by the by-law to provide technical guidance on modelling embodied carbon emissions and demonstrating compliance with the requirements in the VBBL. The guidelines may also be used for requirements in policies or programs to report or reduce embodied carbon in construction, such as rezoning policies or owner's project requirements.

The sections in these guidelines are as follows.

1. General:

   This section and the preceding sub-sections provide general information about these guidelines, including references.

2. Compliance:

   This section describes the process for determining compliance with an embodied carbon requirement. It includes two ways to comply: an absolute path and a baseline path.

3. Specifying the Object of Assessment:

   This section defines the object of assessment and system boundary, which set the physical and temporal scope of the calculation of embodied carbon. The system boundary is defined by specifying the inclusion and exclusion of life cycle stages, building elements, and lifespan of the building and building elements. Appendix B.2 provide additional information on specifying the object of assessment.

4. Quantifying Embodied Carbon:

   This section provides guidance using a whole-building life cycle assessment (wbLCA) methodology to estimate embodied carbon emissions. The content of this section applies to both proposed design and baseline embodied carbon assessment. This section covers guidance on establishing a bill of materials, quantifying embodied carbon, and treatment of special topics, including design for disassembly, biogenic carbon, and naturally occurring concrete carbonation.

5. Determining the Baseline:

   This section provides guidance on creating a functionally equivalent baseline for compliance through the baseline path, which is one of the two compliance paths described in Section 2.

[1] https://free.bcpublications.ca/civix/document/id/public/vbbl2019/1173727518

6. Documentation:

   This section describes the documents that must be submitted to the City of Vancouver at the time of rezoning and Building Permit applications.

For further guidance on calculating embodied carbon and whole-building life cycle assessment, refer to the National Research Council of Canada's National Guidelines for Whole-building Life Cycle Assessment (Referred to as "NRC Guidelines" in this document. See Appendix A.2 (b) (i)).

## Intent

This document provides technical guidance on modelling embodied carbon and demonstrating compliance with the City of Vancouver's requirements to report, limit, or reduce embodied carbon.

The intent of this document is to provide guidance on:

- Embodied carbon modelling used for reporting as part of compliance;
- Identifying embodied carbon limits used for compliance;
- Creating a functionally-equivalent baseline; and,
- Submission requirements used for compliance.

The intended audiences for this document are individuals or companies modelling the embodied carbon of a building to report and demonstrate compliance with embodied carbon requirements (the "user"). This document is not intended to provide guidance to the building industry on how to reduce embodied carbon emissions. Various industry and research organizations have provided resources on reducing embodied carbon, including those listed in Appendix A.2 (g).

## Application

These guidelines are developed to be used for modelling embodied carbon emissions and demonstrating compliance with the embodied carbon requirements specified in Section 10.4 of the VBBL.

The guidelines may also be used for assessing and reporting the embodied carbon of Part 9 buildings, however, the VBBL does not currently have any embodied carbon requirements for Part 9 buildings.

**Note:**

The embodied carbon requirements of the VBBL do not apply to alterations to existing buildings, except where the alteration is a major new addition. Where additions are so significant that they are generally treated as the construction of an entirely new building, such as the addition of a new tower onto an existing building, the requirements may be applicable.

While the embodied carbon requirements of the VBBL apply to all new Part 3 buildings, there are some unique cases where they were not intended to apply, and compliance need not be demonstrated, such as where the only Part 3 building is a parkade below exclusively Part 9 buildings (i.e. stacked townhomes above a parkade).

Where uncertainty exists, applicants should consult with building officials to confirm the applicability of embodied carbon requirements.

# Definitions and Acronyms

## Definitions

Any terms not defined below shall be as defined by the VBBL or the NRC Guidelines (See Appendix A.2 (b) (i)). Some definitions are identical to those in the VBBL or NRC Guidelines and are copied here for clarity and convenience.

***Biogenic Carbon*** is carbon stored in biomaterials through natural processes, but not fossilized or derived from fossil resources.

***Bill of Materials*** is a list of individual building materials and products and their quantities that make up a building.

***Concrete Carbonation*** is a naturally occurring reaction in concrete products when atmospheric $CO_2$ (in the presence of water) reacts with the cement. Carbon is sequestered in the process and the strength of concrete increases. However, it also creates an acidic environment, which can corrode steel reinforcing bars.

***Certified Professional***, as defined in the Certification of Professionals By-law[2], is the professional who facilitates the issuance of building permits for new or existing buildings by taking on the full review and inspection role on behalf of the City. Under the Certified Professional permit process, permit issuance can be staged, allowing construction to start earlier than otherwise. Certified Professionals do not replace registered professionals normally involved in a construction project but rather provide an additional level of Building By-law review traditionally carried out by City staff.

***Embodied Carbon, Embodied Carbon Impacts, Whole-building Embodied Carbon,*** and ***Whole-building Embodied Carbon Impacts*** refer to the greenhouse gas emissions associated with materials and construction processes throughout the life cycle of a building, except emissions from building energy use. This can include emissions from material extraction, manufacture, transportation, construction, replacement, refurbishment, demolition, removal, and other processes. For the purposes of these guidelines, *embodied carbon* and these related terms are the total global warming potential (GWP) impact calculated in compliance with these guidelines. Embodied carbon is measured in kilograms of carbon dioxide equivalent ($kgCO_2e$).

***Embodied Carbon Baseline, Functionally-equivalent Baseline,*** and ***Baseline*** for the purposes of these guidelines are derived from a single theoretical "typical" design (i.e., an archetype), based on standardized assumptions and the proposed design being assessed for compliance, all as specified and in compliance with these guidelines. Calculating the embodied carbon of the baseline is one way to create an embodied carbon benchmark, for the purpose of demonstrating relative embodied carbon performance.

For the purposes of demonstrating compliance with the embodied carbon requirements of the Vancouver Building By-law (VBBL), any of the pathways for calculating the embodied carbon benchmark included in Section 2 shall be consider equivalent to a functionally-equivalent baseline.

[2] https://vancouver.ca/home-property-development/certified-professional-program.aspx

*Embodied Carbon Benchmark* refer to a reference point against which comparisons can be made, for the purposes of demonstrating relative embodied carbon performance (i.e., a percent improvement). This benchmark can be a baseline or absolute carbon intensity ($kgCO_2e/m^2$).

*Embodied Carbon Limit* for the purposes of these guidelines is the embodied carbon impacts that shall not be exceeded by the proposed design to comply with an embodied carbon requirement, such as those set in the VBBL. It is the highest embodied carbon impacts, and the minimum performance level, allowed.

*Embodied Carbon Requirement* refers a requirement to consider embodied carbon during building design or construction and may include a requirement to achieve relative embodied carbon performance (i.e., a percent improvement) over a benchmark.

*Environmental Product Declaration (*EPD) is a third party–verified document written in conformance with regional or international standards that reports the environmental impacts of a product, including its global warming potential (GWP), based on life cycle assessment (LCA) models.

*Global Warming Potential (GWP)* for the purposes of these guidelines is an environmental indicator used to describe the climate-related environmental impacts of a product or building. It is a result and output of life cycle assessment (LCA), and expressed in terms of tonnes or kilograms of carbon dioxide equivalent ($tCO_2e$ or $kgCO_2e$). In this context it is often has the same meaning as embodied carbon.

> **Note:** Global Warming Potential is also the term used for factors that allow comparisons of the global warming impacts of different gases. They are among many factors used in life cycle impact assessment, and used in creating emissions inventories of organizations and nations. In this context, the larger the GWP, the more that a given gas warms the Earth compared to $CO_2$ over a given time period.

*Gross Floor Area (GFA)* for the purposes of these guidelines is as defined in Appendix A of the NRC Guidelines (see Appendix A.2 (b) (i)), except that calculation of gross floor area shall exclude any floor area of a parkade (refer to definition of parkade). GFA measures fully-enclosed spaces to the outside face of enclosing walls, without deductions in area for interior walls, columns, and floor openings such as stairwells, elevators, ducts, or other openings.

*Life Cycle Assessment (LCA)* is the process of evaluating a system, component, product, assembly, or building, from the moment of extraction of raw materials to transportation, processing, manufacturing, use, recyclability, and disposal. Through this methodology, the cumulative and ultimate environmental benefits and impacts are assessed. This is often referred to as a cradle-to-grave assessment, if product, use, and end-of-life stages are included. If benefits and load beyond the building life are added, the assessment is referred to as cradle-to-cradle assessment (See Appendix B.1 for more information on the life cycle stages).

*Life Cycle Inventory (LCI)* is a list of input and output flows for a particular process. The flows are resource use, such as materials, energy, and water, as well as emissions to air, land, and water. It is the data collection step of life cycle assessment.

*Life Cycle Impact Assessment (LCIA)* is a set of characterization factors that are applied to an LCI to arrive at environmental indicator results. These results may estimate “end-point” impacts, such as damage to

human health, or “mid-point” impacts, such as global warming potential. It is the “what does it mean” step of life cycle assessment, where the inventory is analyzed for environmental impact.

*Object of Assessment* is the building and building elements included in the embodied carbon assessment, as defined in accordance with Section 3 of these guidelines.

*OmniClass* is a comprehensive standardized classification system used in the construction industry, developed by the National Institute of Building Sciences (NIBS) in the United States. It is used to categorize and organize information related to building projects, including components, materials, systems, and processes throughout the whole project life cycle.

*Parkade* for the purposes of these guidelines is a building or part thereof for the storage or parking of motor vehicles and containing no provision for the repair or servicing of such vehicles.

> **Note:** This is the same as the definition of “Storage Garage” in the Vancouver Building By-law.

*Product Environmental Profile (PEP)* is an EPD that covers electrical, electronic, and HVAC products (See Environmental Product Declaration (EPD) definition).

*Proposed Design* is the building design that is assessed for compliance with an embodied carbon requirement, at the time of that assessment. For example, for a building being assessed for compliance with embodied carbon requirements in the VBBL, it is the proposed design reflected in the Building Permit application documents. For preliminary stage assessments such as during rezoning, the proposed design being assessed and submitted may be one of many possible designs and represent one of many pathways to achieving compliance with an embodied carbon requirement. Where details are not known at the time of assessment, refer to guidance in Section 4 of this document and in Table 1 and Table 2.

*System Boundary* is the physical, geographical, and temporal scope of the assessment, including life cycle stages, building elements, processes, flows, and activities included or excluded from the life cycle assessment.

*UniFormat* is a widely used elemental classification system produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

*User* is the individual or company that uses these guidelines to model the embodied carbon of a building for reporting and demonstrate compliance with embodied carbon requirements.

*Whole-building Life Cycle Assessment (wbLCA)* is the process of conducting an LCA for a building as opposed to the building products and elements. See the definition for life cycle assessment (LCA).

## Acronyms

| | |
|---|---|
| BIM | Building Information Model |
| CLF | Carbon Leadership Forum |
| CP | Certified Professional |
| EPD | Environmental Product Declaration |
| GFA | Gross Floor Area |
| GWP | Global Warming Potential |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IGU | Insulated Glass Unit |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| MEP | Mechanical Electrical Plumbing |
| MURB | Multi-unit Residential Building |
| NRC | National Research Council of Canada |
| PEP | Product Environmental Profile |
| VBBL | Vancouver Building By-law |
| wbLCA | Whole-building Life Cycle Assessment |
| XPS | Extruded Polystyrene (insulation) |

# Embodied Carbon Guidelines

## 1 General

### 1.1 References

The normative standards and guidelines referenced in this document are listed in Appendix A.1. The embodied carbon assessment shall comply with the most recent version of these references. Where there are differences between this document and the referenced standards and guidelines, the provisions of this document shall apply.

The most commonly used software tools for building embodied carbon assessment – listed in Appendix A.2 (a) – claim that their tool and the databases within them comply with the normative references.

The informative references are listed in Appendix A.2. These references are provided as additional resources but compliance with them is not required.

# 2 Compliance

Compliance with an embodied carbon requirement shall be determined by following the steps in this section. To determine compliance:

1) Calculate the embodied carbon of the proposed design;
2) Calculate the embodied carbon benchmark using one of two pathways;
3) Calculate the embodied carbon limit by multiplying the benchmark by a reduction factor; and,
4) Compare the embodied carbon limit with the embodied carbon of the proposed design.

Compliance shall then be documented in accordance with Section 6.

**Note:**

The Embodied Carbon Design Report, which is one of the documentation requirements (see Section 6.1), automatically calculates the embodied carbon benchmark and limit and determines compliance, using the user inputs and the formulas in the following sub-sections.

## 2.1 Calculate the Embodied Carbon of the Proposed Design

Define the object of assessment according to Sections 3 and calculate the embodied carbon of the proposed design following Section 4.

## 2.2 Calculate the Embodied Carbon Benchmark

Determine the embodied carbon benchmark using one of the two following pathways:

### (a) Absolute Path

Calculate the embodied carbon benchmark from an absolute embodied carbon intensity using the following formula:

$$EC_{BM} = ECI \times GFA_P$$

Where:
$EC_{BM} = Embodied\ Carbon\ Benchmark$ (in $kgCO_2e$)
$GFA_P = Gross\ Floor\ Area\ of\ the\ Proposed\ Building$ (in $m^2$)
*(Excluding parkade. See Definitions and Acronyms for guidance on calculating GFA.)*
$ECI = Absolute\ Embodied\ Carbon\ Intensity$ (in $kgCO_2e/m^2$)

**Note:**

For compliance with the Vancouver Building By-law, the following value may be used:

*ECI* = 400 $kgCO_2e/m^2$

The absolute embodied carbon intensity value (400 $kgCO_2e/m^2$) is for the mandatory scope of the object of assessment, as specified in Section 2. This value is based on data collected from embodied carbon submissions for the City of Vancouver rezoning requirements from 2017 to 2023. As more data is collected, the value may be refined to reflect new data, different building types, or other important variables in wbLCA.

**Example:**

If the absolute embodied carbon intensity is 400 $kgCO_2e/m^2$, and the gross floor area of the proposed design is 10,000 $m^2$ (reminder: parkade is excluded from this area), the embodied carbon benchmark can be calculated as follows:

$EC_{BM} = 400 \times 10{,}000$
$EC_{BM} = 4{,}000{,}000$ $kgCO_2e$

(b) **Baseline Path**

Create a functionally-equivalent baseline following Section 5. The baseline shall follow the same guidance as the proposed design for specifying the object of assessment (Section 3) and calculating the embodied carbon (Section 4).

$$EC_{BM} = EC_{BL}$$

Where:
$EC_{BM} = Embodied\ Carbon\ Benchmark\ (in\ kgCO_2e)$
$EC_{BL} = Embodied\ Carbon\ of\ the\ Baseline\ (in\ kgCO_2e)$

**Note:**

The embodied carbon benchmark calculated from the absolute path is independent of the parkade area, and two buildings with the same GFA will have the same benchmark regardless of the size of the parkade.

Since all the structure is included in the object of assessment, as specified in Section 3.3, a building with less parkade structure will find it easier to meet the benchmark and the resulting limit compared to a building with more parkade structure. See Figure 1 for an example of the areas included in object of assessment and areas included in calculating GFA.

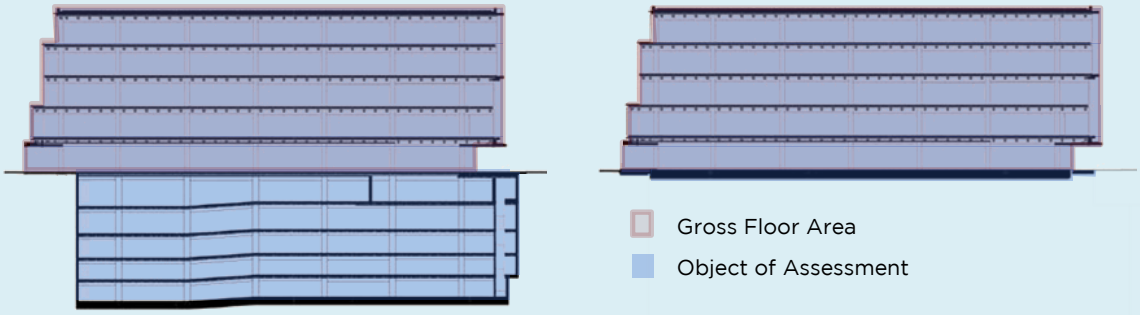


**Figure 1: Areas Included in Gross Floor Area and Object of Assessment**

By comparison, the baseline path provides more flexibility with respect to parking than the absolute path. This is consistent with the intent of the baseline path – while more complicated, it removes many variables from compliance considerations, such as parking, height, soil conditions, shape, overall material efficiency, and more.

## 2.3 Calculate the Embodied Carbon Limit

Calculate the embodied carbon limit by multiplying the embodied carbon benchmark by a reduction factor.

$EC_L = EC_{BM} \times f$

Where:

$f = reduction\ factor\ to\ be\ applied\ to\ the\ benchmark, in\ accordance\ with\ the\ embodied\ carbon\ requriements$

**Note:**

The VBBL requirements effective in 2023 require that embodied carbon impacts not be more than double a functionally-equivalent baseline (i.e. the benchmark, as per the definition of functionally-equivalent baseline), so in this case $f$ = 2.0.

For the proposed requirements for new Part 3 buildings in the 2025 update of the VBBL*, approved in principle by City Council in May 2022, a 10% reduction requirement means $f$ = 0.9, and for a 20% reduction requirement $f$ = 0.8.

* The proposed 2025 VBBL updates, including requirements for responsible materials, are available on the City's website[3].

## 2.4 Determine Compliance

To comply with an embodied carbon requirement, the embodied carbon of the proposed design shall not exceed the embodied carbon limit.

$EC_P \leq EC_L$

Wherein:

$EC_P = Embodied\ Carbon\ of\ the\ Proposed\ Design$ (in $kgCO_2e$)

$EC_L = Embodied\ Carbon\ Limit$ (in $kgCO_2e$)

### (a) Multiple Buildings

Multiple buildings that are part of the same permit application may be combined in one calculation of embodied carbon, if they share a common parkade, or a common podium, because they use the same below-grade concrete structural design.

The combined buildings shall either all be up to 6 storeys or all be more than 6 storeys. Otherwise the embodied carbon of the connected buildings shall be reported separately. In this case, the user shall use their professional judgement to allocate the shared spaces between the connected buildings, for instance based on their relative GFA or use of the common spaces, such as shared underground parkade.

If the buildings have no common spaces, the embodied carbon calculation and reporting shall be done separately for each building.

For demonstrating compliance at the time of Building Permit, large developments with multiple parcels must provide at least one calculation for each parcel of the development, and results may be averaged, per gross floor area, across a development up to the level of each parcel.

Rezoning applications with two or more buildings are not required to calculate embodied carbon emissions per building. They may calculate embodied carbon per building type and estimate the total embodied carbon by multiplying the estimated embodied carbon intensity

[3] The proposed 2025 VBBL updates are available here: https://council.vancouver.ca/20220517/documents/R1a.pdf#page=15

by the total gross floor area of each archetype. Refer to Sections 4.2 and 4.3 for guidance on assumption for estimating material quantities and embodied carbon when project-specific data may not be available, including at the rezoning stage.

## 2.5 Document Compliance

See Section 6 for compliance documentation and submittal requirements.

# 3 Specification of the Object of Assessment

## 3.1 General

This section specifies the object of assessment and system boundary. These set the scope of the calculation of embodied carbon for compliance with embodied carbon requirements.

## 3.2 Life Cycle Stages

Figure 2 in Appendix B.1 (a) shows different life cycle stages and modules in a wbLCA. A description of each module is provided in Appendix B.1 (b).

### (a) Required Scope:

Embodied carbon shall be calculated using a cradle-to-grave life cycle boundary and include modules A1-A5, B1-B5, and C1-C4, wherever data is available.

For further options for end-of-life scenarios, refer to Section 4.3 (c) (vi) for salvaging and reusing and Section 4.3 (c) (vii) for design for disassembly practices.

### (b) Optional Scope:

Module D shall not be included in the embodied carbon calculations used for compliance. However, embodied carbon from module D may be calculated and reported separately.

## 3.3 Building Elements

A list of the building elements that must be included in the embodied carbon reporting and compliance are provided in Section 3.3 (a). Optional elements specified in Section 3.3 (b) may be included in the embodied carbon reporting scope.

Users may include some or all of the optional elements in the scope of assessment when demonstrating compliance in the baseline path (Section 2.2 (b)), although their inclusion is not mandatory. If any optional scopes are included for demonstrating compliance, the scope of the proposed design and the baseline must be the same.

If any optional scopes are included for the compliance purposes, the embodied carbon emissions and percentage reduction achieved shall be reported both with and without the optional scopes in the spaces provided in the Embodied Carbon Design Report (Design Report) (See Section 6.1).

Similar to the NRC Guidelines (see Appendix A.2 (b) (i)), the building elements in this section are organized by OmniClass element classification. The break down in the following sections are in Level 1 and 2. A detailed list of mandatory and optional elements, with Level 3 and 4 OmniClass breakdown is provided in Table 5 in Appendix B.2.

The user shall use the building element lists provided here and in Table 5, to identify the required and optional elements and sub-elements. However, they can use other classification systems to create their bill of materials, such as UniFormat that is commonly used in the industry.

The inclusion and exclusion of optional elements may be decided at Level 4 OmniClass. This means that if a Level 4 optional sub-element is included in reporting and/or compliance, all materials and products for that sub-element shall be included. See Section 4.2 (b) for more information on completeness requirement to comply with VBBL requirements.

(a) Required Scope

(i) Substructure

- Foundations
- Subgrade Enclosures (Below-grade exterior walls)
- Slabs-on-Grade

(ii) Shell

- Superstructure (include above and below-grade floors, above and below-grade columns and beams, above and below-grade interior shear walls, above and below-grade stairs[4], balconies, roof structure, and canopies).
- Exterior Vertical Enclosures (include above-grade structural and non-structural exterior walls, exterior windows and doors).
- Exterior Horizontal Enclosures (include roofing, roof windows, and skylights)

(b) Optional Scope

(i) Interiors

- Interior Construction (include above and below-grade interior non-structural walls, partitions, windows, doors, raised floors, and suspended ceilings)
- Interior Finishes (include above and below-grade wall finishes, flooring, stair finishes, and ceiling finishes)

(ii) Services

- Conveying
- Plumbing
- Heating, Ventilation, and Air Conditioning (HVAC)
- Fire Protection
- Electrical
- Communications
- Electronic Safety and Security
- Integrated Automation

[4] The structural elements on the below-grade interior are included in the Shell, Superstructure, classification, because the Substructure in the OmniClass only covers foundations, exterior walls, and slab-on-grade.

(iii) **Equipment and Furnishings**

(iv) **Special Construction & Demolition**

- Including building demolition and selective demolition

(v) **Sitework**

- Including excavation, parking lots, and landscaping

**Note:**

These guidelines use the OmniClass classification to specify which elements are included in the object of assessment, in alignment with the NRC Guidelines (See Appendix A.2 (b) (i)).

The building element lists provided in this section and in Table 5, Appendix B.2 are provided to help users identify required and optional elements and sub-elements. While this is used for clarity on "what's in", it does not mean the inputs or bill of materials must be organized according to OmniClass. Oher classification systems may be used for inputs and the bill of materials, such as UniFormat that is commonly used by industry and quantity surveyors.

**Note:**

As noted above and elsewhere, the parkade is included in the object of assessment. This includes the elements of foundations and below-grade exterior walls, floors, columns and beams, shear walls, and stairs.

**Note:**

The required scope specified in this section and Table 5 in Appendix B.2, are subject to availability of data from the project and software tool. The user may specify any required scopes that are excluded from reporting with a brief explanation in the Design Report (See Section 6.1).

# 4 Quantifying Embodied Carbon

## 4.1 General

All calculations of embodied carbon shall comply with this section, regardless of whether it is for the proposed or baseline design, unless otherwise allowed by these guidelines.

### (a) Calculation Methodology

Embodied carbon shall be calculated using a wbLCA methodology in compliance with these guidelines.

## 4.2 Establishing a Bill of Materials

A bill of material is a list of individual building materials and product and their quantities that make up the physical building. The bill of materials is used to assess the embodied carbon of a building.

### (a) Sources

The NRC Guidelines (see Appendix A.2 (b) (i)) list three mechanisms for obtaining materials and product quantities, referred to as bill of materials:

- A building information model (BIM)
- A cost estimate
- Takeoffs from drawings

If the bills of materials created from a BIM or cost estimate is missing any of the required elements (e.g., foundations) or quantities of materials or products within a required element (e.g., concrete reinforcement), those quantities shall be added and accounted for in the embodied carbon assessment (See Section 3.3 for the list of required elements).

The quantity of missing elements, materials, and products can be manually calculated through takeoffs or estimated using other sources. The project team may use their professional judgement to identify non-major elements, materials, and products that are challenging to be quantified through quantity takeoff. For these elements, the quantities of equivalent elements in default assemblies in the wbLCA or embodied carbon assessment software tools can be used, such as "Constructions" in One Click LCA[5] and the assembly approach in Athena Impact Estimator[6]. If used at Building Permit stage, these tools must be able to reflect the building geometry and design.

[5] See Appendix A.2 (a) (v).
"Constructions" in the One Click LCA tool are predefined construction assemblies and components with multiple options per assembly.
[6] See Appendix A.2 (a) (i).

### (b) Completeness

Quantification of materials and flows shall correspond to the level of development, timing of the assessment, and availability of information for the proposed design, as well as the relative importance to the embodied carbon results and the purpose of the study (e.g., informing proposed design, meeting requirements, or performance declaration).

The bill of materials shall include all the major materials and products used in the required elements, specified in Table 5, Appendix B.2. The users may use their professional judgment to identify the cut-off points for minor material 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.

> **Note:**
>
> Materials and components in the substructure and shell elements that perform as thermal, moisture, acoustic, and fire protection functions are required to be included. For example, fire rated gypsum boards or concrete topping on mass-timber floors are to be included, as they are considered part of the required scope.

#### (i) Rezoning Application and Schematic Design Stage

For calculations at the preliminary or schematic design stage, such as those made as part of a rezoning application, there may be limited information available for the proposed design. The purpose of the study at this stage is not to demonstrate compliance, but to inform building design to reduce embodied carbon and prepare for future compliance. For this purpose, very basic quantity estimates – such as an order of magnitude estimate, or a 'Class D – Indicative Estimate' according to the KPMB Lab WBLCA Classification System[7] – for the materials with the most relative importance to embodied carbon may be sufficient to inform design and begin the process of reducing the embodied carbon of the building design.

#### (ii) Building Permit Application and Construction Documents Stage

As the project progresses and more information about the options for building elements become available, the project team shall create a more accurate embodied carbon model to inform the design. Quantification of materials and flows in embodied carbon calculations used to demonstrate compliance with an embodied carbon requirement, such as a Building Permit application, shall generally conform to the level of detail of a 'Class B – Design Estimate' according to the according to the KPMB Lab WBLCA Classification System[8].

[7] See Appendix A.2 (b) (ii).
[8] Level of Detail (LOD) of 300-350 in BIM.

### (c) Material and product Types

If certain materials and product types are not specified in project documents, the project team shall use their professional judgement to specify them based on local common practices specific to their building archetype.

Table 1 provide general guidance for common material and product types for local practices in Vancouver. While the project teams can use this table as a guide, they should primarily rely on their professional judgment to identify whether typical materials and assemblies for their building archetype and design requirements vary from the information in this table.

**Table 1: Default Common-practice Assemblies and Materials for the Key Building Elements**

| Building Elements (OmniClass) | | | Default Material and Product Assumption |
|---|---|---|---|
| **Level 1** | **Level 2** | **Level 3** | |
| Substructure | Foundations | - | • Steel-reinforced Concrete*<br>• Subgrade Insulation: Extruded Polystyrene (XPS) |
| | Subgrade Enclosures | Walls for Subgrade Enclosures | |
| | Slab-on-Grade | - | |
| Shell | Superstructure | Floor Construction: Vertical (i.e. columns) | • Steel-reinforced Concrete* |
| | | • Floor Construction: Horizontal (i.e. beams and floor plates)<br>• Roof Construction | • Typical Span: Steel-reinforced Concrete*<br>• Long Span: Steel Trusses |
| | Exterior Vertical Enclosure | Exterior Walls** | • Type:<br>  ○ Office and Commercial Storefront: Aluminum Curtain Wall<br>  ○ Residential (7+ storeys): Aluminum Window Wall<br>  ○ Other: Steel Framed Wall<br>• Framing: 6” deep steel framing @ 16” on-centre<br>• Sheathing: Gypsum Board***<br>• Thermal Insulation (Cavity): Mineral Wool Batt Insulation<br>• Thermal Insulation (Continuous): Heavy Density Mineral Board<br>• Cladding: Galvanized Steel |
| | | Exterior Windows | • Window Frame: Aluminum<br>• Insulated Glass Unit (IGU): As required to meet the thermal performance<br>• Window-to-wall ratio: As required to meet the thermal performance |

| Building Elements (OmniClass) | | | Default Material and Product Assumption |
|---|---|---|---|
| Level 1 | Level 2 | Level 3 | |
| | Exterior Horizontal Enclosures | Roofing | • Insulation:<br>  ○ Conventional Roof: Polyiso<br>  ○ Inverted Roof: Extruded Polystyrene (XPS)<br>• Interior Sheathing: Gypsum Board***<br>• Membrane: 2-ply Styrene Butadiene Styrene (SBS) |
| Interiors (Optional) | Interior Construction (Optional) | Interior Partitions | • Framing: 6" deep steel framing @ 16" on-centre<br>• Sheathing: Gypsum Board*** on Both Sides<br>• Acoustic Insulation (where required): Mineral Wool Batt Insulation |
| | Interior Finishes (Optional) | Wall Finishes | • Paint |
| | | Floor Finishes | • Office Units: Carpet<br>• Residential and Hotel Suites: Vinyl<br>• Retail: Ceramic Tiles<br>• Industrial: Exposed Concrete<br>• Healthcare: Ceramic Tiles<br>• All Building Types:<br>  ○ Hallways (except for retail): Carpet<br>  ○ Below-grade and Service Rooms: Exposed Concrete<br>  ○ Bathrooms and Showers: Ceramic Tiles |
| | | Ceiling Finishes | • Drop Ceiling: Acoustic Tile<br>• Other: Gypsum Board*** with Skim Coat and Paint |

* If no detailed steel reinforcement (rebar) quantities are available, the user may use their professional judgement to estimate the quantity of rebars. They may also use the mid-range in the One Click LCA's recommended average concrete reinforcement quantities[9]. This reference provides guideline on typical ranges in rebar for different building elements in kg rebar/$m^3$ concrete. 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.

** For mixed-use buildings with multiple enclosure types, the enclosure assembly types in the embodied carbon model shall follow the pattern of enclosure in proposed design (e.g., a mixed-use building that uses window wall enclosure across the residential portions of the building and used curtain wall for the commercial portion). The pattern shall be matched in the baseline modelling for the baseline path (Section 2.2 (b)).

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

[9] https://oneclicklca.zendesk.com/hc/en-us/articles/360020943800-Average-Quantities-of-Reinforcement-in-Concrete

## 4.3 Embodied Carbon Quantification

### (a) Software Tools

#### (i) Rezoning Application and Schematic Design Stage

In addition to the wbLCA or embodied carbon assessment software tools specified in the following sub-section, rezoning applications may use early design tools, such as the Carbon Designer tool of One Click LCA[10], the assembly approach in Athena Impact Estimator, and Embodied Carbon Pathfinder[11].

> **Note:**
>
> Early design tools with the ability to reflect geometry and industry-wide material EPDs – such as Carbon Designer and the assembly approach in Athena Impact Estimator, can provide a more accurate estimate.
>
> Project teams are advised to consider the results from tools such as Embodied Carbon Pathfinder as a high-level, order-of-magnitude estimate. These tools estimate embodied carbon based on modelled scenarios for select building archetypes, and are not specific to a project's geometry or material quantities. Project teams are encouraged to model the embodied carbon of their specific project early in the design process to help inform design and material selection.

#### (ii) Building Permit Application and Construction Documents Stage

The software tools used for VBBL requirements shall comply with EN 15978:2011 or an equivalent regional standard (See Appendix A.1 (a) (i)). A list of commonly used tools that are accepted for compliance with VBBL are provided in Appendix A.2 (a).

These guidelines require a cradle-to-grave life cycle boundary, that means modules A, B, and C shall be included in the assessment. However, software tools that are missing modules beyond A1-A3, but are working towards adding them such as EC3 and tallyCAT, may still be used for compliance. To do so, the methodology provided in Section 4.3 (c) (viii) shall be used to estimate emissions beyond modules A1-A3.

### (b) Data Sources

Except as required or allowed in this section, scenarios, flow types, data quality of Life Cycle Inventory (LCI) flows, sets of environmental data, data quality of environmental data, and Life Cycle Impact Assessment (LCIA) method used to calculate embodied carbon shall be as built into the software tool.

[10] https://www.oneclicklca.com/carbon-designer/
[11] https://www.buildingpathfinder.com/

(i) Impact Indicators

The LCIA method used in the software tool shall be TRACI v2.1 or newer (See Appendix A.1 (b) (i)). The tools listed in Appendix A.2 (a) use TRACI for embodied carbon assessment of buildings in North America.

Calculation of embodied carbon for demonstrating compliance with an embodied carbon standard only require reporting of the Global Warming Potential (GWP) environmental impact category. Other environmental impact category results are optional and may be reported separately, if available in the software tool used.

(ii) Environmental Product Declarations (EPDs)

The EPDs in the LCA databases of the software tools used for VBBL compliance shall comply with the latest version of ISO 21930 (2017), which is the standard used in North America (See Appendix A.1 (c) (i)).

If an ISO 21930-compliant EPD is not available for an imported product, it is acceptable to use data from EPDs that comply with the equivalent EPD standard in it respective region. For instance, European products that their EPDs are published prior to July 2022, shall comply with EN 15804+A1 and those published since July 2022 shall comply with EN 15804+A2[12].

The EPDs used in the software tools in Appendix A.2 (a) are acceptable, as the tool providers claim to comply with the above standards.

If EPDs outside the software tools are used for manual calculations, as allowed in Section 4.3 (c) (i), the latest version of the EPDs shall be used. EPDs that are expired may not be used, unless no valid EPD is available for a specific product.

(c) Assumptions, Data Modifications, and Manual Calculations

Where the software tool allows it and the user has access to higher quality project-specific or regional data, the user may modify the data within the software tool to reflect the higher quality data.

If there are data limitations in the software tool, the user may utilize manual calculations outside of the software and replace relevant data from the tool.

Any changes to the default software tool data and assumptions, whether it is done inside or outside the tool, shall be described and justified in the space provided the Design Report (See Section 6.1). The manual calculation data shall be submitted (see Section 6.2 (b)) and additional details may be provided in a supporting report (see Section 6.2 (c)).

[12] See Appendix A.1 (c) (c).
EN 15804+A1 uses CML method instead of TRACI, which is the common LCIA method used in North America. EN 15804+A2 uses the Product Environmental Footprint (PEF) method. TRACI, CML, and PEF use the same unit of measurement for GWP ($kgCO_2e$). However, they use different units for some other impact indicators. Therefore, European EPDs, that comply with EN 15804 is accepted for European products, if only GWP, i.e. embodied carbon, is reported and if no ISO 21930-compliant EPD, which reports using TRACI method is available for them.
- CML is the methodology required by the European EN 15978 and EN 15804 standards. See the following link for more information on CML: https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors
- PEF is developed by the European Commission to advance various product sustainability initiatives of the European Commission. See the following link for more information on PEF: https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

The following sub-sections describes the possible assumptions, modifications, and calculations and the life cycle module impacted by them.

### (i) Material type and EPDs (Modules Depend on the Scope of EPDs)

In software tools that allow selecting EPDs, such as One Click LCA[13], EC3[14], and tallyCAT[15], product-specific EPDs shall be used for the proposed design, when available and when a single product and manufacturer has been specified and no acceptable alternate has been identified in the project documents. Where acceptable alternates with available EPDs have been identified, the alternative with the highest product-specific GWP shall be used. If maximum GWPs have been specified, a product-specific EPD that is closest in GWP to the maximum GWP may be used.

When the specified products do not have product-specific EPDs, or if specific products or GWP maximums have not been specified, industry-wide EPDs shall be used, when available. If the baseline compliance path is used (Section 2.2 (b)), the baseline shall also use industry-wide EPDs.

The 2023 CLF North American Material Baselines Report (Referred to as "CLF Baselines Report" in this document. See Appendix A.1 (d) (i)) shall be referenced to identify the relevant industry-wide EPDs. Where available, B.C. or Canadian industry-wide EPDs shall be used.

For some material categories, industry-wide EPDs are not available in certain software tools or no industry-wide EPD exist. In these cases, a product-specific EPD that is closest in GWP to the "baseline" value outlined in the latest version of CLF Baselines Report may be used.

Table 2 provides additional guidance for the default material type and EPD-choice assumptions, including relevant organizations that publish industry-wide EPDs. These may be used when project or product-specific material types and EPDs are not available.

[13] See Appendix A.2 (a) (v).
[14] See Appendix A.2 (a) (iv).
[15] See Appendix A.2 (a) (iii).

**Note:**

Where software tools that do not allow selecting EPDs are used, such as Athena Impact Estimator and tallyLCA, the default GWP values in the tool may be used.

Where software tools that do not allow selecting EPDs are used, the project team are still able to demonstrate embodied carbon reduction through specifying low-carbon intensity products. In this case, the user may manually calculate the reduction achieved outside the software tool by replacing the default GWP with the one specified in the EPD or the specifications.

If the baseline compliance path is used (Section 2.2 (b)), and the GWP of a product in the proposed design varies from the baseline, and the GWP in the tool for that particular product does not match the industry-wide EPD, the baseline shall also be manually modified outside the software tool to replace the GWP of that product with the industry-wide EPD.

If the EPD used only covers modules A1-A3, the user shall only replace modules A1-A3 and leave the data from modules B and C as is. If the tool does not allow separating emissions by modules and products, the user may remove the impacts from all the modules for the default material or products that are going to be replaced. They may then replace the A1-A3 emissions with the data from the EPDs used and use the relative estimates provided in Section 4.3 (c) (viii) to calculate modules A4-A5, B, and C for the replaced product.

Table 2: Default Materials and Product Assumptions and EPD Selection

| Material/Product | Default Material Type and EPD Assumptions |
|---|---|
| Concrete | All concrete shall assume baseline mixes specified in the BC provincial industry-wide EPD[16], with matching air entrainment and at equivalent strength to the proposed design, unless lower strengths are enabled by structural design efficiencies as described in "Design Structure for Material Efficiency" section of Table 3.<br><br>If no information is available on the proposed design, consider assuming the following compressive strengths can be used:<br>• Foundation, Footings, Slab-on-grade - 25 MPa<br>• Exterior Walls, Interior Walls - 35 MPa<br>• Suspended Floor and Roof Slabs and Beams - 35 MPa<br>• Stairs, Columns, Shear Walls - 40 MPa<br><br>If no information is available on air entrainment for concrete in the proposed design, air-entrained concrete mixes can be assumed for building elements exposed to exterior conditions (e.g., foundations, parkade slabs, exterior walls, slab-on-grade, etc.) and non-air entrained concrete mixes can be assumed for elements not exposed (e.g., interior concrete elements).<br><br>**Note:**<br>Athena Impact Estimator and tallyLCA tools currently do not include BC provincial industry-average concrete mixes EPDs in their database.<br>Projects that use Athena tool can select the "Benchmark" mixes defined within older CRMCA 2017 Canadian Industry-Average EPD that is currently available in the tool.<br>Projects using tallyLCA may use the national average values from the US-specific NRMCA 2019 data that is currently available in the tool.<br>If in future BC-average EPDs become available, BC values shall be used.<br>If the project teams wish to claim embodied carbon reduction for using low-carbon intensity concrete, using these tools, they shall follow the guidance provided in this Note box. |
| Insulation | **XPS:**<br>The newer generation of XPS are compliant with Canadian HFC regulation and shall be referenced (e.g., Owens Corning FOAMULAR NGX, SOPREMA SOPRA- XPS, KingSpan GreenGuard LG XPS, or DuPont's ST-100 XPS). The conventional XPS insulation products that use HFC blowing agents shall not be referenced, as those are banned in Canada due to new regulations that came into effect on Jan. 1, 2021.<br><br>The CLF Baselines Report averages XPS from both HFC and HFO blowing agent products to derive an average GWP value (See Appendix A.1 (d) (i)). Since XPS insulations that use HFC blowing agents are banned in Canada, the baseline value for XPS in CLF Baselines Report shall not be used. |

[16] https://pcr-epd.s3.us-east-2.amazonaws.com/810.CRMCA_EPD_BC.pdf

| Material/Product | Default Material Type and EPD Assumptions |
|---|---|
| | **Closed Cell Spray Foam:**<br>If the Closed Cell Spray Foam (ccSPF) insulation is proposed, it shall reference the newer generation of low-GWP blowing agents compliant with Canadian HFC regulation. Reference the SPFA Industry-wide EPD (2018) for Spray Foam using HFO blowing agents. The conventional ccSPF insulation products that use HFC blowing agents shall not be referenced, as those are banned in Canada due to new regulations that came into effect on Jan. 1, 2021.<br><br>The CLF Baseline Report averages ccSPF from both HFC and HFO blowing agent products to derive an average GWP value. Do not use this baseline value. |
| Windows and Glazing | If the software tool does not have data specific to the window frame of the proposed design, a different window frame can be a proxy value.<br><br>If the software tool does not have data specific to the triple-pane windows:<br>• If the software tool allows it, window frame and glazing layers can be modelled separately.<br>• If the tool only allows using EPDs that combine window frame and glazing, the emissions can be approximated by referencing a double pane window EPD with appropriate window frame and adding an additional pane of flat glass or processed glass with the same area as the proposed window. |
| Steel Reinforcement (Rebar) | The fabricated rebar EPD published by Concrete Reinforcing Steel Institute (CRSI) shall be referenced.<br><br>The user do not need to model recycled content in the rebar, as the CRSI EPD specifies the recycled-content steel, which is 98%.<br><br>**Note:**<br>Post-tensioned slabs reduce rebar quantities in structural concrete. However, post Tension (PT) Tendons typically use much lower recycled content steel and have higher GWP impacts compared to conventional rebar. If no EPD is available for PT tendons, embodied carbon calculations shall approximate the impacts by doubling the PT tendon quantity and map to conventional rebar EPD (CRSI industry-wide EPD). |
| Steel | For non-rebar steel including Plate Steel, Hollow Structural Section (HSS), Hot-Rolled Sections, Steel Framing, and Open Web Steel Joist, baselines shall reference the relevant industry-wide EPD.<br><br>Where available in the software tool refer to:<br>• Fabricated steel data instead of unfabricated steel<br>• Canadian industry-wide EPDs over US industry-wide EPDs.<br><br>Examples of organizations that have published industry-wide EPDs are Canadian Institute of Steel Construction (CISC), American Institute of Steel Construction (AISC), American Galvanizers Association (AGA), Steel Framing Industry Association (SFIA), Metal Building Manufacturers Association (MBMA), Steel Joist Institute (SJI), Steel Tube Institute (STI), Steel Deck Institute (SDI), and Metal Construction Association (MCA). |

| Material/Product | Default Material Type and EPD Assumptions |
|---|---|
| Aluminum | Aluminum products shall reference the relevant industry-wide EPD.<br><br>Where available, reference Canadian industry-wide EPDs (e.g., AluQuebec) over US industry-wide EPDs. Examples of industry-wide EPDs are:<br>• Extruded Aluminum: Aluminum Extruders Council (AEC)<br>• Curtain Wall: AluQuebec<br>• Aluminum Windows: AluQuebec<br>• Aluminum Sheet/Cladding: AluQuebec, Aluminum Association, Ceilings & Interior Systems Construction Association (CISCA), Metal Construction Association (MCA) |
| Wood | Refer to Section 4.4 (a) on biogenic carbon calculation.<br><br>Wood products shall reference relevant industry-wide EPDs from the Canadian Wood Council (CWC) or other relevant organizations. |
| Services | **(Optional)**<br><br>Product-specific EPDs, Product Environmental Profiles[17] (PEPs), or industry-wide data shall be used.<br><br>If none of the above data sources are available, the project team can calculate the embodied carbon of building services using guidance from TM65 Embodied Carbon in Building Services: A Calculation Methodology and TM65LA Embodied carbon in building services: Using TM65 outside the UK (See Appendix A.2 (d)).<br><br>Refrigerant emissions shall not be included in the embodied carbon assessment or compliance[18]. |

**Note:**

EC3 and tallyCAT both use EC3 database, which by default displays uncertainty-adjusted GWP (uaGWP) values that apply an uncertainty factor on top of the Reported GWP values in EPDs. Users may use the uaGWP results for analysis. However if in the future there is an option to export the project results in "Reported GWP", those values shall be used, instead of the uaGWP values in submissions.

(ii) **Transportation to Construction Site (Module A4)**

Where the tool allows it, scenarios and data related to the transportation to construction site can be adjusted to reflect project-specific or typical local distances and transportation modes.

(iii) **Construction Site Emissions (Module A5)**

The construction site emissions shall be per the default scenarios in the software tool.

[17] http://www.pep-ecopassport.org/create-a-pep/
[18] Reporting and reducing refrigerant GHGs is considered under the 2025 VBBL operational carbon requirements. https://council.vancouver.ca/20220517/documents/R1a.pdf#page=15

If the tool allows it, the user can replace the default values with more representative regional data, e.g., from comparable recent projects. Data required from construction sites include construction waste generation and management as well as the electricity and natural gas consumption – for instance for using the equipment and tools, heating, and cooling. This data can be used to estimate the GHG emissions associated with the construction site activities inside the software tool or manually.

If the proposed design specifies requirements resulting in embodied carbon reduction on construction processes, the proposed design requirements may replace the default values in the tool, if the tool allows it. For instance, the proposed design can specify a maximum construction waste generation bellow the default scenarios in the software tool or specify using prefabricated assemblies that can cut down construction waste generation compared to on-site construction.

(iv) **Lifespan of Buildings, Elements, and Products (Module B)**

Embodied carbon calculations shall assume 60 years for the reference study period and the required service life of the building, regardless of the actual required service life of the building.

The calculations may assume shorter lifespans for products and elements, based on default assumptions in the software tools. Where the tools allow modifying the lifespans, they may be replaced with the lifespan based on the EPDs, warranty documents provided by the product suppliers, or values provided in Table 6 in Appendix C.1.

(v) **Waste Management at the End-of-Life (Module C)**

Where the tool allows it, default scenarios for waste management at the end of building life can be updated to better reflect the project-specific or regional waste management practices.

For instance, the waste diversion scenarios may be modified to reflect higher reusability or recyclability rates at the end of the project life compared to the default values in the tools, resulting from materials choices or building design.

(vi) **Salvaging and Reusing (Modules A-C)**

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 quantity of reused materials and components shall be excluded from all the life cycle stages (A-C) in the embodied carbon assessment. When calculating the floor area of the building for calculating the embodied carbon intensity, the reused portion should be included in the floor area, unless it the area is underground parkade area.

The embodied carbon from the demolition of the portion of the existing building that is removed from the site shall not be included in the embodied carbon calculation.

(vii) **Design for Disassembly (Modules C-D)**

Design for Disassembly (DfD) enables future reuse and recycling and thus reduces emissions from module C and D. However, currently there is no quantitative approach to measure how DfD solutions may reduce embodied carbon.

The project design team are encouraged to incorporate the latest version of CSA Z782 (see Appendix A.2 (a) (i)) or ISO 20887 (see Appendix A.2 (a) (ii)) standards. These guidelines provide guidance on design for disassembly and adaptability. If the design

team uses the directions in these standards for designing any of the building elements, they can assume 50% reduction in modules C1-C4 emissions of those building elements.

This credit can be claimed if the software tool used provides the embodied carbon result by elements and life cycle stages. The credit should be reported separately in the space provided in the Design Report (See Section 6.1) with a brief description of the approach taken. Additional information may be provided in the supporting report (See Section 6.2 (c)).

(viii) **Life Cycle Stages Beyond Product (Modules A4-A5, B, and C)**

Where the software tool scope is missing data for any of the life cycle stages beyond product stage (i.e. beyond modules A1-A3), for example EC3 and tallyCAT and Builders for Climate Action's BEAM Estimator[19]), the following methodology may be used as an interim solution to report whole-building embodied carbon emissions[20]:

- Construction process stage – transportation to the construction site (module A4) impacts shall be assumed equal to 4% of the A1-A3 impacts;
- Construction process stage – construction (module A5) impacts shall be assumed equal to 6% of the A1-A3 impacts;
- Use stage (modules B1-B5) impacts shall be assumed equal to 10% of the A1-A3 impacts;
- End-of-life stage (modules C1-C4) impacts shall be assumed equal to 5% of the A1-A3 impacts.

**Note:**

The above assumptions are provided as an interim measure to allow using the tools that are currently missing, but are working towards adding, life cycle stages beyond the product stage.

These assumptions can only be used when a full life cycle stage is missing in a software tool and not when one or some modules within a life cycle stage is missing.

For the purposes of compliance with the VBBL embodied carbon requirements, these assumptions shall only be used for EC3 and tallyCAT, among the software tools that are listed in Appendix A.2 (a).

[19] https://www.buildersforclimateaction.org/beam-estimator.html
Note that the BEAM Estimator tool is only applicable for Part 9 buildings and cannot be used for compliance with VBBL requirements for Part 3 buildings.
[20] These percentages are derived from the relative impacts of life cycle stages from about 80 wbLCAs, using Athena Impact Estimator and One Click LCA tools. This includes the data from *Carbon Footprint Benchmarking of BC Multi-Unit Residential Buildings*, Athena Institute, May 2017. http://www.athenasmi.org/wp-content/uploads/2017/09/BC_MURB_carbon_benchmarking_final_report.pdf.

## 4.4 Treatment of Special Topics

### (a) Biogenic Carbon

Reporting the embodied carbon impacts associated with biogenic carbon is optional.

If included, they shall be calculated using the methodology included within the software tool used. The results shall be reported separately and shall not be included in demonstration of compliance with the embodied carbon limit.

### (b) Concrete Carbonation

Naturally occurring concrete carbonation may be calculated and reported.

If reported, they shall be calculated using the default modelling by the software tool used. The results shall be reported separately and shall not be included in the embodied carbon calculations used for compliance.

### (c) Land Use Change

The direct and induced land use change impacts shall not be included in the embodied carbon calculation.

> **Note:**
>
> European EPDs, that follow EN 15804+A1, may roll up the biogenic carbon into the A1-A3 value. The EPDs following EN 15804+A2, report GWP in four categories: fossil fuel use, biogenic carbon, and land use, and total, which is the sum of the three former GWP indicators.
>
> If these European EPDs are used outside the software tools for manual calculations, as allowed in Section 4.3 (c) (i), the user shall only use fossil GWP for embodied carbon reporting and compliance. Biogenic carbon may be reported separately, but shall not be used for compliance with the embodied carbon reduction requirements of VBBL.
>
> For EPDs that are based on EN 15804+A1, the user may need to parse out the fossil and biogenic GWP results by reading the EPD details (e.g. in the LCA interpretation section).

# 5 Creating a Baseline

This section provides guidance on creating a baseline for compliance through the baseline path described in Section 2.2 (b).

## 5.1 General

### (a) Calculation Methodology

Except as allowed by this section, calculation of embodied carbon shall be the same for the baseline and proposed design and in accordance with Sections 3 and 4 of these guidelines.

The software tool used to calculate embodied carbon shall be the same for the proposed and the baseline.

## 5.2 Functional Equivalency

The baseline shall be functionally equivalent with the proposed design and meet all the VBBL and zoning requirements.

### (b) Thermal Equivalence

The proposed design and the baseline shall have functionally-equivalent thermal performance, as determined by the building architect, envelope engineer, mechanical engineer, or energy modeller.

The thermal equivalency may be approximate and as determined by those noted above. As such, approximate equivalency of clear-wall assembly R-value is acceptable for the embodied carbon modeling of the baseline. Detailed calculations of thermal bridging and thermal equivalence can be conducted but are not required.

Unless justification is provided, according to the thermal performance calculations or professional judgment, the glazing ratio and number of panes shall be the same in the baseline and the proposed design.

### (c) Structural Equivalence

The proposed design and the baseline shall have functionally-equivalent structural performance, as determined by the building structural engineer or architect. However, the structural systems do not have to be the same. For instance, a high-rise mass timber building can assume the baseline structure to be concrete, as this is currently the common practice.

For more guidance, refer to the “Design Structure for Material Efficiency” section of Table 3.

The Whole Building Life Cycle Assessment: Reference Building Structure and Strategies, published by ASCE/SEI, can be referred to for additional guidance on creating an equivalent baseline structure (See Appendix A.2 (f) (i)).

### (d) Geometry Equivalence

Except as allowed in Section 5.4, the proposed design and the baseline shall have functionally-equivalent building geometry and program (i.e., services and function of the

spaces, number of residential units and occupancy numbers for multi-unit residential buildings (MURBs), building shape and orientation).

## 5.3 Approaches to Creating a Baseline

There are two acceptable approaches for creating a baseline: using an early design iteration and using the proposed design.

### (a) Using an Early Design Iteration

A useful approach to developing a baseline is to calculate the embodied carbon of an earlier iteration of the proposed design, and then use that as the starting point for creating an improved design with lower embodied carbon.

The early design iteration chosen as the baseline must meet the functional equivalency requirements specified in Section 5.2. Slight variations in the geometry resulting from the design iterations are acceptable, if the baseline and proposed design offer the same services and functions. The project team shall use their professional judgement to decide whether the variations between the design versions are acceptable.

The material quantities in the baseline that are derived from an early design iteration may be attained from a lower quality data source than the proposed design. If certain materials, product types, and quantities are not specified in the early design, the user shall collaborate with the project team to determine these factors for establishing the baseline.

For non-major materials and components that are challenging to quantify, identified by the project team based on their professional judgement, the project team can utilize data from comparable recent projects as a reference to estimate the quantity of materials in the baseline. As an example, the quantity of structural steel connections can be estimated based on the amount of this material per gross floor area obtained from a similar recent project.

Early-design wbLCA or embodied carbon assessment tools can also be used to estimate the missing material quantities.

### (b) Using the Proposed Design

The user can modify the proposed design wbLCA to create the baseline to demonstrate compliance.

This approach ensures the baseline is functionally-equivalent to the proposed design, has a similar level of detail, and the user is aware of all sources of difference between the embodied carbon of the proposed design and the baseline (e.g., material substitutions and material efficiencies).

To do so, a copy of the proposed design wbLCA is created. The quantities, types, and EPDs of the materials used in the proposed design to reduce embodied carbon are replaced with the common-practice quantities, types, and EPDs.

Section 0 offers further guidance on material and component assumptions for the baseline.

## 5.4 Default Baseline Assumptions

The project team shall use their professional judgement to specify the baseline materials and assemblies that reflect local common practice specific to the given building archetype. See Section 4.2 (c) for more guidance on identifying the common-practice approaches. See Section 4.3 (c) for guidance on default material type and EPD assumptions.

Table 3 provides additional guidance on calculating the embodied carbon of the baseline, relative to the proposed design. Table 3 is loosely organized by embodied carbon reduction strategies adapted from the Carbon Leadership Forum's Embodied Carbon Reduction Checklist[21]. Refer to the resources provided in the Intent Section for ideas and strategies to reduce embodied carbon.

Where baseline assumptions specified by the project team vary from Table 1, Table 2, and Table 3, a description shall be provided in the spaces provided in the Design Report (see Section 6.1) or the supporting report (see Section 6.2 (c)).

**Table 3: Calculating Embodied Carbon of the Baseline Relative to the Proposed Design**

| Baseline | Proposed Design |
|---|---|
| **1. Build Less, Reuse More** | |
| Reduce Demolition | |
| **(Out of scope)**<br><br>If the proposed design includes partial or complete removal of any existing building or building element on the site, the baseline shall not include the emissions from the demolition or deconstruction of the existing building. | **(Out of scope)**<br><br>See Section 4.3 (c) (vi) |
| Reuse/Retrofit Existing Buildings | |
| The baseline shall assume entirely new construction for all building areas, even if some portions of the building will be retained and reused in the proposed design. | See Section 4.3 (c) (vi) |
| Use Salvaged or Refurbished Materials | |
| The baseline shall assume entirely new materials for all materials and assemblies, even if salvaged materials are used in the proposed design. | See Section 4.3 (c) (vi) |
| Design for Disassembly (DfD) | |
| **(Optional)**<br><br>Even if DfD is incorporated in the proposed design, default module C and D assumptions in the software tool shall be used for the baseline.<br><br>The baseline module C and D data may be modified if the project team can provide more representative project-specific or regional data on these modules. | **(Optional)**<br><br>See Section 4.3 (c) (vii) |

[21] https://carbonleadershipforum.org/ec-checklist-template

<table>
<tr><th>Baseline</th><th>Proposed Design</th></tr>
<tr><td colspan="2">2. Design Lighter and Smarter</td></tr>
<tr><td colspan="2">Reduce Floor Area of Below-Grade Construction</td></tr>
<tr><td>The baseline shall assume one of the following options to identify the parkade area of the baseline:<br><br>Option 1. The minimum parking requirements in the City of Vancouver Parking By-law[22];<br>Option 2. The number of storeys provided in Table 4; or,<br>Option 3. The same as the proposed design.<br><br>Table 4: Assumptions for Below-Grade Parkade Levels in the Baseline
<table>
<tr><th>Above-Grade Storeys</th><th colspan="2">Below-Grade Parkade Storeys</th></tr>
<tr><th>Proposed Design</th><th>Baseline<br>(Developments with Multiple Buildings over Parkade)</th><th>Baseline<br>(All Other Developments)</th></tr>
<tr><td>1-3</td><td>1</td><td>1</td></tr>
<tr><td>4-6</td><td>RR zones: 1<br>All others: 2</td><td>RR zones: 1<br>All others: 2</td></tr>
<tr><td>7-12</td><td>2</td><td>2</td></tr>
<tr><td>13-18</td><td>3</td><td>3</td></tr>
<tr><td>19-24</td><td>3</td><td>4</td></tr>
<tr><td>25-30</td><td>3</td><td>5</td></tr>
<tr><td>31-36</td><td>3</td><td>6</td></tr>
<tr><td>37-42</td><td>3</td><td>7</td></tr>
<tr><td>43+</td><td>3</td><td>8</td></tr>
</table>
Note:<br><br>The project team may use their professional judgement to estimate the quantity of materials used in the baseline parkade, if different from the proposed design.<br><br>A possible approach is to calculate the embodied carbon intensity per stall or per level of parkade in the proposed design. The intensity can then be multiplied by the number of stalls (Option 1) or the number of parkade storeys in the baseline (Option 2) to estimate the embodied carbon of the parkade in the baseline.</td><td>As per the proposed design</td></tr>
<tr><td colspan="2">Design Structure for Material Efficiency</td></tr>
<tr><td>The baseline may assume a typical structural design, appropriate to the building and functionally equivalent to the proposed design, as determined by the building structural engineer.<br><br>Where intentional design choices are made that vary from a typical design and result in embodied carbon reduction, those may be reflected in differences between the baseline and the proposed design. Otherwise, both the baseline and proposed design</td><td>As per the proposed design</td></tr>
</table>

[22] https://vancouver.ca/your-government/parking-bylaw.aspx

| Baseline | Proposed Design |
|---|---|
| shall have the same structural design assumptions. Examples of these design choices for the structural elements include:<br>• Reducing bay sizing and column and beam spacing;<br>• Reducing member cross sections;<br>• Avoiding cantilevers and transfer slabs;<br>• Reducing rebar and tendons quantities and concrete volume in structural concrete by using post-tensioned concrete slabs;<br>• The knock-on effects of lighter structures, e.g., using void systems, timber structural elements, lighter enclosure and façade systems may result in smaller footings and foundations;<br>• Allowing for the preservation of an existing structure;<br>• Exposing structural materials where possible to avoid finishing.<br><br>For more guidance, refer to Table 1 and Table 2 in this document. The Whole Building Life Cycle Assessment: Reference Building Structure and Strategies by ASCE/SEI can also be referred to for additional guidance (See Appendix A.2 (f) (i)).<br><br>**Note:**<br>If an early design iteration is used as the baseline (section 5.3 (a)), contingency factors assumed in early design (e.g. adding an extra 10% to structural materials quantity) shall be excluded. Embodied carbon reduction from removing the contingency factors cannot be accounted for in compliance. | |
| Choose Finishes Carefully | |
| **(Optional)**<br><br>If included in the embodied carbon of the proposed design, the baseline may assume typical interior finishes, appropriate to the building and functionally equivalent to the proposed design, as determined by the building architect.<br><br>See Table 1 for more guidance on interior material and assembly types. | **(Optional)**<br><br>As per the proposed design |
| Minimize Construction and Demolition Waste | |
| As per the default scenarios in the software tools for modules A5 and C1-C4.<br><br>The baseline data may be modified, if the tool allows it, and if the project team can provide more representative project-specific, city-wide or regional waste management data. | As per the proposed design |
| **3. Use Low-Carbon Alternatives** | |
| Select Lower-Carbon Structural and Enclosure Materials and Assemblies | |
| The baseline structure and enclosure assemblies and materials shall reflect local typical practice for the building type and application. The project team should use their professional judgement to specify the local common practice for the building archetype and application. | As per proposed design |

| Baseline | Proposed Design |
|---|---|
| Refer to Table 1 for more guidance on common materials and assemblies in Vancouver local practices. | |
| Select Carbon-Storing Materials | |
| **(Optional for reporting)**<br>**(Out of scope for compliance)**<br><br>If reported for the proposed design, the baseline shall also report biogenic carbon. The results shall be reported separately and shall not be included in demonstration of compliance. | **(Optional for reporting)**<br><br>**(Out of scope for compliance)**<br><br>See Section 4.4 (a) |
| Select Lower-Carbon Mechanical, Electrical, and Plumbing (MEP) Systems | |
| **(Optional)**<br><br>If included in the proposed design, the baseline shall assume typical MEP design that meets the operational carbon requirements in VBBL, as determined by the building mechanical engineer.<br><br>Refer to Table 2 for more guidance on calculating embodied carbon of services. | **(Optional)**<br><br>As per the proposed design |
| **4.Procure Low-Carbon Products** | |
| Use Zero-carbon Construction | |
| For transportation to site and construction site emissions, the baseline shall be as per the default scenarios in the software tool for modules A4 and A5.<br><br>The embodied carbon emissions from construction site (A5) tend to be under-reported in the software tools. If the project team intends to claim embodied carbon reduction from construction site, the user may replace the default values in the tool for the baseline with more comprehensive data that the project team may have from comparable recent projects. | See Sections 4.3 (c) (ii) and (iii) |
| Specify Lower-carbon Options | |
| The baseline shall use the industry-wide EPD available for a material or product, using the most recent version of the CLF Baselines Report (See Appendix A.1 (d) (i)). The most local EPD shall be selected, by order of priority: BC, Canada, and North America.<br><br>Refer to Section 4.3 (c) (i) for more guidance on choosing the industry-wide EPDs for common materials and products. | See Section 4.3 (c) (i) |

# 6 Documentation

The documents specified in Sections 6.1 and 6.2 shall be submitted at the time of Building Permit application. For multi-staged permits under the Certified Professional Program[23], the embodied carbon documents are required at Full Construction permit.

For rezoning application requirements, refer to the applicable policy and/or bulletin[24]. There is no requirements for Development Permit application.

Resubmission of these documents are not required at Occupancy Permit stage.

The documents and data collected will be utilized for compliance purposes. In addition, anonymized data might be shared with research entities and policy makers for informing future policy and regulatory enhancements.

## 6.1 Embodied Carbon Design Report (Required)

Compliance with embodied carbon requirements in the VBBL shall be demonstrated by submitting the Embodied Carbon Design Report[25].

The Design Report shall be submitted in in both Excel and PDF formats.

Where, as allowed by these guidelines, manual changes to the software tool have been made, or alternates to the default assumptions specified in these guidelines used, a summary and justification shall be submitted in the spaces provided in the Design Report.

Projects with multiple buildings shall follow the guidance provided in Section 2.4 (a) to decide whether the embodied carbon compliance of the buildings should be reported separately or together. If reported separately, one Design Report shall be submitted per building.

## 6.2 Other Submittal Requirements

In addition to the Design Report, projects shall provide the following, if they are applicable.

Unless otherwise instructed, these documents should be submitted as separate files.

### (a) Raw Data from the Software Tool (Required)

The export of raw data from the software tool used, containing both the embodied carbon emissions breakdown and the bill of materials (i.e. material quantities), shall be submitted.

Depending on the software tool used, this data may be provided in a single or two separate documents in Excel format. The users shall follow the guidance provided on preparing and submitting raw data outputs from each software tool[26].

[23] https://vancouver.ca/home-property-development/certified-professional-program.aspx
[24] https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx#bylaws-policies-guidelines
[25] The Embodied Carbon Design Report is available under the "Document" section in the following link: https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx#embodied-carbon
[26] See the following link for guidance on preparing and submitting raw data outputs from each software tool: https://tinyurl.com/COV-ECDR.

If modifications are made to the raw data outside the software tool, after they are exported as allowed in Section 4.3 (c), the user shall submit the raw data before the manual changes for this submission requirement.

The manual changes outside the tool should be clearly explained in the spaces provided in the Design Report (See Section 6.1). The user shall submit the modified versions of the raw outputs as described in Section 6.2 (b). Additional details may be provided in the supporting report (See Section 6.2 (c)).

### (b) Manual Calculations (Required)

Where manual calculations have been conducted outside the software tool due to the limitations in the tool, a document or documents containing these calculations shall be submitted. Any manual calculations shall be as permitted in Section 4.3 (c).

This submission shall be submitted in Excel format. This is in addition to the raw data submission noted in Section 6.2 (a). It may be a modified version of the raw data exported from the software tool, if changes are made directly on the raw data from the tool, or may also be a separate file containing the manual calculations.

### (c) Supporting Report (Optional)

It is optional to submit a supporting report along with the Design Report. This report may be auto-generated by the software tool or be a customized report created by the project team. This report shall be in PDF format.

The report may contain further information that could not be included in the Design Report, such as modelling assumptions, data sources, or approaches taken to reduce embodied carbon emissions, including any reused elements or design for disassembly strategies.

# Appendices

## Embodied Carbon Guidelines

# Appendix A: References

## A.1 Normative References

### (a) Quantifying Whole-building Embodied Carbon

(i) EN 15978:2011 Sustainability of Construction Works – Assessment of environmental performance of buildings – Calculation method[27], 2011

(ii) ISO 21931-1:2022 Sustainability in Buildings and Civil Engineering Works — Framework for Methods of Assessment of the Environmental, Social and Economic Performance of Construction Works as a Basis for Sustainability Assessment — Part 1: Buildings[28]

### (b) Life cycle Inventory (LCIA)

(i) Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI) v2.1[29], 2012

### (c) Environmental Product Declarations (EPDs)

(i) ISO 21930:2017 Sustainability in Buildings and Civil Engineering Works — Core Rules for Environmental Product Declarations of Construction Products and Services[30], 2017

(ii) EN 15804+A1 or EN 15804+A2 Sustainability of Construction Works — Environmental Product Declarations — Core Rules for the Product Category of Construction Products[31], 2014 and 2019

### (d) Industry-wide Embodied Carbon Intensities

(i) 2023 CLF North American Material Baselines Report[32], 2023 (referred to as CLF Baselines Report in this document)

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[27] https://www.en-standard.eu/bs-en-15978-2011-sustainability-of-construction-works-assessment-of-environmental-performance-of-buildings-calculation-method/

[28] https://www.iso.org/obp/ui/#iso:std:iso:21931:-1:ed-2:v1:en
The current version of the (i) (2022) references EN 15978:2011 as the main standard for wbLCA. The new version of ISO 21931-1 (2022) was not available at the time. The NRC Guidelines specifies that this new version of the ISO standard may be relevant but EN 15978 remains the main reference for NRC Guidelines. This is because ISO 21931 is a framework and does not provide the same level of detailed instruction as EN 15978.

[29] https://www.epa.gov/chemical-research/tool-reduction-and-assessment-chemicals-and-other-environmental-impacts-traci

[30] ISO 21930 is an international standard that provides principles, specifications and requirements for building product EPDs. ISO 21930 is the standard used in North America for building products.
https://www.iso.org/standard/61694.html#:~:text=ISO%2021930%3A2017%20provides%20the,any%20type%20of%20construction%20works.

[31] EN 15804 is a European standard that European building product EPDs had to comply with until July 2022.
https://www.en-standard.eu/une-en-15804-2012-a1-2014-sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products/
In 2019, a major addendum was added to EN 15804, which became mandatory in July 2022.
https://www.en-standard.eu/csn-en-15804-a2-sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products/

[32] At the time of publishing these guidelines, 2023 is the latest version of the CLF Baseline Report, which is available here:
https://carbonleadershipforum.org/clf-material-baselines-2023/

## A.2 Informative References

### (a) Common wbLCA and Embodied Carbon Assessment Software Tools

The following are the most common software tools used in North America for embodied carbon assessment of Part 3 buildings. These tools claim to be developed based on the applicable normative standards listed in Appendices A.1 (a) to A.1 (c). These tools are acceptable for compliance with VBBL.

If other tools are used, the user must check with the tool providers to ensure the tool and the databases used within the tool are developed in accordance with the standards specified in the Appendices A.1 (a) to A.1 (c).

If the user modifies the default embodied carbon results from the software tool used to incorporate EPDs that are not available in, the user shall ensure the EPD used comply with one of the standards specified in Appendix A.1 (c).

(i) Athena Impact Estimator[33]

(ii) tallyLCA[34] (formerly known as Tally)

(iii) tallyCAT[35]

(iv) Embodied Carbon in Construction calculator (EC3)[36]

(v) One Click LCA[37]

### (b) Whole-building Embodied Carbon Assessment

(i) NRC National Guidelines for Whole-Building Life Cycle Assessment[38], 2022 (referred to as NRC Guidelines in this document)

(ii) KPMB Lab WBLCA Classification System[39], 2022

(iii) BSR/ASHRAE/ICC Standard 240P, Evaluating Greenhouse Gas (GHG) and Carbon Emissions in Building Design, Construction and Operation, Advisory Public Review Draft[40], 2023 (referred to as ASHRAE/ICC 240p in this document)

### (c) Building Element Classification

(i) OmniClass[41], Table 21 - Elements[42], 2012

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[33] https://calculatelca.com/software/impact-estimator/
[34] https://www.buildingtransparency.org/tally/tally-lca/
[35] https://www.buildingtransparency.org/tally/tallycat/
[36] https://carbonleadershipforum.org/ec3-tool/
[37] https://www.oneclicklca.com/construction/life-cycle-assessment-software/
[38] https://nrc-publications.canada.ca/eng/view/object/?id=f7bd265d-cc3d-4848-a666-8eeb1fbde910
[39] http:\\kpmb.com/wp-content/uploads/2022/09/WBLCA-Classification-System.pdf
[40] This reference is a draft standard and is subject to change. However, the content provided valuable resource for these guidelines. An advisory public review was open for the draft standard in April-May 2023. See the following link for more information: https://www.ashrae.org/about/news/2023/ashrae-and-the-international-code-council-seeking-comments-on-greenhouse-gas-emissions-evaluation-standard
[41] https://www.csiresources.org/standards/omniclass
[42] OmniClass consists of 15 tables for classifying the entire built environment throughout the full project life cycle. Table 21 (Elements) provides a hierarchical taxonomy for classifying and identifying elements within a facility.

(d) **Building Services Embodied Carbon Assessment (Optional)**

(i) TM65 Embodied Carbon in Building Services: A Calculation Methodology[43], 2021

(ii) TM65LA Embodied carbon in building services: Using TM65 outside the UK[44], 2022

(e) **Design for Disassembly (Optional)**

(i) CSA Z782-06 Guideline for Design for Disassembly and Adaptability in Buildings[45], 2006

(ii) ISO 20887:2020 Sustainability in Buildings and Civil Engineering Works — Design for Disassembly and Adaptability — Principles, Requirements and Guidance[46], 2020

(f) **Determining the Baseline**

(i) ASCE/SEI Whole Building Life Cycle Assessment: Reference Building Structure and Strategies[47], 2018

(g) **Embodied Carbon Reduction**

(i) CLF Embodied Carbon Reduction Checklist[48]

(ii) CLF Embodied Carbon Toolkit for Architects[49]

(iii) MEP 2040 initiative[50]

(iv) Architecture 2030[51]

(v) Structural Engineering Institute, SE 2050 initiative[52]

[43] Developed by the UK Chartered Institution of Building Services Engineers (CIBSE), TM65 provides guidance on how to use EPDs to assess the embodied carbon of building services equipment, and where EPDs are not available, it provides guidance on how to estimate the embodied carbon.
https://www.cibse.org/knowledge-research/knowledge-portal/embodied-carbon-in-building-services-a-calculation-methodology-tm65

[44] https://www.cibse.org/knowledge-research/knowledge-portal/tm65la-using-the-tm65-methodology-outside-the-uk-pdf-2022

[45] https://www.csagroup.org/store/product/Z782-06/
This guideline by Canadian Standard Association provides a framework for reducing the negative environmental impact of building construction and waste through design for disassembly and adaptability

[46] https://www.iso.org/standard/69370.html

[47] https://ascelibrary.org/doi/book/10.1061/9780784415054

[48] https://carbonleadershipforum.org/ec-checklist-template

[49] https://carbonleadershipforum.org/clf-architect-toolkit

[50] https://www.mep2040.org/

[51] https://architecture2030.org/embodied-carbon-actions/

[52] https://se2050.org/

# Appendix B: Additional Information on the Specification of the Object of Assessment

## B.1 Life Cycle Stages

### (a) Life Cycle Stages and the System Boundary for Compliance

The following graph shows the life cycle stages and the system boundary for a wbLCA to comply with these guidelines.

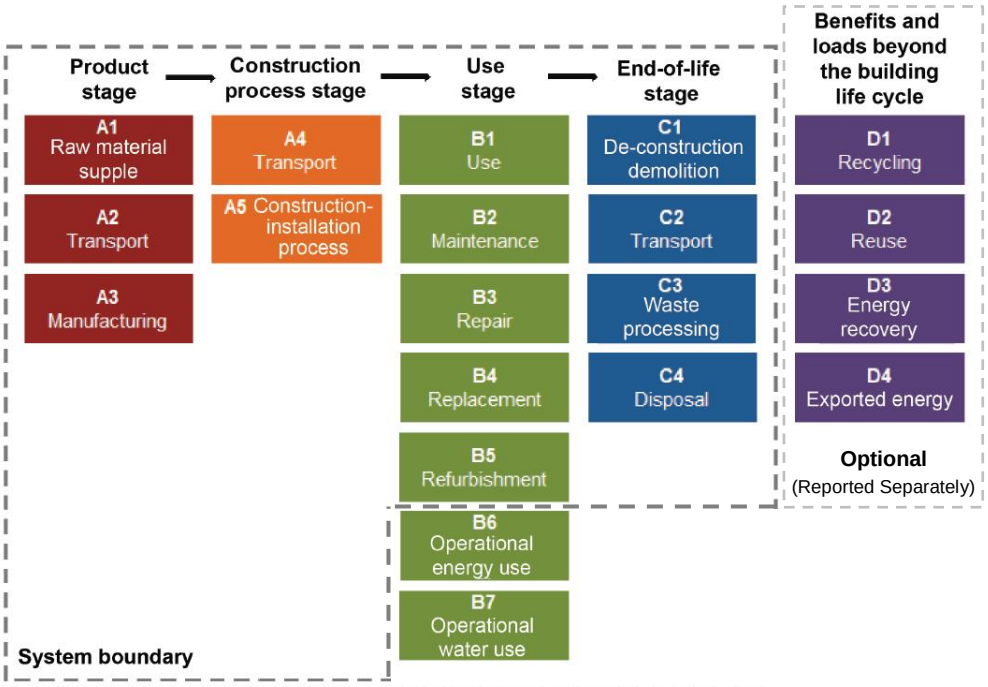


**Figure 2: Life Cycle Stages and the System Boundary**
(Source: Figure 4, NRC Guidelines (See Appendix A.2 (b) (i)), Modified)

### (b) Description of Life Cycle Stages

The following definitions for the life cycle stages are from ASHRAE/ICC 240p.

#### (i) Product Stage (Modules A1-A3)

- **Raw material supply (Module A1):**

  The raw material supply module includes all processes and materials associated with harvesting, extraction, collection, and further production of raw materials.

- **Raw material transport (ModuleA2):**

  The raw material transport module includes the transport of raw materials to a product manufacturing facility or to multiple manufacturing facilities.

- Manufacturing (Module A3):

The manufacturing module includes the processes and materials required for the fabrication and production of a product. These typically occur within a manufacturing facility.

(ii) Construction stage (Modules A4-A5)

- Transportation to the construction site (Module A4):

  The transportation to the construction site module includes the delivery of all materials and products included in the bill of materials to the construction site.

- Construction (Module A5):

  The construction module assessment includes processes and materials required for the assembly of the project on a site. These include construction waste generation and management as well as the electricity and natural gas consumption – for instance for using the equipment and tools, heating, and cooling.

(iii) Use stage (Modules B1 – B7)

- In-use emissions (Module B1):

  The in-use emissions module captures the non-energy related emissions that occur during the life of the building associated with normal conditions of use of the products and components installed in the project. This module also includes emissions from materials such as off-gassing or blowing agents in insulation, processes such as carbonation, and fugitive emissions of refrigerants.

- Maintenance (Module B2):

  The maintenance module includes all processes and materials used for planned maintenance required to sustain the functions of the building and building systems, including the production, transportation, and end-of-life treatment of materials used in the maintenance processes.

- Repair (Module B3):

  The repair module assessment includes all processes and materials required to sustain the functions of the building outside of regularly planned maintenance, including production and transport of materials and components, waste management and end-of-life treatment of materials and components removed from the building, and production, transport and disposal of ancillary materials used during the repair.

- Replacement (Module B4):

  The replacement module assessment includes all processes, materials, and components used in replacing components in their entirety at the end of their service life, including production and transportation of new materials and components, waste management and end-of-life treatment of materials and components removed from the building, and production, transport and disposal of ancillary materials used during the replacement.

- **Refurbishment (Module B5):**

  The refurbishment module assessment includes all processes, materials, and components used during refurbishment or retrofit processes within the larger project, including production and transportation of new materials and components, waste management and end-of-life treatment of materials and components removed from the building, and production, transport and disposal of ancillary materials used during the refurbishment activity.

- **Operational energy use (Module B6):**

  The operational energy use module includes energy use within the project during the service life of the building, including regulated, non-regulated, and other energy use associated with building user activities (e.g., plug loads and fuel-based process loads).

- **Operational water use (Module B7):**

  The operational water use module includes water use and its treatment during the service life of the building, including drinking water used by building-integrated systems and appliance use. Excludes water systems and equipment.

(iv) **Deconstruction and end-of-life (Modules C1-4)**

- **Deconstruction (Module C1):**

  The deconstruction module includes all on-site and off-site processes and inputs for the decommissioning, dismantling, deconstructing, and/or demolishing the project.

- **End-of-life transportation (Module C2):**

  The end-of-life transportation module includes all transportation between the site and the final sorting, disposal, or end-of-waste location, including transportation to and from intermediate storage or waste processing locations.

- **Processing for reuse, recovery, or recycling (Module C3):**

  The processing for reuse, recovery, or recycling module includes all processes and material flows required for recycling, reusing, or recovering construction products, materials, construction elements, and debris to reach their end-of-waste state as recovered material re-entering the market.

- **Disposal (Module C4):**

  The disposal module includes all processes and material flows required for waste disposal and treatment, including neutralization, incineration, landfilling, and management of the disposal site.

  - Disposal management shall include on-site transport and energy and water use related to waste processing at the disposal location.
  - For end-of-life processes with long-term emissions, such as landfilling, a period of 100 years shall be used to calculate relevant emissions.
  - Environmental loads from energy recovery process shall be included in the disposal stage assessment.

(v) **Benefits and loads beyond the system boundary (Modules D1-D2)**

- **Future substitution of resources (Module D1):**

  The future substitution of resources module includes all environmental loads and benefits from reused products, recycled materials, secondary fuels, and recovered energy leaving a project for use in a subsequent product system as material.

- **Exported energy (Module D2):**

  The exported energy module includes all environmental loads and benefits for recovered and exported energy used to meet the energy demand outside of the project.

## B.2 Building Elements, Required and Optional Scope for Compliance

Table 5 expands upon the element list provided in Table 9 in NRC Guidelines (see Appendix A.2 (b) (i)), Building Model Scope Definition. Table 9 of the NRC Guidelines offer a Level 3, UniFormat[53] Level 3 OmniClass element list (See Appendix A.2 (c)). To provide further clarity on the element scope for VBBL compliance, Table 5 includes Level 4 OmniClass element titles. The last column of Table 5 specifies whether each element is required, optional, or out of scope for VBBL compliance.

**Note:**

The required scope specified in Table 5 are subject to availability of data from the project and software tool. The user shall specify the required scope that are excluded from reporting with a brief explanation in the Design Report (See Section 6.1).

[53] https://www.csiresources.org/standards/uniformat

**Table 5: Mandatory and Optional Element Scope for Compliance with VBBL**
(Adapted from Table 9, NRC Guidelines (See Appendix A.2 (b) (i)))

Legend:

| Required | Optional | Exclude |
|---|---|---|

| UniFormat Level 3 | OmniClass Level 3 | | Level 4 | | Inclusion in Scope |
|---|---|---|---|---|---|
| A | 01 00 00 | Substructure | | | |
| A10 | 01 10 | Foundations | | | |
| A 1010 | 01 10 10 | Standard Foundations | 01 10 10 10 | Wall Foundations | Required |
| | | | 01 10 10 30 | Column Foundations | |
| | | | 01 10 10 90 | Standard Foundation Supplementary Components | Optional |
| A1020 | 01 10 20 | Special Foundations | 01 10 20 10 | Driven Piles | Required |
| | | | 01 10 20 15 | Bored Piles | |
| | | | 01 10 20 20 | Caissons | |
| | | | 01 10 20 30 | Special Foundation Walls | Optional |
| | | | 01 10 20 40 | Foundation Anchors | |
| | | | 01 10 20 50 | Underpinning | |
| | | | 01 10 20 60 | Raft Foundations | Required |
| | | | 01 10 20 70 | Pile Caps | |
| | | | 01 10 20 80 | Grade Beams | |
| A20 | 01 20 | Subgrade Enclosures | | | |
| A2010 | 01 20 10 | Walls for Subgrade Enclosures | 01 20 10 10 | Subgrade Enclosure Wall Construction | Required |
| | | | 01 20 10 20 | Subgrade Enclosure Wall Interior Skin *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 01 20 10 90 | Subgrade Enclosure Wall Supplementary Components | Optional |
| A40 | 01 40 | Slabs-on-Grade | | | |
| A4010 | 01 40 10 | Standard Slabs-on-Grade | - | - | Required |
| A4030 | 01 40 20 | Structural Slabs-on-Grade | - | - | Required |
| A4040 | 01 40 30 | Slab Trenches | - | - | Optional |
| A4040 | 01 4040 | Pits and Bases | - | - | Optional |
| A4090 | 01 40 90 | Slab-On-Grade Supplementary Components | 01 40 90 10 | Perimeter Insulation | Required |
| | | | 01 40 90 20 | Vapor Retarder | |
| | | | 01 40 90 30 | Waterproofing | |
| | | | 01 40 90 60 | Subbase Layer | |
| | | | 01 40 90 50 | Mud Slab | Optional |
| A60 | 01 60 | Water and Gas Mitigation | | | |
| A6010 | 01 60 10 | Building Sub-drainage | 01 60 10 10 | Foundation Drainage | Optional |
| | | | 01 60 10 20 | Under-slab Drainage | |
| A6020 | 01 60 20 | Off-Gassing Mitigation | 01 60 20 10 | Radon Mitigation | Exclude |
| | | | 01 60 20 50 | Methane Mitigation | |
| A90 | 01 90 | Substructure Related Activities | | | |
| A9010 | 01 90 10 | Substructure Excavation | 01 90 10 10 | Backfill and Compaction | Optional |
| A9020 | 01 90 20 | Construction Dewatering | - | - | Exclude |
| A9030 | 01 90 30 | Excavation Support | 01 90 30 10 | Anchor Tiebacks | Exclude |
| | | | 01 90 30 20 | Cofferdams | |
| | | | 01 90 30 40 | Cribbing and Walers | |
| | | | 01 90 30 60 | Ground Freezing | |
| | | | 01 90 30 70 | Slurry Walls | |
| A9040 | 01 9040 | Soil Treatment | - | - | Exclude |

| UniFormat Level 3 | OmniClass Level 3 | | Level 4 | | Inclusion in Scope |
|---|---|---|---|---|---|
| B | 02 00 00 | Shell | | | |
| B10 | 02 10 | Superstructure | | | |
| B1010 | 02 10 10 | Floor Construction | 02 10 10 10 | Floor Structural Frame *(Include above and below-grade floors, columns, beams, and shear walls[54])* | Required |
| | | | 02 10 10 20 | Floor Decks, Slabs, and Toppings *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 02 10 10 30 | Balcony Floor Construction | |
| | | | 02 10 10 40 | Mezzanine Floor Construction | |
| | | | 02 10 10 50 | Ramps | |
| | | | 02 10 10 90 | Floor Construction Supplementary Components | Optional |
| B1020 | 02 10 20 | Roof Construction | 02 10 20 10 | Roof Structural Frame | Required |
| | | | 02 10 20 20 | Roof Decks, Slabs, and Sheathing | |
| | | | 02 10 20 30 | Canopy Construction | |
| | | | 02 10 20 90 | Roof Construction Supplementary Components | Optional |
| B1080 | 02 10 80 | Stairs | 02 10 80 10 | Stair Construction *(Include above and below-grade stairs)* | Required |
| | | | 02 10 80 30 | Stair Soffits *(Include above and below-grade stairs)* | |
| | | | 02 10 80 50 | Stair Railings | Optional |
| | | | 02 10 80 60 | Fire Escapes | |
| | | | 02 10 80 70 | Metal Walkways | |
| | | | 02 10 80 80 | Ladders | |
| B20 | 02 20 | Exterior Vertical Enclosures | | | |
| B2010 | 02 20 10 | Exterior Walls | 02 20 10 10 | Exterior Wall Veneer | Required |
| | | | 02 20 10 20 | Exterior Wall Construction *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 02 20 10 30 | Exterior Wall Interior Skin *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 02 20 10 40 | Fabricated Exterior Wall Assemblies *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 02 20 10 50 | Parapets | |
| | | | 02 20 10 60 | Equipment Screens | Optional |
| | | | 02 20 10 80 | Exterior Wall Supplementary Components | |
| | | | 02 20 10 90 | Exterior Wall Opening Supplementary Components | |

[54] The structural elements on the below-grade interior are included in the Shell, Superstructure, classification, because the Substructure in the OmniClass only covers foundations, exterior walls, and slab-on-grade.

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| B2020 | 02 20 20 | Exterior Windows | 02 20 20 10 | Exterior Operating Windows | Required |
| | | | 02 20 20 20 | Exterior Fixed Windows | |
| | | | 02 20 20 30 | Exterior Window Wall | |
| | | | 02 20 20 40 | Exterior Special Function Windows | |
| B2050 | 02 20 50 | Exterior Doors and Grilles | 02 20 50 10 | Exterior Entrance Doors | Required |
| | | | 02 20 50 20 | Exterior Utility Doors | |
| | | | 02 20 50 30 | Exterior Oversize Doors | Optional |
| | | | 02 20 50 40 | Exterior Special Function Doors | Optional |
| | | | 02 20 50 60 | Exterior Grilles | |
| | | | 02 20 50 70 | Exterior Gates | |
| B2070 | 02 20 70 | Exterior Louvers and Vents | 02 20 70 10 | Exterior Lovers | Optional |
| | | | 02 20 70 50 | Exterior Vents | |
| B2080 | 02 20 80 | Exterior Wall Appurtenances | 02 20 80 10 | Exterior Fixed Grilles and Screens | Optional |
| | | | 02 20 80 30 | Exterior Opening Protection Devices | |
| | | | 02 20 80 50 | Exterior Balcony Walls and Railings | |
| | | | 02 20 80 70 | Exterior Fabrications | |
| | | | 02 20 80 80 | Bird Control Devices | |
| B2090 | 02 20 90 | Exterior Wall Specialties | - | - | Optional |
| B30 | 02 30 | Exterior Horizontal Enclosures | | | |
| B3010 | 02 30 10 | Roofing | 02 30 10 10 | Steep Slope Roofing *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | Required |
| | | | 02 30 10 50 | Low-Slope Roofing *(Include thermal, moisture, acoustic, and fire protection layers, if any)* | |
| | | | 02 30 10 70 | Canopy Roofing | |
| | | | 02 30 10 90 | Roofing Supplementary Components | Optional |
| B3020 | 02 30 20 | Roof Appurtenances | 02 30 20 10 | Roof Accessories | Optional |
| | | | 02 30 20 30 | Roof Specialties | |
| | | | 02 30 20 70 | Rainwater Management | |
| B3040 | 02 3040 | Traffic Bearing Horizontal Enclosures | 02 30 40 10 | Traffic Bearing Coatings | Optional |
| | | | 02 30 40 30 | Horizontal Waterproofing Membrane | |
| | | | 02 30 40 50 | Wear Surfaces | |
| | | | 02 30 40 90 | Horizontal Enclosure Supplementary Components | |
| B3060 | 02 30 60 | Horizontal Openings | 02 30 60 10 | Roof Windows and Skylights | Required |
| | | | 02 30 60 50 | Vents and Hatches | Optional |
| | | | 02 30 60 90 | Horizontal Opening Supplementary Components | |
| B3080 | 02 30 80 | Overhead Exterior Enclosures | 02 30 80 10 | Exterior Ceilings | Optional |
| | | | 02 30 80 20 | Exterior Soffits | |
| | | | 02 30 80 30 | Exterior Bulkheads | |
| C | 03 00 00 | Interiors | | | |
| C10 | 03 10 | Interior Construction | | | |
| C1010 | 03 10 10 | Interior Partitions | 03 10 10 10 | Interior Fixed Partitions | Optional |
| | | | 03 10 10 20 | Interior Glazed Partitions | |
| | | | 03 10 10 40 | Interior Demountable Partitions | |
| | | | 03 10 10 50 | Interior Operable Partitions | |
| | | | 03 10 10 70 | Interior Screens | |
| | | | 03 10 10 90 | Interior Partition Supplementary Components | |
| C1020 | 03 10 20 | Interior Windows | 03 10 20 10 | Interior Operating Windows | Optional |
| | | | 03 10 20 20 | Interior Fixed Windows | |

| UniFormat Level 3 | OmniClass Level 3 | | Level 4 | | Inclusion in Scope |
|---|---|---|---|---|---|
| | | | 03 10 20 50 | Interior Special Function Windows | |
| | | | 03 10 20 90 | Interior Window Supplementary Components | |
| C1030 | 03 10 30 | Interior Doors | 03 10 30 10 | Interior Swinging Doors | Optional |
| | | | 03 10 30 20 | Interior Entrance Doors | |
| | | | 03 10 30 25 | Interior Sliding Doors | |
| | | | 03 10 30 30 | Interior Folding Doors | |
| | | | 03 10 30 40 | Interior Coiling Doors | |
| | | | 03 10 30 50 | Interior Panel Doors | |
| | | | 03 10 30 70 | Interior Special Function Doors | |
| | | | 03 10 30 80 | Interior Access Doors and Panels | |
| | | | 03 10 30 90 | Interior Door Supplementary Components | |
| C1040 | 03 10 40 | Interior Grilles and Gates | 03 10 40 10 | Interior Grilles | Optional |
| | | | 03 10 40 50 | Interior Gates | |
| C1060 | 03 10 60 | Raised Floor Construction | 03 10 60 10 | Access Flooring | Optional |
| | | | 03 10 60 10 | Platform/Stage Floors | |
| C1070 | 03 10 70 | Suspended Ceiling Construction | 03 10 70 10 | Acoustical Suspended Ceilings | Optional |
| | | | 03 10 70 20 | Suspended Plaster and Gypsum Board Ceilings | |
| | | | 03 10 70 50 | Specialty Suspended Ceilings | |
| | | | 03 10 70 70 | Special Function Suspended Ceilings | |
| | | | 03 10 70 90 | Ceiling Suspension Components | |
| C1090 | 03 10 90 | Interior Specialties | 03 10 90 10 | Interior Railings and Handrails | Optional |
| | | | 03 10 90 15 | Interior Lovers | |
| | | | 03 10 90 20 | Information Specialties | Exclude |
| | | | 03 10 90 25 | Compartments and Cubicles | |
| | | | 03 10 90 30 | Service Walls | |
| | | | 03 10 90 35 | Wall and Door Protection | |
| | | | 03 10 90 40 | Toilet, Bath, and Laundry Accessories | |
| | | | 03 10 90 45 | Interior Gas Lighting | |
| | | | 03 10 90 50 | Fireplaces and Stoves | |
| | | | 03 10 90 60 | Safety Specialties | |
| | | | 03 10 90 70 | Storage Specialties | |
| | | | 03 10 90 90 | Other Interior Specialties | |
| C10 | 03 20 | Interior Finishes | | | |
| C2010 | 03 20 10 | Wall Finishes | 03 20 10 10 | Tile Wall Finish | Optional |
| | | | 03 20 10 20 | Wall Paneling | |
| | | | 03 20 10 30 | Wall Coverings | |
| | | | 03 20 10 35 | Wall Carpeting | |
| | | | 03 20 10 50 | Stone Facing | |
| | | | 03 20 10 60 | Special Wall Surfacing | |
| | | | 03 20 10 70 | Wall Painting and Coating | |
| | | | 03 20 10 80 | Acoustical Wall Treatment | |
| | | | 03 20 10 90 | Wall Finish Supplementary Components | |
| C2020 | 03 20 20 | Interior Fabrications | - | - | Optional |
| C2030 | 03 20 30 | Flooring | 03 20 30 10 | Flooring Treatment | Optional |
| | | | 03 20 30 20 | Tile Flooring | |
| | | | 03 20 30 30 | Specialty Flooring | |
| | | | 03 20 30 40 | Masonry Flooring | |
| | | | 03 20 30 50 | Wood Flooring | |
| | | | 03 20 30 60 | Resilient Flooring | |
| | | | 03 20 30 70 | Terrazzo Flooring | |
| | | | 03 20 30 75 | Fluid-Applied Flooring | |
| | | | 03 20 30 80 | Carpeting, Athletic Flooring | |

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| | | | 03 20 30 85 | Entrance Flooring | |
| | | | 03 20 30 90 | Flooring Supplementary Components | |
| C2040 | 03 20 40 | Stair Finishes | 03 20 40 20 | Tile Stair Finish | Optional |
| | | | 03 20 40 40 | Masonry Stair Finish | |
| | | | 03 20 40 45 | Wood Stair Finish | |
| | | | 03 20 40 50 | Resilient Stair Finish | |
| | | | 03 20 40 60 | Terrazzo Stair Finish | |
| | | | 03 20 40 75 | Carpeted Stair Finish | |
| C2050 | 03 20 50 | Ceiling Finishes | 03 20 50 10 | Plaster and Gypsum Board Finish | Optional |
| | | | 03 20 50 20 | Ceiling Paneling | |
| | | | 03 20 50 70 | Ceiling Painting and Coating | |
| | | | 03 20 50 80 | Acoustical Ceiling Treatment | |
| | | | 03 20 50 90 | Ceiling Finish Supplementary Components | |
| D | 04 00 00 | Services | | | |
| D10 | 04 10 | Conveying | | | |
| D1010 | 04 10 10 | Vertical Conveying Systems | 04 10 10 10 | Elevators | Optional |
| | | | 04 10 10 20 | Lifts | |
| | | | 04 10 10 30 | Escalators | |
| | | | 04 10 10 50 | Dumbwaiters | |
| | | | 04 10 10 60 | Moving Ramps | |
| D1030 | 04 10 30 | Horizontal Conveying | 04 10 30 10 | Moving Walks | Optional |
| | | | 04 10 30 30 | Turntables | |
| | | | 04 10 30 50 | Passenger Loading Bridges | |
| | | | 04 10 30 70 | People Movers | Exclude |
| D1050 | 04 10 50 | Material Handling | 04 10 50 10 | Cranes | Exclude |
| | | | 04 10 50 20 | Hoists | |
| | | | 04 10 50 30 | Derricks | |
| | | | 04 10 50 40 | Conveyors | |
| | | | 04 10 50 50 | Baggage Handling Equipment | |
| | | | 04 10 50 60 | Chutes | |
| | | | 04 10 50 70 | Pneumatic Tube Systems | |
| D1080 | 04 10 80 | Operable Access Systems | 04 10 80 10 | Suspended Scaffolding | Exclude |
| | | | 04 10 80 20 | Rope Climbers | |
| | | | 04 10 80 30 | Elevating Platforms | |
| | | | 04 10 80 40 | Powered Scaffolding | |
| | | | 04 10 80 50 | Building Envelope Access | |
| D20 | 04 20 | Plumbing | | | |
| D2010 | 04 20 10 | Domestic Water Distribution | 04 20 10 10 | Facility Potable-Water Storage Tanks | Optional |
| | | | 04 20 10 20 | Domestic Water Equipment | |
| | | | 04 20 10 40 | Domestic Water Piping | |
| | | | 04 20 10 60 | Plumbing Fixtures | |
| | | | 04 20 10 90 | Domestic Water Distribution Supplementary Components | |
| D2020 | 04 20 20 | Sanitary Drainage | 04 20 20 10 | Sanitary Sewerage Equipment | Optional |
| | | | 04 20 20 30 | Sanitary Sewerage Piping | |
| | | | 04 20 20 90 | Sanitary Drainage Supplementary Components | |
| D2030 | 04 20 30 | Building Support Plumbing Systems | 04 20 30 10 | Stormwater Drainage Equipment | Optional |
| | | | 04 20 30 20 | Stormwater Drainage Piping | |
| | | | 04 20 30 30 | Facility Stormwater Drains | |
| | | | 04 20 30 60 | Gray Water Systems | |
| | | | 04 20 30 90 | Building Support Plumbing System Supplementary Components | |

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| D2050 | 04 20 50 | General Service Compressed-Air | - | - | Optional |
| D2060 | 04 20 60 | Process Support Plumbing Systems | 04 20 60 10 | Compressed-Air Systems | Optional |
| | | | 04 20 60 20 | Vacuum Systems | |
| | | | 04 20 60 30 | Gas Systems | |
| | | | 04 20 60 40 | Chemical-Waste Systems | |
| | | | 04 20 60 50 | Processed Water Systems | |
| | | | 04 20 60 90 | Process Support Plumbing System Supplementary Components | |
| D30 | 04 30 | Heating, Ventilation, and Air Conditioning (HVAC) | | | |
| D3010 | 04 30 10 | Facility Fuel Systems | 04 30 10 10 | Fuel Piping | Optional |
| | | | 04 30 10 30 | Fuel Pumps | |
| | | | 04 30 10 50 | Fuel Storage Tanks | |
| D3020 | 04 30 20 | Heating Systems | 04 30 20 10 | Heat Generation | Optional |
| | | | 04 30 20 30 | Thermal Heat Storage | |
| | | | 04 30 20 70 | Decentralized Heating Equipment | |
| | | | 04 30 20 90 | Heating System Supplementary Components | |
| D3030 | 04 30 30 | Cooling Systems | 04 30 30 10 | Central Cooling | Optional |
| | | | 04 30 30 30 | Evaporative Air-Cooling | |
| | | | 04 30 30 50 | Thermal Cooling Storage | |
| | | | 04 30 30 70 | Decentralized Cooling | |
| | | | 04 30 30 90 | Cooling System Supplementary Components | |
| D3050 | 04 30 50 | Facility HVAC Distribution Systems | 04 30 50 10 | Facility Hydronic Distribution | Optional |
| | | | 04 30 50 30 | Facility Steam Distribution | |
| | | | 04 30 50 50 | HVAC Air Distribution | |
| | | | 04 30 50 90 | Facility Distribution Systems Supplementary Components | |
| D3060 | 04 30 60 | Ventilation | 04 30 60 10 | Supply Air | Optional |
| | | | 04 30 60 20 | Return Air | |
| | | | 04 30 60 30 | Exhaust Air | |
| | | | 04 30 60 40 | Outside Air | |
| | | | 04 30 60 60 | Air-to-Air Energy Recovery | |
| | | | 04 30 60 70 | HVAC Air Cleaning | |
| | | | 04 30 60 90 | Ventilation Supplementary Components | |
| D3070 | 04 30 70 | Special Purpose HVAC Systems | 04 30 70 10 | Snow Melting | Optional |
| D40 | 04 40 | Fire Protection | | | |
| D4010 | 04 40 10 | Fire Suppression | 04 40 10 10 | Water-Based Fire-Suppression | Optional |
| | | | 04 40 10 50 | Fire-Extinguishing | |
| | | | 04 40 10 90 | Fire Suppression Supplementary Components | |
| D4030 | 04 40 30 | Fire Protection Specialties | 04 40 30 10 | Fire Protection Cabinets | Optional |
| | | | 04 40 30 30 | Fire Extinguishers | |
| | | | 04 40 30 50 | Breathing Air Replenishment Systems | |
| | | | 04 40 30 70 | Fire Extinguisher Accessories | |
| D50 | 04 50 | Electrical | | | |
| D5010 | 04 50 10 | Facility Power Generation | 04 50 10 10 | Packaged Generator Assemblies | Optional |
| | | | 04 50 10 20 | Battery Equipment | |
| | | | 04 50 10 30 | Photovoltaic Collectors | |
| | | | 04 50 10 40 | Fuel Cells | |
| | | | 04 50 10 60 | Power Filtering and Conditioning | |
| | | | 04 50 10 70 | Transfer Switches | |

| UniFormat Level 3 | OmniClass Level 3 | | Level 4 | | Inclusion in Scope |
|---|---|---|---|---|---|
| | | | 04 50 10 90 | Facility Power Generation Supplementary Components | |
| D5020 | 04 50 20 | Electrical Service and Distribution | 04 50 20 10 | Electrical Service | Optional |
| | | | 04 50 20 30 | Power Distribution | |
| | | | 04 50 20 70 | Facility Grounding | |
| | | | 04 50 20 90 | Electrical Service and Distribution Supplementary Components | |
| D5030 | 04 50 30 | General Purpose Electrical Power | 04 50 30 10 | Branch Wiring System | Optional |
| | | | 04 50 30 50 | Wiring Devices | |
| | | | 04 50 30 90 | General Purpose Electrical Power Supplementary Components | |
| D5040 | 04 50 40 | Lighting | 04 50 40 10 | Lighting Control | Optional |
| | | | 04 50 40 20 | Branch Wiring for Lighting | |
| | | | 04 50 40 50 | Lighting Fixtures | |
| | | | 04 50 40 90 | Lighting Supplementary Components | |
| D5080 | 04 50 80 | Miscellaneous Electrical Systems | 04 50 80 10 | Lightning Protection | Optional |
| | | | 04 50 80 10 | Cathodic Protection | |
| | | | 04 50 80 10 | Transient Voltage Suppression | |
| | | | 04 50 80 10 | Miscellaneous Electrical Systems Supplementary Components | |
| D60 | 04 60 | Communications | | | |
| D6010 | 04 60 10 | Data Communications | 04 60 10 10 | Data Communications Network Equipment | Optional |
| | | | 04 60 10 20 | Data Communications Hardware | |
| | | | 04 60 10 30 | Data Communications Peripheral Data Equipment | |
| | | | 04 60 10 50 | Data Communications Software | Exclude |
| | | | 04 60 10 60 | Data Communication Program and Integration Services | |
| D6020 | 04 60 20 | Voice Communications | 04 60 20 10 | Voice Communications Switching and Routing Equipment | Optional |
| | | | 04 60 20 20 | Voice Communications Terminal Equipment | |
| | | | 04 60 20 30 | Voice Communications Messaging | Exclude |
| | | | 04 60 20 40 | Call Accounting | |
| | | | 04 60 20 50 | Call Management | |
| D6030 | 04 60 30 | Audio-Video Communication | 04 60 310 10 | Audio-Video Systems | Optional |
| | | | 04 60 30 50 | Electronic Digital Systems | |
| D6060 | 04 60 60 | Distributed Communications and Monitoring | 04 60 60 10 | Distributed Audio-Video Communications Systems | Exclude |
| | | | 04 60 60 30 | Healthcare Communications and Monitoring | |
| | | | 04 60 60 50 | Distributed Systems | |
| D6090 | 04 60 90 | Communications Supplementary Components | 04 60 90 10 | Supplementary Components | Exclude |
| D70 | 04 70 | Electronic Safety and Security | | | |
| D7010 | 04 70 10 | Access Control and Intrusion Detection | 04 70 10 10 | Access Control | Exclude |
| | | | 04 70 10 50 | Intrusion Detection | |
| D7030 | 04 70 30 | Electronic Surveillance | 04 70 30 10 | Video Surveillance | Exclude |
| | | | 04 70 30 50 | Electronic Personal Protection | |
| D7050 | 04 70 50 | Detection and Alarm | 04 70 50 10 | Fire Detection and Alarm | Exclude |
| | | | 04 70 50 20 | Radiation Detection and Alarm | |

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| | | | 04 70 50 30 | Fuel-Gas Detection and Alarm | |
| | | | 04 70 50 40 | Fuel-Oil Detection and Alarm | |
| | | | 04 70 50 50 | Refrigeration Detection and Alarm | |
| | | | 04 70 50 60 | Water Intrusion Detection and Alarm | |
| D7070 | 04 70 70 | Electronic Monitoring and Control | 04 70 70 10 | Electronic Detention Monitoring and Control | Exclude |
| D7090 | 04 70 90 | Electronic Safety and Security Supplementary Components | 04 70 90 10 | Supplementary Components | Exclude |
| D80 | 04 80 | Integrated Automation | | | |
| D8010 | 04 80 10 | Integrated Automation Facility Controls | 04 80 10 10 | Integrated Automation Control of Equipment | Exclude |
| | | | 04 80 10 20 | Integrated Automation Control of Conveying Equipment | |
| | | | 04 80 10 30 | Integrated Automation Control of Fire-Suppression Systems | |
| | | | 04 80 10 40 | Integrated Automation Control of Plumbing Systems | |
| | | | 04 80 10 50 | Integrated Automation Control of HVAC Systems | |
| | | | 04 80 10 60 | Integrated Automation Control of Electrical Systems | |
| | | | 04 80 10 70 | Integrated Automation Control of Communication Systems | |
| | | | 04 80 10 80 | Integrated Automation Control of Electronic Safety and Security Systems | |
| E | 05 00 00 | Equipment and Furnishings | | | |
| E10 | 05 10 | Equipment | | | |
| E1010 | 05 10 10 | Vehicle and Pedestrian Equipment | 05 10 10 10 | Vehicle Servicing Equipment | Exclude |
| | | | 05 10 10 30 | Interior Parking Control Equipment | |
| | | | 05 10 10 50 | Loading Dock Equipment | |
| | | | 05 10 10 70 | Interior Pedestrian Control Equipment | |
| E1030 | 05 10 30 | Commercial Equipment | 05 10 30 10 | Mercantile and Service Equipment | Exclude |
| | | | 05 10 30 20 | Vault Equipment | |
| | | | 05 10 30 25 | Teller and Service Equipment | |
| | | | 05 10 30 30 | Refrigerated Display Equipment | |
| | | | 05 10 30 35 | Commercial Laundry and Dry Cleaning Equipment | |
| | | | 05 10 30 40 | Maintenance Equipment | |
| | | | 05 10 30 50 | Hospitality Equipment | |
| | | | 05 10 30 55 | Unit Kitchens | |
| | | | 05 10 30 60 | Photographic Processing Equipment | |
| | | | 05 10 30 70 | Postal, Packaging, and Shipping Equipment | |
| | | | 05 10 30 75 | Office Equipment | |
| | | | 05 10 30 80 | Foodservice Equipment | |
| E1040 | 05 10 40 | Institutional Equipment | 05 10 40 10 | Educational and Scientific Equipment | Exclude |
| | | | 05 10 40 20 | Healthcare Equipment | |
| | | | 05 10 40 40 | Religious Equipment | |
| | | | 05 10 40 60 | Security Equipment | |
| | | | 05 10 40 70 | Detention Equipment | |
| E1060 | 05 10 60 | Residential Equipment | 05 10 60 10 | Residential Appliances | Exclude |

| UniFormat Level 3 | OmniClass Level 3 | | Level 4 | | Inclusion in Scope |
|---|---|---|---|---|---|
| | | | 05 10 60 50 | Retractable Stairs | |
| | | | 05 10 60 70 | Residential Ceiling Fans | |
| E1070 | 05 10 70 | Entertainment and Recreational Equipment | 05 10 70 10 | Theater and Stage Equipment | Exclude |
| | | | 05 10 70 20 | Musical Equipment | |
| | | | 05 10 70 50 | Athletic Equipment | |
| | | | 05 10 70 60 | Recreational Equipment | |
| E1090 | 05 10 90 | Other Equipment | 05 10 90 10 | Solid Waste Handling Equipment | Exclude |
| | | | 05 10 90 30 | Agricultural Equipment | |
| | | | 05 10 90 40 | Horticultural Equipment | |
| | | | 05 10 90 60 | Decontamination Equipment | |
| E20 | 05 20 | Furnishings | | | |
| E2010 | 05 20 10 | Fixed Furnishings | 05 20 10 10 | Fixed Art | Exclude |
| | | | 05 20 10 20 | Window Treatments | Optional |
| | | | 05 20 10 30 | Casework | |
| | | | 05 20 10 70 | Fixed Multiple Seating | |
| | | | 05 20 10 90 | Other Fixed Furnishings | |
| E2050 | 05 20 50 | Movable Furnishings | 05 20 50 10 | Movable Art | Exclude |
| | | | 05 20 50 30 | Furniture | Optional |
| | | | 05 20 50 40 | Accessories | |
| | | | 05 20 50 60 | Movable Multiple Seating | |
| | | | 05 20 50 90 | Other Movable Furnishings | |
| F | 06 00 00 | Special Construction and Demolition | | | |
| F10 | 06 10 | Special Construction | | | |
| F1010 | 06 10 10 | Integrated Construction | 06 10 10 10 | Building Modules | Optional |
| | | | 06 10 10 50 | Manufactured/Fabricated Rooms | |
| | | | 06 10 10 70 | Modular Mezzanines | |
| F1020 | 06 10 20 | Special Structures | 06 10 20 10 | Fabric Structures | Optional |
| | | | 06 10 20 20 | Space Frames | |
| | | | 06 10 20 30 | Geodesic Structures | |
| | | | 06 10 20 40 | Manufacturer-Engineered Structures | |
| | | | 06 10 20 60 | Manufactured Canopies | |
| | | | 06 10 20 65 | Rammed Earth Construction | |
| | | | 06 10 20 70 | Towers | |
| F1030 | 06 10 30 | Special Function Construction | 06 10 30 10 | Sound and Vibration Control | Optional |
| | | | 06 10 30 30 | Seismic Control | |
| | | | 06 10 30 50 | Radiation Protection | |
| F1050 | 06 10 50 | Special Facility Components | 06 10 50 10 | Pools | Optional |
| | | | 06 10 50 20 | Interior Fountains | |
| | | | 06 10 50 30 | Interior Water Features | |
| | | | 06 10 50 40 | Aquariums | |
| | | | 06 10 50 50 | Amusement Park Structures and Equipment | |
| | | | 06 10 50 60 | Ice Rinks | |
| | | | 06 10 50 70 | Animal Containment | |
| F1060 | 06 10 60 | Athletic and Recreational Special Construction | 06 10 60 10 | Indoor Soccer Boards | Optional |
| | | | 06 10 60 20 | Safety Netting | |
| | | | 06 10 60 30 | Arena Football Boards | |
| | | | 06 10 60 40 | Floor Sockets | |
| | | | 06 10 60 50 | Athletic and Recreational Court Walls | |
| | | | 06 10 60 60 | Demountable Athletic Surfaces | |
| F1080 | 06 10 80 | Special Instrumentation | 06 10 80 10 | Stress Instrumentation | Exclude |
| | | | 06 10 80 20 | Seismic Instrumentation | |
| | | | 06 10 80 40 | Meteorological Instrumentation | |
| | | | 06 10 80 60 | Earth Movement Monitoring | |

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| F20 | 06 20 | Facility Remediation | | | |
| F2010 | 06 20 10 | Hazardous Materials Remediation | 06 20 10 10 | Transportation and Disposal of Hazardous Materials | Exclude |
| | | | 06 20 10 20 | Asbestos Remediation | |
| | | | 06 20 10 30 | Lead Remediation | |
| | | | 06 20 10 40 | Polychlorinate Biphenyl Remediation | |
| | | | 06 20 10 50 | Mold Remediation | |
| F30 | 06 30 | Demolition | | | |
| F3010 | 06 30 10 | Structure Demolition | 06 30 10 10 | Building Demolition | Exclude |
| | | | 06 30 10 30 | Tower Demolition | |
| | | | 06 30 10 50 | Bridge Demolition | |
| | | | 06 30 10 70 | Dam Demolition | |
| F3030 | 06 30 30 | Selective Demolition | 06 30 30 10 | Selective Building Demolition | Exclude |
| | | | 06 30 30 30 | Selective Interior Demolition | |
| | | | 06 30 30 50 | Selective Bridge Demolition | |
| | | | 06 30 30 70 | Selective Historic Demolition | |
| F3050 | 06 30 50 | Structure Moving | 06 30 50 10 | Structure Relocation | Exclude |
| | | | 06 30 50 30 | Structure Raising | |
| G | 07 00 00 | Sitework | | | |
| G10 | 07 10 | Site Preparation | | | |
| G1010 | 07 10 10 | Site Clearing | 07 10 10 10 | Clearing and Grubbing | Exclude |
| | | | 07 10 10 30 | Tree and Shrub Removal and Trimming | |
| | | | 07 10 10 50 | Earth Stripping and Stockpiling | |
| G1020 | 07 10 20 | Site Elements Demolition | 07 10 20 10 | Utility Demolition | Exclude |
| | | | 07 10 20 30 | Infrastructure Demolition | |
| | | | 07 10 20 50 | Selective Site Demolition | |
| G1030 | 07 10 30 | Site Element Relocations | 07 10 30 10 | Utility Relocation | Exclude |
| G1050 | 07 10 50 | Site Remediation | 07 10 50 10 | Physical Decontamination | Exclude |
| | | | 07 10 50 15 | Chemical Decontamination | |
| | | | 07 10 50 20 | Thermal Decontamination | |
| | | | 07 10 50 25 | Biological Decontamination | |
| | | | 07 10 50 30 | Remediation Soil Stabilization | |
| | | | 07 10 50 40 | Site Containment | |
| | | | 07 10 50 45 | Sinkhole Remediation | |
| | | | 07 10 50 50 | Hazardous Waste Drum Handling | |
| | | | 07 10 50 60 | Contaminated Site Material Removal | |
| | | | 07 10 50 80 | Water Remediation | |
| G1070 | 07 10 70 | Site Earthwork | 07 10 70 10 | Grading | Optional |
| | | | 07 10 70 20 | Excavation and Fill | |
| | | | 07 10 70 30 | Soil Reinforcement | |
| | | | 07 10 70 35 | Slope Protection | |
| | | | 07 10 70 40 | Gabions | |
| | | | 07 10 70 45 | Riprap | |
| | | | 07 10 70 50 | Embankments | |
| | | | 07 10 70 55 | Erosion and Sedimentation Controls | |
| | | | 07 10 70 60 | Soil Stabilization | |
| | | | 07 10 70 65 | Rock Stabilization | |
| | | | 07 10 70 70 | Wetlands | |
| | | | 07 10 70 80 | Earth Dams | |
| | | | 07 10 70 90 | Site Soil Treatment | |
| G20 | 07 20 | Site Improvements | | | |
| G2010 | 07 20 10 | Roadways | 07 20 10 10 | Roadway Pavement | Optional |
| | | | 07 20 10 20 | Roadway Curbs and Gutters | |
| | | | 07 20 10 40 | Roadway Appurtenances | |
| | | | 07 20 10 70 | Roadway Lighting | |

| UniFormat | OmniClass | | | | Inclusion |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | in Scope |
| | | | 07 20 10 80 | Vehicle Fare Collection | |
| G2020 | 07 20 20 | Parking Lots | 07 20 20 10 | Parking Lot Pavement | Optional |
| | | | 07 20 20 20 | Parking Lot Curbs and Gutters | |
| | | | 07 20 20 40 | Parking Lot Appurtenances | |
| | | | 07 20 20 70 | Parking Lot Lighting | |
| | | | 07 20 20 80 | Exterior Parking Control Equipment | |
| G2030 | 07 20 30 | Pedestrian Plazas and Walkways | 07 20 30 10 | Pedestrian Pavement | Optional |
| | | | 07 20 30 20 | Pedestrian Pavement Curbs and Gutters | |
| | | | 07 20 30 30 | Exterior Steps and Ramps | |
| | | | 07 20 30 40 | Pedestrian Pavement Appurtenances | |
| | | | 07 20 30 70 | Plaza and Walkway Lighting | |
| | | | 07 20 30 80 | Exterior Pedestrian Control Equipment | |
| G2040 | 07 20 40 | Airfields | 07 20 40 10 | Aviation Pavement | Optional |
| | | | 07 20 40 20 | Aviation Pavement Curbs and Gutters | |
| | | | 07 20 40 40 | Aviation Pavement Appurtenances | |
| | | | 07 20 40 70 | Airfield Lighting | |
| | | | 07 20 40 80 | Airfield Signaling and Control Equipment | |
| G2050 | 07 20 50 | Athletic, Recreational, and Playfield Areas | 07 20 50 10 | Athletic Areas | Optional |
| | | | 07 20 50 30 | Recreational Areas | |
| | | | 07 20 50 50 | Playfield Areas | |
| G2060 | 07 20 60 | Site Development | 07 20 60 10 | Exterior Fountains | Optional |
| | | | 07 20 60 20 | Fences and Gates | |
| | | | 07 20 60 25 | Site Furnishings | |
| | | | 07 20 60 30 | Exterior Signage | |
| | | | 07 20 60 35 | Flagpoles | |
| | | | 07 20 60 40 | Covers and Shelters | |
| | | | 07 20 60 45 | Exterior Gas Lighting | |
| | | | 07 20 60 50 | Site Equipment | |
| | | | 07 20 60 60 | Retaining Walls | |
| | | | 07 20 60 70 | Site Bridges | |
| | | | 07 20 60 80 | Site Screening Devices | |
| | | | 07 20 60 85 | Site Specialties | |
| G2080 | 07 20 80 | Landscaping | 07 20 80 10 | Planting Irrigation | Optional |
| | | | 07 20 80 20 | Turf and Grasses | |
| | | | 07 20 80 30 | Plants | |
| | | | 07 20 80 50 | Planting Accessories | |
| | | | 07 20 80 70 | Landscape Lighting | |
| | | | 07 20 80 80 | Landscaping Activities | |
| G30 | 07 30 | Liquid and Gas Site Utilities | | | |
| G3010 | 07 30 10 | Water Utilities | 07 30 10 10 | Site Domestic Water Distribution | Optional |
| | | | 07 30 10 30 | Site Fire Protection Water Distribution | |
| | | | 07 30 10 50 | Site Irrigation Water Distribution | |
| G3020 | 07 30 20 | Sanitary Sewerage Utilities | 07 30 20 10 | Sanitary Sewerage Utility Connection | Optional |
| | | | 07 30 20 20 | Sanitary Sewerage Piping | |
| | | | 07 30 20 40 | Utility Septic Tanks | |
| | | | 07 30 20 50 | Sanitary Sewerage Structures | |
| | | | 07 30 20 60 | Sanitary Sewerage Lagoons | |
| G3030 | 07 30 30 | Storm Drainage Utilities | 07 30 30 10 | Storm Drainage Utility Connection | Optional |
| | | | 07 30 30 20 | Storm Drainage Piping | |

| UniFormat | OmniClass | | | | Inclusion in Scope |
|---|---|---|---|---|---|
| Level 3 | Level 3 | | Level 4 | | |
| | | | 07 30 30 30 | Culverts | |
| | | | 07 30 30 40 | Site Storm Water Drains | |
| | | | 07 30 30 50 | Storm Drainage Pumps | |
| | | | 07 30 30 60 | Site Sub-drainage | |
| | | | 07 30 30 70 | Storm Drainage Ponds and Reservoirs | |
| G3050 | 07 30 50 | Site Energy Distribution | 07 30 50 10 | Site Hydronic Heating Distribution | Optional |
| | | | 07 30 50 20 | Site Steam Energy Distribution | |
| | | | 07 30 50 40 | Site Hydronic Cooling Distribution | |
| G3060 | 07 30 60 | Site Fuel Distribution | 07 30 60 10 | Site Gas Distribution | Optional |
| | | | 07 30 60 20 | Site Fuel-Oil Distribution | |
| | | | 07 30 60 30 | Site Gasoline Distribution | |
| | | | 07 30 60 40 | Site Diesel Fuel Distribution | |
| | | | 07 30 60 60 | Site Aviation Fuel Distribution | |
| G3090 | 07 30 90 | Liquid and Gas Site Utilities Supplementary Components | 07 30 90 10 | Supplementary Components | Optional |
| G40 | 07 40 | Electrical Site Improvements | | | |
| G4010 | 07 40 10 | Site Electric Distribution Systems | 07 40 10 10 | Electrical Utility Services | Optional |
| | | | 07 40 10 20 | Electric Transmission and Distribution | |
| | | | 07 40 10 30 | Electrical Substations | |
| | | | 07 40 10 40 | Electrical Transformers | |
| | | | 07 40 10 50 | Electrical Switchgear and Protection Devices | |
| | | | 07 40 10 70 | Site Grounding | |
| | | | 07 40 10 90 | Electrical Distribution System Instrumentation and Controls | |
| G4010 | 07 40 50 | Site Lighting | 07 40 50 10 | Area Lighting | Optional |
| | | | 07 40 50 20 | Flood Lighting | |
| | | | 07 40 50 50 | Building Illumination | |
| | | | 07 40 50 90 | Exterior Lighting Supplementary Components | |
| G50 | 07 50 | Site Communications | | | |
| G5010 | 07 50 10 | Site Communications Systems | 07 50 10 10 | Site Communications Structures | Optional |
| | | | 07 50 10 30 | Site Communications Distribution | |
| | | | 07 50 10 50 | Wireless Communications Distribution | |
| G90 | 07 90 | Miscellaneous Site Construction | | | |
| G9010 | 07 90 10 | Tunnels | 07 90 10 10 | Vehicular Tunnels | Optional |
| | | | 07 90 10 20 | Pedestrian Tunnels | |
| | | | 07 90 10 40 | Service Tunnels | |
| | | | 07 90 10 90 | Tunnel Construction Related Activities | |

# Appendix C: Additional Information on Quantifying Embodied Carbon

## C.1 Lifespan of Elements and Products

**Table 6: Average lifespans for Elements and Products**

(Sources: *Recommended Guidelines for Building Component Lifespans in Whole Building Life Cycle Assessment*[55], Carbon Leadership Forum, 2018; *Instructions for Performing a Multifamily Property Condition Assessment*[56], Fannie Mae, 2019; *Preventive Maintenance Guidebook: Best Practices to Maintain Efficient and Sustainable Buildings*[57], BOMA, 2010)

| Building Element | Sub-element / Product | Service Life (Years)* |
|---|---|---|
| Structure | - | Life of the Building |
| Roofing | Asphalt, Shingles | 20 |
| | Built-up Roof | 20 |
| | Wood Shingles | 25 |
| | Metal | 40 |
| | Slate, Clay, and Concrete Tile | Life of the Roofing |
| Internal Non-load-bearing Walls | Partitioning and Gypsum Board | 30 |
| Interior Wall Finishes | Vinyl | 10 |
| | Wallpaper | 4 |
| | Epoxy | 15 |
| | Fabric | 5 |
| | Wood | 15 |
| | Paint | 10 |
| Floor Finishes | Carpet – Commercial Buildings and Common Area in All Other Buildings | 5 |
| | Carpet – Residential Units | 10 |
| | Vinyl | 12 |
| | Wood (Parquet and Strip) | 30 |
| | Stone and Ceramic | 50 |
| | Epoxy Coating (for concrete and wood flooring) | 10 |
| Ceiling Finishes | Paint | 10 |
| | Acoustic tile (Drop Ceiling) | 10 |

[55] https://www.carbonleadershipforum.org/wp-content/uploads/2018/07/CLF_Recommendations_BuildingComponentLifespans_07-06-2018.pdf
[56] https://multifamily.fanniemae.com/media/6701/display
[57] https://icap.sustainability.illinois.edu/files/projectupdate/2289/Project%20Lifespan%20Estimates.pdf

| Building Element | Sub-element / Product | Service Life (Years)* |
|---|---|---|
| | Plaster or Gypsum Board with Skim Coat | 30 |
| | Metal | 25 |
| | Wood | 30 |
| | Epoxy Coating (for concrete and wood ceiling) | 10 |
| Furniture, Fixtures & Equipment | - | 10 |
| Envelope, Cladding, Exterior Wall Finishes | Paint | 5-10 |
| | Wood Shingle, Clapboard, Stucco, and Composite Wood | 20 |
| | Exterior Insulation Finishing Systems (EIFS) | 20 |
| | Vinyl siding | 25 |
| | Glazed and Metal Curtain Wall | 40 |
| | Aluminum Siding | 40 |
| | Precast Concrete Panel | 45 |
| | Cement-board / Cementitious Siding | 45 |
| | Stone Veneer | 50 |
| | Stucco Systems | Life of the Envelope |
| | Brick, Block, and Stone | Life of the Building |
| Exterior Windows and Doors | - | 30 |
| Mechanical, Electrical, and Plumbing and Services | Water Heating Source | 20 |
| | Space Heating and Air Treatment | 20 |
| | Ductwork | 20 |
| | Electrical Installations | 30 |
| | Lighting Fittings | 15 |
| | Communications Installations and Controls | 15 |
| | Plumbing | 25 |
| | Lifts and Conveyors | 20 |

***** For elements and products where the references vary, the lower-end value is used.

More detailed breakdown of elements service life for multi-unit residential buildings can be found in Instructions for Performing a Multifamily Property Condition Assessment, Fannie Mae, 2019 and for commercial buildings in Preventive Maintenance Guidebook: Best Practices to Maintain Efficient and Sustainable Buildings , BOMA, 2010.