# Second ISC Publication Public Review Draft

## BSR/ASHRAE/ICC Standard 240P

# Quantification of Life Cycle Greenhouse Gas Emissions

Second ISC Public Review (June 2025)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by ASHRAE, ICC, and ANSI. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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**(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

**FOREWORD – NOTE TO COMMITTEE THIS IS NOT PART OF THE BALLOT AND WILL BE UPDATED PRIOR TO PUBLIC REVIEW**

ASHRAE/ICC Standard 240P provides minimum requirement for quantifying both embodied and operational greenhouse gas emissions over the *life-cycle* of buildings, building systems, building equipment and their *sites*.

This Independent Substantive Change draft is the third public review of this standard. The first public review was an advisory public review which resulted in over 400 comments and the second public review which resulted in over 700 comments. The committee would like to thank all the commenters for their comments. During the last few months, the committee has reviewed all the comments and based on that review made substantial changes to the draft. These changes have resulted in reworking whole sections.

Changes made to this draft include, but are not limited to:

A. Definitions updated.
B. Updated Figure of *life-cycle stages* included in the *system boundary*.
C. Changing the default *GWP* value from *GWP*-20 to *GWP*-100.
D. Numerous revisions to Chapter 6, *Embodied Greenhouse Emissions*
E. Fugitive Emissions *GWP* for Refrigerants and other gases expanded.
F. Made Informative Appendix A Normative.

**NOTE TO REVIEWERS:** An independent substantive changes public review means that only the changes in strikethrough and underline are open for public comment. The remainder of the draft is there to provide context for the changes made. Commenters should provide changes that would resolve them when they submit their comment. If you are a prior commenter please closely review the document to see if your comment has been resolved.

ANSI/ASHRAE standards are reviewed every five years to determine if updating is needed. Due to the ever-evolving nature of whole-life carbon reduction, the committee will likely place the document on continuous maintenance once published. This will allow the document to be utilized and updated at a more rapid pace in the future.

**Quantification of Life Cycle Greenhouse Gas Emissions of Buildings**

1. **Purpose**: The purpose of this standard is to provide a methodology to quantify and document greenhouse gas emissions associated with buildings, building systems, and building equipment and their *sites* over their life cycle.
2. **Scope**

**2.1** This standard provides minimum requirements for the quantification of embodied and operational greenhouse gas emissions associated with buildings, and their *sites*.

**2.2** This standard provides minimum requirements for documentation of life-cycle greenhouse gas emissions.

**2.3** This standard does not set benchmarks or establish levels of building performance.

**2.4** This standard shall not be used to circumvent any safety, health, or environmental requirements.

**3.1 Definitions**

~~***adopting authority:*** the governmental unit, agency or agent that adopts this standard.~~

***alteration:*** a replacement or addition to a *building* or its systems and equipment. Routine maintenance, repair, or a change in the *building*'s use classification or category does not constitute an *alteration*.

***as-designed:*** the state that precedes the *as-built* state of a *building* wherein the actual installed conditions, equipment, and systems are not yet completed or installed.

***as-built:*** the state that represents the actual installed conditions, equipment, and systems of a *building*.

***as-built building information model (as-built BIM):*** *building* information model developed after the construction of a *building* or portion of a *building* that captures changes to materials used (type, size, location, etc.) as compared to those captured in the design documents.

***authority having jurisdiction (AHJ):*** the governmental unit, agency, agent or code official responsible for enforcing this standard.

***bill of materials:*** A comprehensive list of the quantity, cost, and mass of individual *building* products, assemblies and materials as delivered to the project *site* for permanent installation in the *building project*. Assemblies may be documented based on their constituent components.

***biomass:*** ~~organic material that comes from living organisms.~~ Material of biological origin excluding material embedded in geological formations and material transformed to fossilized material.

***Biogenic carbon:*** *greenhouse gas emissions* ~~produced~~ from~~in~~ natural processes by living organisms, but not fossilized or derived from fossil resources.

***building*.** Any *structure* used or intended for supporting or sheltering any use or occupancy.

***Building element:*** an individual component or distinct assembly of components serving a specific purpose, such as supporting, enclosing, furnishing, or servicing a *building*.

***building project****:* ~~see *project.*~~ *a construction work that includes a building, system, or site.*

***building site area:*** the total land area, measured on a horizontal plane, of a specific property or location. It includes the entire space within the *site*'s boundaries minus the area of the footprint of the *building*.

***bulk fuel:*** an *imported energy* source that is stored at the *building site* and combusted or otherwise chemically converted on-site for the purpose of energy services, heating, or other amenities, including propane, fuel oil and other petroleum products, hydrogen, coal, wood, and other biofuel or *biomass* products.

***carbonation:*** ~~a chemical process that generates carbonates, bicarbonates, and carbonic acid.~~ *Carbon dioxide* reaction with cementitious products to form calcium carbonate.

***carbon dioxide ($CO_2$)****:* a naturally occurring gas, $CO_2$ is also a by-product of burning *fossil fuels* (such as oil, gas and coal), of burning *biomass*, of land-use changes (LUC) and of industrial processes (e.g., cement production). ~~It is~~ The reference gas against which the *global warming potential (GWP* of other *GHG*s are measured and therefore has a ~~*global warming potential (GWP)*~~ of 1.

***carbon dioxide equivalent ($CO_2e$) ~~emission~~****:* ~~the amount of *carbon dioxide* ($CO_2$) emissions that would cause the same integrated radiative forcing or temperature change, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs.~~ Unit for comparing the radiative forcing of a greenhouse gas to that of *carbon dioxide*.

***carbon sequestration:*** process by which *carbon dioxide* is removed from the atmosphere; can be natural or artificial.

***Conditioned space:*** *a*n area, room or space that is enclosed within the *building thermal envelope* and is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with *conditioned spaces*, where they are separated from *conditioned spaces* by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

***construction documents:*** drawings and specifications used to construct, add to, or alter *building*s, systems, or *equipment*, or portions thereof.

***Construction stage:*** The *life-cycle stage* composed of *Module A4* and *Module A5*.

***construction waste:*** any substance, matter, or byproduct generated from the *building* construction or *demolition* process.

***Cradle-to-gate:*** *see product stage*.

***cradle-to-grave scope:*** *a scope that includes the product stage, construction stage, use stage, and end-of-life stage.*

***decarbonization:*** the process of removing or reducing *greenhouse gas emissions.*

***deconstruction:*** the controlled and intentional selective dismantlement of a *building* or *building elements* in a manner to preserve valuable components for the purposes of reuse, repurposing, ~~and/~~or recycling.

***demolition:*** *t*he controlled and intentional action or process of deconstructing, dismantling, ~~razing, destroying,~~ or ~~wrecking~~ removal by destructive means of a *building* or *building elements.*

***Design for deconstruction****:* designing in such a way that the resources used can be economically recovered and reused.

***disposal management:*** activity that includes on-site transport and energy and water use related to waste processing at the disposal location, including environmental loads from energy recovery processes.

***District energy system***: a system that supplies cooling or heating energy to multiple buildings, consisting of one or more plants producing hot water, steam ~~and/~~or chilled water and distribution systems of pipes to convey hot water, steam or chilled water to the buildings.

***electric vehicle*****:** an automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood *electric vehicles*, plug-in hybrid vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service or another external source of electric current.

***electric vehicle supply equipment*****:** equipment for plug-in electricity transfer including the ungrounded, grounded and equipment grounding conductors, and the *electric vehicle* connectors, attachment plugs, personal protection *system* and all other fittings, devices, power outlets or apparatus installed specifically for the purpose of transferring energy between the premises wiring and an *electric vehicle*.

***embodied greenhouse gas emissions:*** the GHG emissions associated with the extraction, production, transportation, construction or assembly, *deconstruction*, *demolition*, end-of-life, and use of *building* or building site materials.

***emissions factor****:* a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant.

***End-of-life stage****:* The *life- cycle stage* that occurs after the end of ~~*the reference study period*~~ *the use stage* and is comprised of *Module C1, Module C2, Module C3,* and *Module C4.*

***Energy code***: a section, chapter or subset of a *building* code containing written legal requirements that govern the energy efficiency design and construction of residential or commercial ~~*structures*~~ buildings.

***Environmental product declaration (EPD):*** ~~A~~ Quantified environmental impacts ~~information on the life cycle~~ of a product throughout its life cycle according to ISO 14025.

~~***Equipment***: devices for energy conversion or transformation, space heating, space cooling, ventilation, humidification, dehumidification, electric power, lighting, transportation, refrigeration, cooking, or service water heating, or other process loads at a *building* site.~~

***Existing building:*** A *building* or portion thereof that was previously occupied or approved for occupancy by the *AHJ*.

***Exported energy:*** Energy that is delivered from within the ~~asset~~ spatial boundary for use outside the ~~asset~~ spatial boundary. *Exported energy* may result from conversions of ~~renewable~~ energy harvested within the ~~asset~~ spatial boundary or may result from conversions of imported~~non-renewable~~ energy ~~that is delivered to the asset and measured as energy consumed by the asset~~.

***Exterior wall:*** a wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees (1.05 rad) or greater with the horizontal plane.

***Fossil fuels:*** non-renewable energy sources that formed from the decomposition of buried, carbon-based organisms from the geological past, such as coal, natural gas, propane, fuel oil and other petroleum products.

***Fugitive emissions***: the emission, leakage or discharge of gases or vapors from pressure-containing equipment ~~or facilities~~ and components ~~inside~~of *buildings* such as valves, piping flanges, pumps, storage tanks, ~~valves,~~ compressors, etc.

***Global warming potential (GWP)*:** an index ~~developed to provide a simplified means of~~ describing the relative ability of a chemical compound to affect radiative forcing, if emitted to the atmosphere, over its lifetime in the atmosphere, and thereby to affect the global climate. The GWP is defined on a mass basis relative to *carbon dioxide*. The GWP for a compound must be calculated up to a particular integrated time horizon, for example, 20, 100, or 500 years.

***greenhouse gas (GHG):*** Gaseous constituents of the atmosphere, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself and by clouds. ~~This property causes the greenhouse effect. Water vapor ($H_2O$), carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$) and ozone ($O_3$) are the primary GHGs in the Earth's atmosphere.~~

***Greenhouse gas (GHG) emissions****:* The release of *greenhouse gases* into the atmosphere ~~that absorb and emit radiation at specific wavelengths within the range of the electromagnetic spectrum that radiation is emitted by the Earth's surface, the atmosphere and clouds.~~

***greenhouse gas emissions, combustion****: greenhouse gas* emissions associated with the burning of a solid or liquid or gaseous fuel, either within the *system boundary* or to generate electricity, steam, hot water or chilled water that is generated outside the *system boundary* and used within the *system boundary*.

***Greenhouse gas emissions, precombustion:*** *greenhouse gas* emissions associated with fuel extraction, processing, and transport, including *fugitive emissions*, prior to combustion within the *system boundary* or to generate electricity or thermal energy used within the *system boundary*.

***Gross floor area***: the sum of the floor areas of the spaces within the *building*, including basements, mezzanine and intermediate-floored tiers, and penthouses with a headroom height of 2.3 m (7.5 ft) or greater. It is measured from the exterior faces of walls or from the center-line of walls separating *building*s, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof over-hangs, and similar features.

***Imported electricity:*** electricity that is generated outside the *system boundary* and is delivered for use within the *system boundary*.

***Imported energy:*** ~~an energy source that is delivered for use within the *system boundary*.~~ Energy that is transported from outside the ~~*system*~~ *spatial* boundary for use within *the system boundary* including *imported electricity*. *Imported energy* does not include naturally occurring renewable energy, such as wind, solar or geothermal, that is harvested and converted within the *system boundary* for on-site use or for export.

~~***IndustrialProcess gases***: the gaseous materials that are manufactured for use in industry and include but are not limited to nitrogen, oxygen, carbon dioxide, argon, hydrogen, helium and acetylene.~~

***Industry-average EPD:*** *Environmental Product Declaration (EPD)* that declares average values for products of multiple manufacturers in a clearly defined ~~sector and/or~~ geographical area and that use the same *product category rule*.

~~***Land use change:*** process by which human activities transforms or modifies natural landscape.~~

***Licensed design professional:*** individual responsible for the design and preparation of architectural or engineering contract documents. An architect or engineer licensed to practice in accordance with applicable state licensing laws.

***Life-cycle assessment (LCA)*:** the process of evaluating a *project* from *cradle-to-grave* and assigning a value or assessment of its cumulative and ultimate social, environmental and economic costs, benefits, and impacts.

***Life cycle stage:*** a specific phase within the lifecycle of a *building* that marks a distinct set of activities occurring during a defined period.

***material inventory:*** the quantified list of the materials, products, and waste inputs and outputs over the lifecycle of the project based on scenarios applied to the b*ill of materials***.**

***Module A1*****:** The life-cycle module corresponding to all processes and materials associated with harvesting, extraction, collection, and further processing of raw materials.

***Module A2*****:** The life-cycle module corresponding to the transport of raw materials to a product manufacturing facility or to multiple manufacturing facilities.

***Module A3*****:** The life-cycle module corresponding to the processes and materials required for the fabrication and production of a product prior to *Module A4*.

***Module A4*****:** The life-cycle module corresponding to the transportation of all materials and products included in the *bill of materials.*

***Module A5*****:** The life-cycle module corresponding to the processes and materials required for the construction of the *project* on a *site* prior to the issuance of a certificate of occupancy.

***Module B1*****:** The life-cycle module corresponding to 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,* including greenhouse gas emissions from off-gassing materials, processes such as *carbonation*, and *fugitive emissions*.

***Module B2*****:** The life-cycle module corresponding to 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.

***Module B3*****:** The life-cycle module corresponding to all processes and materials required to sustain the functions of the *building* that are not included in *Module B2*, 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.

***Module B4*****:** The life-cycle module corresponding to 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.

***Module B5*****:** The life-cycle module corresponding to 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.

***Module B6*****:** The life-cycle module corresponding to operational energy use of the *project*.

***Module B7*:** The life-cycle module corresponding to operational water use and its treatment.

***Module C1*:** The life-cycle module corresponding to all on-site and off-site processes and inputs for the decommissioning, dismantling, deconstructing, or demolishing the *project*.

***Module C2*:** The life-cycle module corresponding to 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.

***Module C3*:** The life-cycle module that 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 reentering the market.

***Module C4*:** The life-cycle module corresponding to all processes and material flows required for waste disposal and treatment—including neutralization, incineration, landfilling, and *disposal management*.

***Module D:*** The module comprised of *Module D1* and *Module D*2, which quantifies benefits and loads outside of the *system boundary*.

***Module D1:*** The life-cycle module corresponding to all environmental loads and benefits from future substitution of resources due to reused products, recycled materials, secondary fuels, and recovered energy from end of life processes in *Modules A5, B2-B5,* and *C1-C4* ~~leaving a project~~ for use in a subsequent product system as material.

***Module D2*:** The life-cycle module corresponding to all environmental loads and benefits for recovered and exported energy used to meet the energy demand outside of the *project*.

***operational ~~carbon~~ emissions***: the greenhouse gas emissions associated with the operation of an asset (i.e., *building*) during the *use stage* of the asset.

***process application:*** a manufacturing, industrial, or commercial procedure or activity where the primary purpose is other than conditioning *spaces* and maintaining comfort and amenities for the occupants of a *building*.

***process energy:*** *energy* consumed in support of a *process application*.

***process gas:*** any gas that is used in support of a *process application* and that is not *process energy*.

~~***product category rule* (PCR):** product-specific guidelines that determine the requirements for conducting life cycle assessment studies and reporting findings through *EPDs*.~~

***product-specific EPD:*** *Environmental Product Declaration (EPD)* developed by a single-manufacturer that provides data on a single product or product family.

***product stage:*** The *life-cycle stage* comprised of *Module A1*, *Module A2* and *Module A3*.

~~***project****: a construction work that includes a building, system, or site.*~~

***record documents:*** drawings and other documents that record the conditions of the *project* as constructed. These include any refinements of the *construction documents* or bid documents.

***reference study period (RSP)****:* the period over which the time-dependent characteristics of the object of assessment are analyzed.

> ***Informative note:*** The *RSP* is not an assumption of the exact *service life* of a particular product, system or assembly but is intended to represent a consistent *service life* for *building* types covered by this standard that is predictable and relevant for carbon accounting of *building*s.

***Service life:*** the period during which a product or *building* is expected to function as intended before needing replacement or disposal.

***site:*** ~~The area of land adjacent to and intended to support the use of a *building*. A site shall be contiguous or separated only by public rights-of-way.~~ An area of land that is under the control of a single owner or entity, which contains systems or equipment.

***structure:*** that which is built or constructed.

***substructure:*** a portion of a *structure* that is built at or below grade.

***superstructure*****:** a portion of a *structure* that is built above grade.

***system boundary:*** the physical, geographical, and temporal scope of the assessment, including *life-cycle stages*, *building element*s, processes, flows, and activities.

***Use stage*****:** The *life-cycle stage* that occurs from issuance of a certificate of occupancy to the end of the *reference study period* and is comprised of *Module B1, Module B2, Module B3, Module B4, Module B5, Module B6*, and *Module B7*.

**3.2 Abbreviations and Acronyms**

| | |
|---|---|
| *AHJ* | *authority having jurisdiction* |
| BIM | building information modeling |
| *CO2e* | *carbon dioxide equivalent ~~emissions~~* |
| *EPD* | *environmental product declaration* |
| GHG | *greenhouse gas emissions* |
| GWP | *global warming potential* |
| LCA | life-cycle analysis |
| MEP | mechanical, electrical, plumbing |
| ~~PCR~~ | ~~product category rule~~ |
| RSP | *reference study period* |
| WLCA | whole life-cycle analysis |

**4. COMPLIANCE, ADMINISTRATION, AND ENFORCEMENT**

**4.1 Compliance.** Compliance with this standard shall be based on the *System Boundary* determined in accordance with Section 5. As applicable to the *System Boundary*, quantification of *embodied greenhouse gas emissions* in accordance with Section 6, quantification of *operational greenhouse gas emissions* in accordance with Section 7, ~~evaluation of loads and benefits beyond the system boundary in accordance with Section 8~~ documentation of the analysis and results in accordance with Section 9 and, where required by the *AHJ*, evaluation of loads and benefits beyond the *system boundary* in accordance with Section 8 are required.

**4.2 Assessment Type.** Compliance with Sections 6, 7, and 8 requires completion of either an *as-designed* assessment or an *as-built* assessment or a combination of both. Determination of the assessment type used for compliance with each Section shall meet the requirements specified in the relevant section and may be different among sections.

**4.3 Compliance Documentation.** *Construction documents* or *record documents*, as applicable, shall show all the pertinent data and features of the *building*, systems, *equipment* and *sites* in sufficient detail to permit a determination of compliance by the *authority having jurisdiction (AHJ)* and to indicate compliance with the requirements of this standard.

**4.4 Administrative Requirements.** Administrative requirements relating to permit requirements, enforcement by the *AHJ*, locally adopted standards, interpretations, claims of exemption, and rights of appeal are to be specified by the *AHJ*.

**4.5 Other Laws.** The provisions of this standard shall not be deemed to nullify any provisions of local, state, provincial, or ~~federal~~ national law. ~~Where there is a conflict between a requirement of this standard and such other law affecting this calculation methodology, precedence shall be determined by the *adopting authority (AHJ)*.~~

**4.6 Normative Appendices.** The normative appendices to this standard are mandatory requirements of this standard, which, for reasons of convenience, are placed apart from all other normative requirements.

**4.7 Informative Appendices and Notes.** The informative appendices and informative notes contain additional information and are not mandatory or part of this standard.

**4.8 Referenced Standards.** The normative referenced standards herein and listed in Section 10 shall be considered part of the requirements of this standard to the prescribed extent of such reference. Where differences occur between the provisions of this standard and referenced standards, the provisions of this standard shall apply. Informative references are identified in Informative Appendix D to acknowledge sources and are not part of this standard.

**5. System Boundary.** An evaluation of life-cycle *GHG emissions* performed in compliance with this standard shall be based on a *system boundary* ~~which~~ that includes:

a. A spatial boundary as determined in accordance with Section 5.1.
b. *Building element*s identified in Section 5.2.
c. Effects outside the spatial boundary identified in accordance with Section 5.3
d. *Life-cycle assessment* modules as specified in Section 5.4
e. The *reference study period* as determined in accordance with Section 5.5.

Figure 5 illustrates the *life-cycle stages* that shall be included in the *system boundary*.

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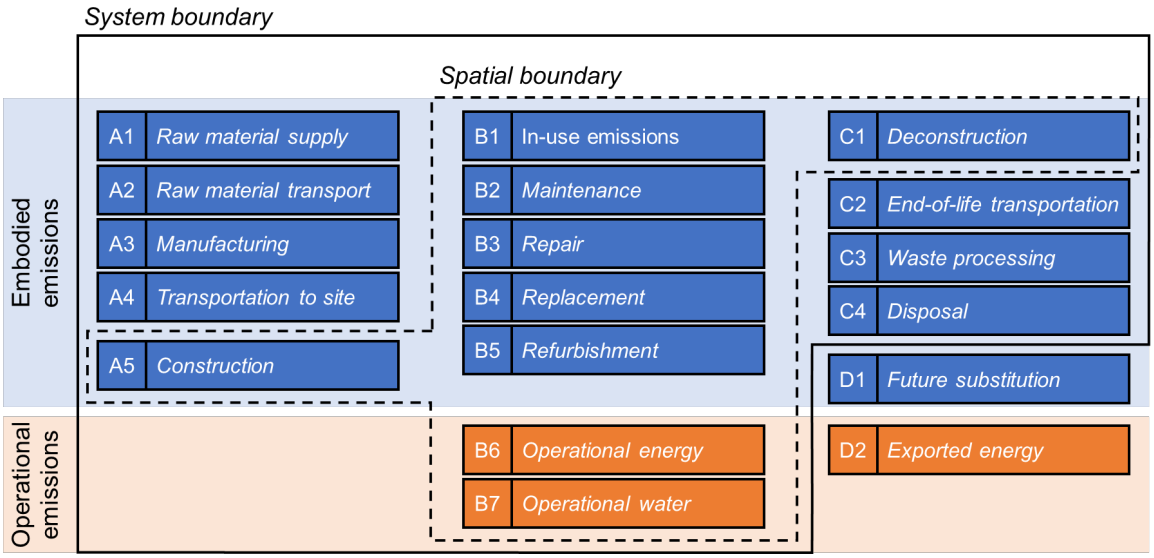

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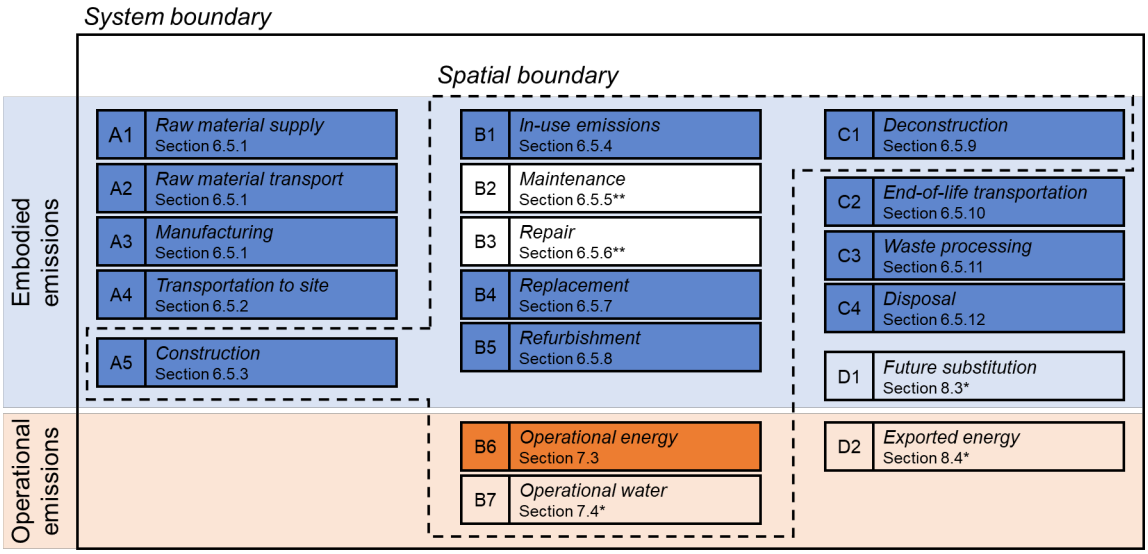


Life cycle modules A0 (Design) and B8 (User Activities) are not addressed within this standard
* Where required by AHJ
** Reserved for future use

**Figure 5: Illustration of *life-cycle stages* included in the *system boundary***

***Informative note**:* Additional information regarding system boundaries can be found in ISO 14064-1, ISO 14040, and ISO 14044.

**5.1. Spatial Boundary.** The spatial boundary shall identify the physical limits of the construction work of the *project*. A spatial boundary shall be a *building* or a portion of a *building* and relevant portions of the *site*, in accordance with Table A1: OmniClass *Building Elements*. Infrastructure, *building* components, and *site* components that are non-contiguous (e.g., off-site renewable energy systems) shall not be included within the spatial boundary.

***Informative note**:* It should be possible to ~~circle~~ draw the spatial boundary on construction drawings.

**5.2. Building Elements.** All the *building elements* listed in Normative Appendix A which are applicable to the spatial boundary identified in section 5.1 shall be included in the *system boundary* and addressed in the evaluation.

**5.3. Effects outside the Spatial Boundary.** Emissions ~~effects~~ that ~~which~~ occur outside the spatial boundary due to ~~construction~~*buildings* or sites within the spatial boundary shall be included in the *system boundary* where required by this standard. Examples include utility and non-utility energy supply systems and ~~infrastructure, *building* components,~~ and *site* components that serve multiple *buildings* such as *district energy systems* and renewable energy where contiguous with the spatial boundary.

**5.4. Scope of *Life Cycle Stages*.** The *system boundary* shall ~~address~~ include all of the following *life- cycle stages*:

a. *Modules A1* through *A5,*

*b.Modules B1, B4, B5, and B6,*

~~*c.Module B7* where required by the *AHJ,* and~~

~~*d.*~~ *c. Modules C1* through *C4, and*

*d. Modules B7 and D where required by the AHJ,*

The *system boundary* determined within the scope of this standard shall not include any of the following:

**a.** ~~Quantification of~~ On-site *biogenic carbon sequestration*,

**b.** avoided *GHG emissions*,

~~**c.** negative emissions,~~

**d.** carbon capture ~~activities~~ other than *carbon sequestration* in products and materials used in the *project*,

**e.** carbon offsets,

**f.** carbon credits,

**g.** *renewable energy* credits, or

**h.** other environmental attribute crediting mechanisms.

**5.5. *Reference Study Period*.** The *reference study period* shall be 60 years, unless otherwise ~~stated~~ required by the *AHJ*.

~~**5.6. Use Cases.** Reserved for future use.~~

## 6. Quantifying Embodied Greenhouse Gas Emissions

**6.1 General** The *embodied greenhouse gas emissions* assessment shall comply withall of items a. though q. below. Where specified by the *AHJ*, compliance with items r. and s. shall also be required.

a. Section 6.1, "General"
b. Section 6.2, "Establishing a Material Inventory"
c. Section 6.3, "Environmental Impact Data"
d. Section 6.4, "Quantification of Uncertainty in Embodied GHG Emissions"
e. Section 6.5.1 "Product (*Modules A1* through *A3*)
f. Section 6.5.2, "Transportation to Site (*Module A4*)"
g. Section 6.5.3, "Construction" (*A5*)
h. Section 6.5.4, "Use Stage" (*B1*)
i. Section 6.5.6, "Repair Emissions (*B3*)"
j. Section 6.5.7, "Replacement Emissions (*B4*)"
k. Section 6.5.8, "Refurbishment Emissions (*B5*)"
l. Section 6.5.9, "Deconstruction and Demolition (*C1*)"
m. Section 6.5.10, "Waste Transportation Emissions (*C2*)"
n. Section 6.5.11, "Waste Processing for Reuse, Recycling, or Recovery (*C3*)"
o. Section 6.5.12. "Waste Disposal (*C4*)"
p. Section 6.6.1 "Biogenic Carbon"
q. Section 6.6.2, " Carbonation"
r. Section 6.4.2.5, "Process Gas Emissions"
s. Section 6.5.5, "Maintenance Emissions (*B2*)"

~~**6.1.1 Scope**~~

~~Section 6 specifies requirements for the *embodied greenhouse gas emissions* assessment for *as-designed* and *as-built* projects across life cycle stages A-D. (See Section 5.4.)~~

### 6.2 Establishing a *Material Inventory*

The assessment shall include a *material inventory* that includes all ~~the following within the *system boundary* in accordance with Section 5.2:C~~

1. ~~Every~~ *building elements* ~~within an Element Category~~ marked as required in Table A.1, *Building Element Categories,* of Appendix A. ~~representing more than 1% of total project cost or mass, and~~

   **Exception to 6.2**: Groups of *building elements* that, in aggregate, ~~make up~~ constitute less than 5% of the estimated or actual total element L3 subcategory (OmniClass number format: xx-xx xx xx) cost or mass shall be permitted to be excluded from the *material inventory*.

   **Informative Notes:** 1. For example, the user may determine that all the connection hardware within the entire element L3 subcategory 12-02 10 80 Stairs, constitutes less than the threshold, in which case all connection hardware may be excluded from the *material inventory* within the element L3 subcategory 21-02 10 80 Stairs.

2. ~~Every *building* element described in Section 6.2.1.~~

   ~~***Informative note:***~~ 2. Refrigerant and *process gases* within the ~~spatial~~ *system boundary* are discussed in Section ~~5.4.2.1.1~~ 6.5.4.2.1.

~~**6.2.1 Required *Building Element***~~

~~**6.2.1.1 *Substructure*.**~~

~~The *assessment* shall include all the following *building* elements:~~

~~a. Foundations: Standard shallow and deep foundations, and special foundations~~

~~b. Subgrade Enclosures: Retaining walls, foundation *site* walls, below-grade insulation and waterproofing.~~

~~c. Slabs-on-Grade: Standard and structural flatwork, slab trenches, pits and bases, and slab-on-grade supplementary components~~

~~d. Water and Gas Mitigation: *Building* subdrainage~~

~~Exception to Section 6.2.2.1: *Substructure building* elements that in aggregate represent less than 5% of the total substructure cost or mass may be excluded.~~

~~**6.2.1.2 *Superstructure*.**~~

~~The *assessment* shall include all the following *building* elements:~~

~~a. Gravity systems: columns, bearing walls, beams, joists, girders, floor plate, roof plate, topping slabs, ledgers, blocking, deck edge angles, and kickers.~~

~~b. Lateral systems: bracing and frames, shear walls, diaphragms.~~

~~c. Connections & Attachments: primary connections (framing to framing), secondary connections (sheathing and nailing), diaphragm connections, secondary reinforcement (drag bars, opening reinforcement, add bars).~~

~~d. Stairs: Stringers, treads, and railing.~~

~~Exception to Section 6.2.1.2: *Superstructure building* elements that in aggregate represent less than 5% of the total *superstructure* cost or mass may be excluded.~~

~~**6.2.1.3 *Enclosure*.**~~

~~The assessment shall include all the following *building elements*:~~

~~a. Exterior Vertical *Enclosures*: Walls, windows, doors and grilles, louvers and vents, wall appurtenances, wall specialties~~

~~b. Exterior Horizontal *Enclosures*: Roofing, traffic bearing horizontal enclosures, horizontal openings, overhead exterior *enclosures*.~~

~~Exception to Section 6.2.1.3: *Enclosure building elements* that in aggregate represent less than 5% of the total enclosure cost or mass may be excluded.~~

~~**6.2.1.4 Interior.**~~

~~The assessment shall include all the following *building* elements:~~

~~a. Interior Construction: Partitions, walls, windows, doors, raised floor construction, suspended ceiling construction.~~

~~b. Interior Finishes: wall finishes, interior fabrications, flooring, ceiling finishes.~~

~~Exception to Section 6.2.1.4: Interior *building* elements that in aggregate represent less than 5% of the total interior cost or mass may be excluded.~~

~~**6.2.1.5 MEP and Services.**~~

~~The assessment shall include all the following *building* elements:~~

~~a. Mechanical, Heating, Ventilating, and Air Conditioning (HVAC): Equipment and their Distribution Systems: distribution systems, and terminals that provide, either collectively or individual, the process of HVAC to a building or portion of a building, eg. ducts and pipes serving mechanical equipment and their insulation, chillers, cooling towers, air cooled condensers, roof top units, air handlers, heat pumps, boilers, chilled beams, VRF systems, heat exchangers, and air conditioners, and unitary systems.~~

~~b. Electrical: Light fixtures, power supply and distribution, and power management systems, including batteries, uninterrupted uninterruptible power supplies, switchgears, transformers, and power generation systems.~~

~~c. Plumbing Equipment Systems: Pipes servicing equipment and fixtures and their insulation.~~

~~d. Other Systems: fire protection systems; vertical transpiration systems; electrical low voltage systems including fire alarm systems, IT systems, security systems, and other control systems; and other MEP systems not included in 6.2.1.5 a-c.~~

~~Exception to Section 6.2.1.5: MEP and Services *building elements* that in aggregate represent less than 5% of the total MEP and Services cost or mass may be excluded.~~

~~**6.2.1.6 Civil/Landscape/Site Material Quantity Calculations.** Reserved for future use.~~

**6.2.2 Material Quantity Data Sources.**

The source of material quantity data for the *material inventory* shall be in accordance with one of the following compliance paths:

**6.2.2.1 As-Designed Assessment Requirements.**

The *material inventory* shall be established using modeled information in accordance with the *construction documents.*

**6.2.2.2 As-Built Assessment Requirements.**
The *Bill of Materials* shall be established using measured quantities of materials in accordance with shop drawings, *as-built* documentation, *record documents*, supplemental records, or through on-site measurement of material quantity or a combination of both.

**6.3 Environmental Impact Data.**
~~The~~ Environmental impact data shall be provided for all materials included in the *material inventory* and all process as described in Section 6.5 Quantification and Boundaries per *Life Cycle Stage*. ~~used to represent products or materials shall be consistent with that of the *building* being assessed and the information and scenarios employed in the assessment shall cover all stages of the building's lifecycle.~~

**6.3.~~2~~1 Data hierarchy and disclosure**

~~**6.3.2.1 Data sources**~~

Data sources shall be selected according to the data hierarchy ~~to match the highest appropriate level of resolution, using the following data hierarchy per modeling assessment~~ in Table 6.3.~~2~~1 ~~below~~. Data uncertainty shall be disclosed and calculated per Section 6.4.2.

**Table 6.3.~~2~~1: Types of environmental impact data to be used during different modeling Assessments**

| Assessment | Greenhouse Gas Emission Data |
|---|---|
| *As-designed* | ~~When~~ Where a specific product and manufacturer has been selected and included in the *construction documents*:<br>a. Facility-specific ~~and/~~or supply-chain specific *EPD* (where the same specific products/systems are specified)<br>b. ~~Product-specific~~ Manufacturer-average *EPD* (where products/systems are specified)<br>c. Industry-~~wide~~ average *EPD* or regionally-appropriate generic values if no ~~product-~~manufacturer-average, or facility-specific *EPD* is available<br>Once materials have been selected, but no specific product ~~and/~~or manufacturer has been specified or purchased:<br>a. Industry-~~wide~~ average *EPD*<br>b. Regionally-appropriate generic values from national or regional datasets<br>c. Regionally-appropriate generic values from other background datasets<br>For materials and products, if an *EPD* is not available:<br>a. Regionally-appropriate generic values from national or regional datasets<br>b. Regionally-appropriate generic values from other background datasets<br>c. Regionally and technically representative product or material-specific ~~Life Cycle Assessment~~ *LCA*<br>d. CIBSE TM 65 product-specific mid-level calculation following local addenda<br>e. CIBSE TM65 product-specific mid-level calculation following original TM65 methodology if local addendum not available<br>f. Proxy *EPD* for similar product type from same manufacturer |

| | |
|---|---|
| *As-built* | ~~When~~ Where a specific product and manufacturer has been purchased ~~and/~~or installed:<br>a. Facility-specific ~~and/~~or supply-chain specific *EPD* (where the same specific products/systems are specified)<br>b. ~~Product-specific~~ Manufacturer-average *EPD* (where products/systems are specified)<br>When a type of product has been purchased ~~and/~~or installed, but the chosen manufacturer does not have one of the above:<br>a. Industry-~~Wide~~ average *EPD*<br>b. Regionally-appropriate generic values from National or Regional datasets<br>c. Regionally-appropriate generic values from other background Datasets<br>For materials and products, if an *EPD* is not available:<br>a. Regionally and technically representative product or material-specific ~~Life Cycle Assessment~~ *LCA*<br>b. CIBSE TM 65, product-specific mid-level calculation following original TM65 methodology if local ~~addenda~~ addendum not available. |

**6.3.~~1~~2 Allowable Data Sources.**
~~The most representative d~~Data sources used for ~~the~~ products and materials shall be ~~used, as indicated~~ in accordance with Table 6.3.~~2~~21. ~~When~~ Where the data source most representative of the *product stage* does not include all required *lifecycle stages* per the building's *system boundary*,~~additional lifecycle stages,~~ generic data shall be used for remaining lifecycle stages.

**6.3.~~1~~2.1 Environmental Product Declarations.** *EPDs* used shall be valid, ~~independently verified, Type III, according~~ and conform to ISO Standard 14025 and ISO Standard 21930:2017 or EN Standard 15804 plus Amendment 2. *EPD*s for electrical equipment conforming to ~~using~~ EN Standard 50693 shall be accepted. ~~for electrical equipment. *EPDs* not meeting these criteria must include additional~~EPDs shall conform to the product category rules (PCR) for the geographical region in which the product is located.

~~***Informative note*: *EPDs* are produced with varying levels of product and supply chain specificity, falling into the following categories:~~

Acceptable *EPD* types are the following:

a. **Industry~~-wide~~ average EPD** shall represent the weighted-average environmental impacts ~~performance~~ of a~~n industry's~~ product, covering participating manufacturers in a given geographical region, which may be multi-national, national, or sub-national in scope..

b. ~~**Product-specific EPD.** Shall reflect manufacturer-specific data.~~ Manufacturer-average EPD shall represent a product or products from a single manufacturer and report environmental impacts based on an average of data from multiple facility locations.

**c. Facility-specific ~~and/~~or supply-chain specific EPD** shall ~~be~~ represent a product~~-specific EPD that uses supply-chain and/or facility-specific data in the LCA process for the chosen product~~ from a single manufacturer and a single facility.

**Informative note:** Some product *EPD*s described in Section 6.3.2.1 include estimates of Operational Energy. However, it is ~~unlikely that the assumed Energy Usage aligns with the objectives of Module B6 and, therefore,~~ unlikely that the assumed Energy Usage aligns with the objectives of *Module B6* and therefore,should not be utilized. Quantification of Operational Greenhouse Gas Emissions shall follow the ~~guidance~~ methodology outlined in Section 7.

**6.3.~~1~~2.2** National ~~or~~ and regional datasets of generic environmental impact ~~figures~~ impacts~~.~~ ~~S~~shall be compliant with ~~ISO 14040 and 14044~~ ISO Standard 21930:2017 or EN Standard 15804 plus Amendment 2 and represent regional supply chains and regionally-specific manufacturing practices, where available.

***Informative note***: This includes datasets such as US Federal LCA Commons or similar reviewed and published LCA datasets of industry-average production data. ~~BECD Database~~. This may also include data utilized in a publicly available software or database that is produced following a published, consistent underlying methodology.

~~**6.3.12.3 Background Datasets.** Shall be produced in accordance with ISO 14040 and 14044 following a documented methodology that is consistent and publicly available.~~

~~***Informative note:*** This includes data utilized in a publicly available software or database that is produced in a publicly published, consistent underlying methodology.~~

**6.3.~~1~~2.4~~3~~ Life Cycle Assessments.** ~~ISO Standard 14040 and ISO Standard 14044 provide the foundational LCA standards.~~ Results from published LCA reports shall be compliant with ISO Standard 21930:2017 or EN Standard 15804 plus Amendment 2. Verified LCA reports shall be critically reviewed by an independent third-party reviewer. ~~assured to be in compliance with such standards~~. Unverified LCA results shall not be permitted. ~~do not incorporate third-party review.~~

~~***Informative note:*** CIBSE's TM65 is considered a form of unverified LCA in that it incorporates life cycle thinking but is not compliant with ISO Standard 14040 or ISO Standard 14044 and does not have a process for third-party review.~~

**6.4 Quantification of Uncertainty in Embodied GHG Emissions.**

An uncertainty factor shall be established per *life cycle stage* in accordance with Sections 6.4.1 through 6.4.3. ~~based on the uncertainty associated with the quantities in the *Bill of Materials* and with environmental impact data representativeness.~~

**6.4.1 Material Quantity Uncertainty Calculation.** ~~This number~~ The calculation of material quantity uncertainty, $U_m$ shall comply with Section 6.4.1.1 or Section 6.4.1.2. ~~represent the accuracy of the quantities of products and materials within the *bill of materials* based on the data source used for quantity takeoff.~~

**6.4.1.1. As-designed assessment.** Where a design phase BIM is used for the calculation of the *Bill of Materials*, material quantity uncertainty shall be ~~3~~% 5%. Where ~~a construction~~ other forms of documentation ~~model is~~ are used, material quantity uncertainty shall be ~~1%~~ 7%.

**6.4.1.2 *As-built* assessment.** Where an *as-built BIM* is the data source for the *Bill of Materials*, material quantity uncertainty shall be 3% ~~1%~~. Where delivered material measurements are used for the *Bill of Materials*, material quantity uncertainty shall be 1% ~~0%~~.

**6.4.2 Emissions Data Uncertainty Calculation.**

Embodied emissions shall be calculated as follows: ~~For each source of greenhouse gas emissions data, data representativeness must be rated per Normative Appendix B Table B.1 and used to calculate the data uncertainty factor, per Equation 6.4.2.1. This is combined to create a results uncertainty factor per reported value per~~

~~Equation 6.4.2.2.~~

~~Calculation per datum shall follow Equation 6.4.2.1:~~

1.Calculate a datum uncertain score, $U_S$, for each datum, *i*, in accordance with Equation 6.4.2.1.

$$US = U1 + U2 + U3 + U4 + U5 + U6 \quad (6.4.2.1)$$

Where the following are determined in accordance with Appendix B Table B.1
~~*US* is the datum uncertainty score~~
$U_1$ is the value of Geographic Representativeness
$U_2$ is the value of Technological Representativeness
$U_3$ is the value of Product Representativeness
$U_4$ is the value of Temporal Representativeness
$U_5$ is the value of Data Granularity
$U_6$ is the value of Verifiability.

2, Determine the datum uncertainty factor, $U_F$, for each datum, i, ~~B~~based on the value of *US* computed in (1)~~, the following datum uncertainty factor shall be assigned~~ in accordance with Table 6.4.3.

Based on the value of *U*, the following datum uncertainty factor shall be assigned in accordance with Table 6.4.3.

**Table 6.4.3: Data uncertainty factor**

| *US* | <10 | 10 - <15 | 15 - <20 | 20 - <25 | 25 - <30 | 30 - <35 | 35 - <40 | 40 |
|---|---|---|---|---|---|---|---|---|
| Uncertainty Factor | 10% ~~7%~~ | 8% ~~6%~~ | 7% ~~5%~~ | 5% ~~4%~~ | 4% ~~3%~~ | 3% ~~2%~~ | 2% ~~1%~~ | 1% ~~0%~~ |

3. Calculate ~~For each calculation reported from Section 6.5, uncertainty in~~ the whole building uncertainty result, $U_R$ in accordance with ~~emission result should be reported as the square root of the sum of the squares of numerical uncertainty factors used within the calculation, per~~ Equation 6.4.2.3:

$$\sum_{datum}^{n} UF * E_t \qquad U_R = \sqrt{\sum_{i=1}^{n} [(UF]_i * E_i)^2} \quad (6.4.2.3)$$

where
~~$U_R$ is the uncertainty result~~
$UF_{datum}$ is the Uncertainty factor for environmental datum *i*, determined in (2) ~~per Table 6.4.3~~
*n* is the number of materials or products included in the assessment
$E_i$ is the total greenhouse gas emissions ~~associated with environmental datum~~ calculated for the associated product or material in accordance with Section 6.5.

4. The uncertainity result percentage, $U_{RP,}$ shall be calculated in accordance with ~~For final reported uncertainty calculation, this shall be converted back to a percentage figure per~~ Equation 6.4.2.4:

$$U_{RP} = \frac{U_R}{E} \quad (6.4.2.4)$$

Where
$U_{RP}$ is the Uncertainty Result as a percentage
$U_R$ is the result of Equation 6.4.2.3
$E$ is the total reported emissions included in $U_R$ *and calculated in accordance with Section 6.5*.

**6.4.3 Reported Uncertainty Calculation.**

~~For each reported value~~, The total combined uncertainty percentage, $U_{Total,P}$, shall be calculated in accordance with Equation 6.4.3. ~~as the sum of the material quantity uncertainty from Section 6.4.1 and emissions data uncertainty percentage from Equation 6.4.2.4.~~

$$U_{Total,P} = \sqrt{U_M{}^2 + U_{RP}{}^2} \quad (6.4.3)$$

where
$U_M$ is the material uncertainty determined in accordance with Section 6.4.1
$U_{RP}$ is the emissions uncertainty result percentage calculated in accordance with Section 6.4.2

~~This percentage value~~ $U_{Total,P}$ shall be multiplied by the sum of all emissions calculated per Section 6.5 and added to that sum to create the overall embodied emissions value.

**Informative Note:** *This process is meant to provide a benefit to projects able to calculate a more accurate overall embodied emissions value using preferred data types within the data hierarchy without preventing the calculation of embodied emissions for materials and products where preferable data sources are unavailable.*

**6.5 Quantification and Boundaries per *Life Cycle Stages***

**6.5.1 Product (Modules A1 through A3)**

~~This stage~~ The assessment shall ~~include~~ calculate emissions associated with the creation of finished physical materials to be permanently installed in the *building* and associated *site* in accordance with~~. These include all processes associated with raw material extraction and processing intermediate transportation during the manufacturing process, and manufacturing. Calculation of these emissions follows~~ ~~using~~ Equation 6.5.1,~~and~~ and either Section 6.5.1.1 or Section 6.5.1.2.

$$EM_{LCS} = \sum_p m_p \times CF_p \quad (6.5.1)$$

where
$EM_{LCS}$ are the *greenhouse gas emissions* for the relevant *life cycle stage* (kg $CO_2$e).
$p$ is a given product or material.
$mp$ is the quantity of product, $p$, in accordance with Section 6.2.
$CFp$ is the product's ~~embodied carbon~~ *emissions factor* for the relevant *life cycle stage* per Section 5.4.

> ***Informative note*:** Where the units of mp and CFp do not match, the material quantity should be converted to match the units of the ~~embodied carbon~~ *emissions factor* using industry or product-specific density data. ~~Where this data is unavailable, *ASHRAE Handbook of Fundamentals* average density data for the material should be used.~~

**6.5.1.1 As-Designed Compliance Path**
Material quantities shall be taken from the *Bill of Materials*, per Section 6.2, and.~~T~~the ~~embodied carbon~~ *emissions factor* for *A1-A3* for each material or product shall be sourced per Section ~~6.3.3.~~ 6.3.2.~~2.2.~~

**6.5.1.2 As-Built Compliance Path:**
Material quantities shall be taken from the *Bill of Materials,* per ~~[~~Section 6.2~~]~~, and the ~~embodied carbon~~ *emissions factor* for *A1-A3* for ~~that~~ each material or product shall be sourced per Section ~~6.3.4.~~ 6.~~2.2.2.~~3

**6.5.2 Transportation to Site (*Module A4*)**
~~This stage~~ The assessment shall include all emissions arising from the ~~travel~~ transportation of products from the point of final manufacture or fabrication to the *building* or *site* in accordance with Section 6.5.2.1 or Section 6.5.2.2.

**6.5.2.1 As-Designed Compliance Path.**
Material or product quantities ~~shall be obtained from the material quantities (per Section 6.2) and~~ shall be multiplied by the appropriate emission factor from Table 6.5.2.1.

For transportation scenarios not covered by Table 6.5.2.1 the calculation method in Section 6.5.2.2 shall be used with assumed means of transportation and estimated transportation distances. Alternate return trip factors shall be permitted for specific materials or products where supported by documentation approved by the *AHJ*.

Exceptions to Section 6.5.2.1:

1. ~~For transportation scenarios not covered by Table 6.5.2.1 (e.g. manufactured in other continents) or for construction sites outside of North America, the *as-built* path should be used based on assumed means of transportation and estimated transportation distances.~~ Where *Module A4 GHG emissions* are calculated in accordance with Section 6.5.2.2 using typical distances from a government database applicable to the *project* location.
2. ~~Where A4 is included in the relevant *EPD*, the corresponding *GWP* value for *A4* shall supersede the transportation factors provided in Table 6.5.2.1.~~ Where *Module A4 GHG emissions* are calculated in accordance with Section 6.5.2.2 using project-specific transportation data.

**Table 6.5.2.1: Default emission factors for transportation to site in ~~North America~~ the contiguous United States, Mexico and Canada**

| Type/Source of product | Emission factor | |
|---|---|---|
| Ready-mixed concrete from a local plant ~~[1]~~ | ~~11.3~~x 9.75 | $kgCO_2e/yd^3$ |
| Manufactured products ~~[2]~~ | | |
| Locally manufactured & sourced (within 100 miles) | ~~25.7~~ 42.2 | $kgCO_2e$/ton |
| Regionally manufactured & sourced (~~within~~between 100 and 500 miles) | ~~129~~ 211 | $kgCO_2e$/ton |
| ~~Nationally~~ Manufactured & sourced on same continent (beyond 500 miles) | ~~257~~ 422 | $kgCO_2e$/ton |
| European manufactured to Eastern ~~US~~ North America | ~~459~~ 314 | $kgCO_2e$/ton |
| European manufactured to Western ~~US~~ North America | ~~331~~ 525 | $kgCO_2e$/ton |
| Asian manufactured to Eastern ~~US~~ North America | ~~500~~ 546 | $kgCO_2e$/ton |
| Asian manufactured to Western ~~US~~ North America | ~~371~~ 335 | $kgCO_2e$/ton |

~~[1] Established based on data from 2021 NRMCA Fleet Benchmarking and Costs Survey~~

~~[2] Established based on EPA Emission Factors for Greenhouse Gas Inventories, 2023. Includes return factor of 0.5 for local and regional trucking.~~

***Informative Note:*** *The emission factor for ready-mix concrete is based on an average one-way haul distance of 15 miles and includes a return trip. For products manufactured within 500 miles, a return trip factor of 0.5 is included in the emission factor*.

### 6.5.2.2 As-Built Compliance Path

~~Material quantities shall be obtained from the *Bill of Materials* (per Section 6.2).~~ The assessment shall calculate GHG emissions associated with transportation of products to the *building* or site in accordance with Equation 6.5.2.2. Transportation distance ($d_D$) and applicable means of transportation shall be per contractor tracking or as verified by *licensed design professionals*. Where travel distance per contractor tracking is not available, it shall be taken as the straight-line distance from point of final manufacture or fabrication to the *building* or site multiplied by 1.4. Alternate return trip factors shall be permitted for specific materials or products where supported by documentation approved by the *AHJ*.

~~Calculations of *A4 GHG emissions* shall follow Equation 6.5.2.2:~~

$$EM_{A4} = \sum_{p} m_p \times d_p \times EFO_p \times (1 + RF_p) \quad (6.5.2.2)$$

where
*p* is a given product or material delivered to the *site*
*mp* is the quantity of product or material *p* expressed as a mass or a volume
$d_p$ is the travel distance of product or material *p* from point of final manufacture or fabrication ~~last point of sale~~ to the site
*EFOp* is the emission factor for outbound trip based on applicable transportation mode from Table 6.5.2.2.
*RFp* is the return trip factor for the applicable mode of transportation from Table 6.5.2.2.

**Exceptions to 6.5.2.2:**

1. In instances where measured data cannot be tracked or verified, the default factors provided in Section 6.5.2.for the *As-Designed* Compliance Path shall be used.
2. Where transport-specific *emissions factors* are known (e.g. *electric vehicles* used for transportation), these shall supersede the transportation factors provided in Table 6.5.2.2.

**Table 6.5.2.2: *Emission Factors* by Transport Mode for Use in Calculating A4 *Emissions*.**

| Mode of transportation | GHG emission factor for outbound trip (EFO) | Return trip factor (RF) [3] |
|---|---|---|
| Concrete mixing truck | ~~0.381~~ 0.325 $kgCO_2e/yd^3$-mile ~~[1]~~ | 1.0 |
| Truck | ~~0.171~~ 0.281 $kgCO_2e$ per ton-mile ~~[2]~~ | 0.5 for trips up to 500 miles<br>0.0 for trips longer than 500 miles |
| Air | ~~0.704~~ 0.855 $kgCO_2e$ per ton-mile ~~[2]~~ | - |
| Ship or Barge | ~~0.045~~ 0.023 $kgCO_2e$ per ton-mile ~~[2]~~ | - |
| Rail | ~~0.021~~ 0.015 $kgCO_2e$ per ton-mile ~~[2]~~ | - |

~~[1] Established based on data from 2021 NRMCA Fleet Benchmarking and Costs Survey~~
~~[2] Established based on EPA Emission Factors for Greenhouse Gas Inventories, 2023.~~

**6.5.3 Construction (A5)**

~~This stage~~ The assessment shall ~~include~~ calculate *GHG emissions* associated with preparation activities occurring ~~on construction~~ at the *building* or site until *project* delivery in accordance with Section 6.5.3.1 through 6.5.3.3, ~~inclusive of pre-construction *demolition* (*A5*-1), if applicable, and construction activities (*A5*-2), as well the impacts from waste generated during construction (A5-3)~~ and inclusive of materials left in place from the construction process. Worker transportation to and from the site during the construction process shall be excluded.

**6.5.3.1 Pre-construction *Demolition* (A5-1)**

~~This stage~~ The assessment shall ~~include~~ calculate *GHG emissions* due to any *demolition* or *deconstruction* of existing *structures* required for the *project* prior to starting construction, including *GHG emissions* from disposal of materials, in accordance with Section 6.5.3.1.1 or Section 6.5.3.1.2.

**6.5.3.1.1. As-Designed Compliance Path.**

*GHG emissions* shall be estimated based on 35 kg $CO_2e/m^2$ of the *gross floor area* of the *building* being demolished.

**6.5.3.1.2 As-Built Compliance Path.**

~~Follow procedure~~ The assessment shall calculate *GHG emissions* in accord~~ing~~ance ~~to~~ with Section 6.5.3.2.2 (*As-Built* Compliance Path for A5-2) for *GHG emissions* arising from *demolition* activities on *site* and in accordance with Section 6.5.3.3.2 (*As-Built* Compliance Path for A5-3) for *GHG emissions* arising from *demolition* waste.

**6.5.3.2 Construction Activities (A5-2)**

~~This stage~~ The assessment shall ~~include any~~ calculate *GHG emissions* associated with all activit~~y~~ies requiring the use of equipment, tools, or facilities consuming fuel, energy, or water on the construction *site* in accordance with Section 6.5.3.2.1 or Section S.5.3.3.2. ~~This~~ The calculation shall include~~s~~, but ~~is~~ not be limited to: *site* preparation, groundwork and excavation, ground improvement, connection to utilities, installation of temporary elements necessary for construction, removal of such elements, installation of all materials considered in *A1-A4*, storage of materials on-site or in the staging area, any field assembly or production occurring on site prior to installation, any transportation or lifting of materials occurring on-*site*, and use of facilities and trailers by workers on *site*.

**6.5.3.2.1 As-Designed Compliance Path.**

*GHG emissions* shall be estimated based on 40 kg $CO_2e/m^2$ of the *project gross floor area*.

**6.5.3.2.2 As-Built Compliance Path.**

Electricity, natural gas, or other fuels, and water consumption shall be determined from utility bills or meter readings. Fuel consumption shall be determined from delivery tickets, invoicing, ~~or estimated from~~ GPS trackers or telematic data. Where fuel consumption data on a per *building* basis is not available, estimates based on allocation shall be permitted where acceptable by the *AHJ*. Additional water brought to the *site* shall be determined from delivery tickets, invoices, or submittals. *GHG emissions* associated with energy usage shall be calculated in accordance with Section 7.3.3. GHG emissions associated with water usage shall be calculated in accordance with Section 7.4.2.

**6.5.3.3 Construction Waste (A5-3)**

~~This stage~~ The assessment shall ~~include~~ calculate the GHG emissions associated with manufacturing, transportation, ~~storage,~~ and end-of-life impacts ~~related to~~ of materials wasted on *site*, inclusive of packaging in accordance with Section 6.5.3.1 or Section 6.5.3.2. The methodologies in Sections 6.5.1 ~~for~~ (*Modules A1-A~~43)~~ 6.5.2 (A4), ~~and~~* 6.5.10 (*Module C2)~~C1~~C2-~~C4~~*, 6.5.11 (*Module C3) and 6.5.1.2 (*Module C4)~~and *D1-2* [Sections 6.5.1, 6.5.2, 6.5.5, and 6.5.6 and 6.5.10 to 6.5.12] in this Standard~~ shall be used to calculate ~~embodied emissions for the quantities of wasted materials.~~*GHG emissions* associated with materials wasted on site. *Construction waste* quantities estimated for the purpose of ~~calculating A5-3 emissions~~ this section shall be ~~are~~ in additional to the material quantities established per Section 6.2.

***6.5.3.3.1 As-Designed* Compliance Path.**

On-site material waste quantities shall be calculated ~~using~~ by multiplying the material quantities determined in

accordance to Section 6.2 by the wastage rates ~~provided~~ in Table 6.5.3.3.~~, except where otherwise provided in Module A5 data from the relevant *EPD* or in published industry standards. The weight of packaging shall be calculated as 20% of all *construction waste* generated on site, unless packaging is already included in the relevant *EPD*.~~ Wasted packaging quantities shall be additive and shall be estimated by multiplying the total mass of on-site material waste calculated in accordance with this section, excluding ready-mix concrete and structural materials with a density exceeding 50 lbs/ft3, by the following percentages: 3.0% for wood pallets, 1.2% for paper and cardboard, and 0.8% for plastics (totaling an additional 5% by mass for packaging).

Exception to Section 6.5.3.3.1: ~~Packaging for ready-mix concrete shall be taken as zero.~~

1. Where on-site material wastage rates from a government database applicable to the *project* location are available, they shall supersede the wastage rates in Table 6.5.3.3 and the default values for estimating packaging.
2. Where *GHG emissions* for on-site wastage are included and itemized in the relevant *EPD,* and where project-specific data is not available, the corresponding *GWP* value shall be allocated to A5-3 and supersede the wastage rates in Table 6.5.3.3 and the default values for estimating packaging.
3. Where project-specific data for on-site *construction waste* is available, it shall supersede the wastage rates in Table 6.5.3.3 and the default values for estimating packaging.

**6.5.3.3.2 *As-Built* Compliance Path.**

The same method described in Section 6.5.4.3.3.1 for the *As-Designed* Compliance Path shall be used. Where available, the values from Table 6.5.4.3.3 shall be replaced by project-specific wastage rates measured by the contractor responsible for installation. For project size over 2,000 square feet, the following quantities shall be reported by the contractor at completion:

a. Weight of waste collected for disposal (landfilled or incinerated)

b. Weight of waste collected to be reused on-*site* or off-*site*

c. Weight of waste collected for recycling (including take-back programs).

d. Weight of waste collected for organic collection (where diverted from landfill).

**Table 6.5.3.3: Default on-site material wastage rates**

| | On-site wastage rate (See Note 1) |
|---|---|
| **Pre-fabricated assemblies** | |
| Standardized assembly and small MEP equipment (400 lbs or less) selected from a manufacturer's catalogue. See Notes 2 and 4. | 1% |
| Custom assembly made to order and large MEP equipment (more than 400 lbs). See Notes 3 and 4. | 0% |
| **By delivery/installation method** | |
| Delivered by a concrete mixer truck and poured in place (ready-mix concrete) | 5% |
| Sprayed (shotcrete, sprayed fire resistive material) | 10% |
| Soil mixing or jet grouting (grout) | 20% |
| Driven into the ground (piles): | |
| - precast concrete | 5% |
| - steel piles or casing | 3% |
| - timber piles | 20% |
| Troweled (mortar, skim coating) | 15% |
| Liquid applied (paint, self-leveling concrete topping, roof membranes) | 10% |
| **By element size/type** | |
| Blocks and bricks | 5% |
| Tiles (including carpet) and siding | 8% |
| Sheets, boards or panels delivered in standard sizes to be cut as needed on site (See Note 5): | |
| - metal (steel decking, roofing, flashing, welded wire fabric) | 10% |
| - non-metal (gypsum, plywood) | 15% |
| Elements delivered to site in standard length to be trimmed as needed to required length on site (metal studs, light-weight timber framing, plumbing pipes) | 10% |
| Rebar | 3% |
| Steel connection materials (bolts, studs, welding electrodes, straps, anchors) | 5% |

Notes:

1. For materials not listed in this table, the wastage rate shall be taken as 5%.

2. Applies to standardized pre-fabricated assemblies or equipment that are shipped to site ready to be installed without any *alterations* resulting in wastage such as cutting or trimming or drilling. For example: standard windows, small appliances.

3. Applies to custom pre-fabricated assemblies meeting all of the following: .

a. Weighs more than ~~200~~ 400 lbs per piece

b. Fabricated to the specific dimensions required for the *project*.

c. Shipped to site as a kit of parts or as a single piece ready to be installed without any *alteration*s resulting in wastage such as cutting or trimming or drilling.
For example: unitized curtainwall, volumetric modular construction, structural steel members, glue-laminated members~~beams~~ and CLT panels, architectural precast panels.

4. Any additional material to be applied on site such as coatings or connection materials shall be accounted for separately with applicable on-site wastage ratios.

5. Applies to flat products at least 18in in two directions. Otherwise use "tiles" or "elements delivered to site in standard length."

**6.5.4 Use Stage (B1)**
All material-related GHG *emissions* and ~~carbon~~ removals arising from *building* components during the *reference study period* shall be calculated in accordance with Section 6.5.4.1 and 6.5.4.3, ~~reported in *B1*, including: ***B1-1***: material emissions and uptake and ***B1-2***: *fugitive emissions.*~~

***Informative note***: Material emissions included in B1-1 are through processes such as product off-gassing. Uptake is through direct material removal of carbon through processes such as *carbonation* but not including removals from *biomass* growth on the *building* or site. Detailed guidance on calculating and reporting carbon uptake is given in Section 6.5.13.

**6.5.4.1 Material emissions and uptake (B1-1).**
GHG ~~E~~emissions shall be calculated for applicable materials ~~using Equation 6.5.1 from~~ in accordance with Section 6.5.1. with ~~carbon~~ GHG *emissions factors* for *Module B1*.

**6.5.4.2 Fugitive Emissions ~~(*Modules B1-2*).~~** GHG emissions associated with fugitive emissions shall be calculated in accordance with Sections 6.5.4.2.1 through 6.5.4.2.5.

**6.5.4.2.1 Data Requirements – Fugitive Emissions.** GHG emissions shall be calculated using data complying with Section 6.5.4.2.1.1 through 6.5.4.2.1.3.

**6.5.4.2.1.1 Fugitive Emissions.** The *greenhouse gas emissions assessment* shall include *fugitive emissions* occurring during the ~~*installation*~~ *construction stage* (*Module A5*), *use stages* (*Modules B1-B5*), and *end-of-life stage* (*Module C1*) of the *project* including refrigerants in refrigeration and HVAC *equipment* and gases in *permanently installed* fire suppression equipment. A methodology for assessing *greenhouse gas emissions* from ~~*Industrial*~~*process gases* is included in this section but is not required unless directed by the *AHJ.*

**6.5.4.2.1.2 Global Warming Potentials**. All calculations in this section shall use the 100-year *global warming potentials* values from Table C.1 in Normative Appendix C. Where Table C.1 does not include values for gases associated with the *project*, values approved by the *AHJ* shall be used.

**Exception to 6.5.4.2.1.2:** Where the *AHJ* requires a greenhouse gas assessment using a 20-year *global warming potential* basis, ~~and~~ *emissions factors* for all refrigerants and other gases shall use the 20-year *global warming potential* basis values in Table C.1. Where Table C.1 does not include values for gases associated with the *project*, values approved by the *AHJ* shall be used.

**6.5.4.2.1.3 Leakage rates.** Leakage rates shall be determined in accordance with Section ~~6.5.2.3~~6.5.4.2.2.2 or Section ~~6.5.2.4~~6.5.4.2.2.3 or Section 6.5.4.2.2.4 or the leakage rates from Table C.2 shall be used.

**6.5.4.2.2 Quantifying Greenhouse Gas Emissions from Fugitive Emissions.** GHG emissions associated with *fugitive emissions* shall be calculated in accordance with Sections 6.5.4.2.2.1 and 6.5.4.2.2.2.

**6.5.4.2.2.1 Refrigeration and HVAC Equipment Emissions.** GHG emissions associated with refrigeration and HVAC equipment shall be calculated in accordance with Sections 6.5.4.2.2.1.1 and 6.5.4.2.2.1.2.

**6.5.4.2.2.1.1 Equipment and refrigerant inventory.** An inventory of refrigeration and HVAC equipment shall be performed and reported in accordance with Section 9. This shall include the types and quantity of equipment, each type of refrigerant used, and mass of each type of refrigerant.

**6.5.4.2.2.1.2 Refrigerant replacement**. ~~When calculating life cycle emissions for the assessment~~reference study ~~period, it~~ GHG emissions calculations shall be assumed that the refrigerant will be replaced in kind during the ~~assessment~~*reference study period*.

**Exception to 6.5.4.2.2.1.2** Where a jurisdiction has mandated GWP limits on refrigerants, and where approved by the *AHJ*, the mandatory *GWP* limit shall be used after the end of the default *service life* of the equipment.

**6.5.4.2.2.2 Calculate emissions during installation (*Module A5*)**. GHG emissions associated with *fugitive emissions* from ~~Determine~~ equipment ~~that was~~ installed during the ~~assessment~~ *reference study period* and charged on-site shall be calculated in accordance with Section 6.5.4.2.2.2.1 or Section 6.5.4.2.2.2. *GHG emissions* calculations shall not include *fugitive emissions* from equipment that was pre-charged ~~by the manufacturer shall not be included~~.

**6.5.4.2.2.2.1 *As-Designed* Compliance Path**. Refrigerant leakage rate shall be obtained from Table C.2.

**6.5.4.2.2.2.2 *As-Built* Compliance Path.** Refrigerant leakage rate shall be obtained from contractor submittals where available, with default to Table C.2 where data are unavailable.

GHG emissions associated with ~~For~~ each new piece of equipment, shall be calculated using ~~use~~ Equation 6.5.4.2.2.2.2 ~~to calculate fugitive *greenhouse gas emissions* during installation~~.

$$GHG_{ref,ie} = \sum_{n=1}^{N} REF_{ch,site} \times x_i \times GWP_{ref} \; \sout{GEF_{ref}} \qquad (6.5.4.2.2.2)$$

where

n = installation event within *building* life-cycle

N = total anticipated installation events throughout the full *building* life-cycle, for each unique refrigerant type and to be estimated based on typical equipment life per ASHRAE Equipment Life Expectancy Chart shown in Appendix A.

$GHG_{ref,ie}$= *Greenhouse gas emissions* of leaked refrigerant during installation, $kgCO_2e$

$REF_{ch,site}$ = Mass of refrigerant charged within the *site* boundary during installation, kgREF

$x_i$ = Fraction of refrigerant charged within the *site* boundary and leaked during installation, determined based on the compliance path

~~$GEF_{ref}$~~ $GWP_{ref}$ = ~~*Greenhouse gas emissions* factor~~ *global warming potential* of leaked refrigerant, $kgCO_2e$/kgREF

**6.5.4.2.3 Calculate operating emissions (B1)**. GHG emissions associated with ~~Determine~~ *fugitive greenhouse gas emissions* associated with equipment leaks, piping leaks, and service losses over the ~~assessment~~*reference study period* shall be calculated in accordance with Section 6.5.4.2.3.1 or Section 6.5.4.2.3.2.

***6.5.4.2.3.1. As-Designed* Compliance Path.** Operating refrigerant leakage rate shall be obtained from equipment *EPD*s where available. Table C.2 shall be used where *EPD* data are unavailable.

**6.5.4.2.3.2 *As-Built* Compliance Path.** An average annual leakage rate for each piece of equipment shall be determined based on ~~the lesser of~~ all available annual refrigerant replacement data, not to exceed ~~and~~ the five

most recent years of refrigerant replacement data. GHG emissions shall be calculated for ~~For~~ each piece of equipment, using Equation 6.5.4.2.3.2. ~~to calculate emissions.~~

$$GHG_{ref,oe} = \sum_{t=1}^{T} REF_{ch,tot} \times x_o \times ~~GEF_{ref}~~ GWP_{ref}$$

(6.5.4.2.3.2)

where
t = timestep
T = Total timesteps of the ~~assessment~~*reference study period*
$GHG_{ref,oe}$ = *Greenhouse gas emissions* of leaked refrigerant during operations, $kgCO_2e$
$REF_{ch,tot}$ = Mass of pre-charged refrigerant and refrigerant charged onsite (total refrigerant charge), kgREF
$x_o$ = Fraction of total refrigerant charge leaked during operations as determined from Table based on the compliance path

~~$GEF_{ref}$~~ $GWP_{ref}$ = ~~*Greenhouse gas emissions* factor~~ *global warming potential* of leaked refrigerant, $kgCO_2e/kgREF$

**6.5.4.2.3.3 Calculate disposal emissions (C4)**. GHG associated with all equipment ~~Identify any~~ disposed ~~equipment~~ during the ~~assessment~~*reference study period* shall be calculated in accordance with Section 6.5.4.2.3.1 or Section 6.5.2.3.3.2.

**6.5.4.2.3.3.1 *As-Designed* and *As-Built* Compliance Path.** The recovery rate used to determine disposal emissions shall be obtained from equipment *EPD*s where available. Table C.2 shall be used where *EPD* data are unavailable. ~~For~~ GHG emissions shall be calculated for each piece of disposed equipment, ~~use~~ using Equation 6.5.4.2.3.3.1. ~~to calculate emissions.~~

$$GHG_{ref,de} = \sum_{n=1}^{N} REF_{ch,tot}\,(1 - Z_d) \times ~~GEF_{ref}~~ GWP_{ref}$$

(6.5.4.2.3.3.1)

where
n = disposal event within building life-cycle
N = total disposal events throughout the building life-cycle to be estimated based on typical equipment life per ASHRAE Equipment Life Expectancy Chart in Appendix A.

$GHG_{ref,de}$ = *Greenhouse gas emissions* of refrigerant at disposal, $kgCO_2e$
$REF_{ch,tot}$ = Mass of pre-charged refrigerant and refrigerant charged within the site boundary (total refrigerant charge), kgREF
$Z_d$ = Refrigerant recovery efficiency during the disposal process as determined from Table C.2~~7.5.1.3~~
~~$GEF_{ref}$~~ $GWP_{ref}$ = ~~*Greenhouse gas emissions* factor~~ *global warming potential* of leaked refrigerant, $kgCO_2e/kgREF$

**6.5.4.2.4 Fire Suppression Operating System Emissions (B1).** *GHG emissions* associated with ~~This section will specify the method to calculate emissions from~~ permanently installed fire suppression systems shall be calculated in accordance with Section 6.5.2.4.1. ~~Under this method, the user shall multiply the capacity of the system by an emissions factor for the system. Emissions shall be calculated in accordance with section 6.5.4.2.4.1~~ The user shall perform an inventory of systems and determine the number and types of fire

suppression systems, by gas type, and the fire suppressant capacity of each system. If the gas type used has a *GWP* greater than 0.0, total emissions shall be calculated in accordance with section 6.5.4.2.4.1.

**6.5.4.2.4.1 Calculate total emissions.** ~~Determine the total capacity of each permanently installed system.~~

~~**6.5.4.2.4.1 Calculate total emissions**~~. ~~**6.5.4.2.4.1.1** ***As-Designed*** **and** ***As-Built*** **Compliance Path**~~The user shall calculate total GHG emissions in accordance with Equation 6.5.4.2.4.1. ~~add the capacities of each fixed/permanently installed system for each gas and multiply the total capacity by the appropriate emissions factor.~~ Annual emissions from fixed/permanently installed systems shall be ~~are~~ assumed to be 2.5 percent (0.025) of the total capacity of the system for each gas. The ~~emission factors~~ *global warming potentials* ~~provided~~ to be used shall be those for the applicable gas ~~for this method are as provided~~ in Table ~~B.2~~C.1. ~~Multiply the emissions of each fire suppressant by its GWP from Table B.2~~C.1. ~~to calculate $CO_2$~~ equivalent emissions

$$GHG_{fs} = \sum_{t=1}^{T} FS_{ch,tot} \times .025 \times ~~GEF_{fs}~~ GWP_{fs}$$
(6.5.4.2.4.1)
Where
$GHG_{fs}$ = *Greenhouse gas emissions* associated with fixed fire suppression system, $kgCO_2e$
$FS_{ch,tot}$ = Total capacity of the fixed installed fire suppression system, kgFS
.025 = annual fraction of leaked fire suppression gas
~~*GEF*~~$GWP_{fs}$ = ~~*Greenhouse gas emissions* factor~~ *global warming potential* of the fire suppression gas, $kgCO_2e/kgFS$

**6.5.4.2.5 ~~Industrial~~ Process Gas Emissions**
Where the ~~*authority having jurisdiction*~~*AHJ* requires that a *greenhouse gas assessment* include ~~*industrial*~~*process gases*, the ~~project~~ assessment shall comply with Sections 6.5.4.2.5.1 and 6.5~~7~~.4.2.5.2.

***Informative notes****:*
1. Process gases include but are not limited to nitrogen, nitrous oxide, oxygen, *carbon dioxide*, argon, hydrogen, helium and acetylene and are used in a wide range of industries, which include oil and gas, petrochemicals, chemicals, power, mining, steelmaking, metals, environmental protection, medicine, pharmaceuticals, biotechnology, food, water, fertilizers, nuclear power, electronics and aerospace.
2. It is assumed that all *process gas* purchased during the *reference study period* is used and released during the *reference study period*.

**6.5.4.2.5.1 Determine** ~~***industrial****~~***process gases***. ~~The user shall determine whether any *industrial*~~*process gases* ~~with a *GWP* greater than 0.0 will be used in processes. If so, the user shall estimate~~ ~~t~~The mass of each gas with a GWP greater than 0.0 to be purchased during the ~~assessment~~*reference study period* shall be estimated. ~~If~~ Where data is not available in mass units, ~~the user may need to~~ converting from volume to mass using the density of the specific gas shall be permitted. ~~It is assumed that~~ All gas purchased during the ~~assessment~~*reference study period* shall be assumed to be ~~is~~ used and released during the ~~assessment~~*reference study period*. Where ~~If the user makes~~ a bulk purchase of gas will be ~~and plans on~~ used~~ing~~ ~~the gas~~ over multiple years, ~~the user shall~~ dividing~~e~~ the bulk amount by the expected years of usage shall be permitted. ~~and consider that to be the purchase amount for the current assessment~~reference study period, ~~as well as the applicable future assessment~~reference study ~~periods.~~

**6.5.4.2.5.2. Calculate emissions.** ~~Determine~~ GHG emissions associated with total amount of *process gases* purchased shall be calculated in accordance with Section 6.5.4.2.5.2.1 or Section 6.5.4.2.5.2.2.

~~**6.5.4.2.5.2. Calculate emissions**~~. **6.5.4.2.5.2.1 *As-Designed* Compliance Path** GHG emissions shall be calculated in accordance with Equation 6.5.4.2.5.2.1 using ~~The user shall sum the amount of gas to be purchased for each gas type and multiply the total by~~ the appropriate GWP values from Table 7.5.1.2(1) or Table 7.5.1.2(2). ~~to calculate CO2 equivalent emissions.~~

$$GHG_{tot} = (PG1_{,tot} \times \text{~~GEF~~}GWP_{pg1}) + (PG2_{tot} \times \text{~~GEF~~}GWP_{pg2}) \ldots \quad (6.5.4.2.5.2)$$

Where
$GHG_{tot}$ = Total *greenhouse gas emissions* from ~~*industrial*~~*process gases, kg$CO_2$e*
$PG1_{tot}$ = Total ~~*industrial*~~*process gas* type 1 total purchased, kgPG1
~~GEF~~$GWP_{pg1}$ = ~~Greenhouse gas emissions factor~~*global warming potential* for ~~*industrial*~~*process gas* type 1, kg$CO_2$e/kgPG1
$PG2_{tot}$ = Total ~~*industrial*~~*process gas* type 2 total purchased, kgPG2
~~GEF~~$GWP_{pg2}$ = ~~*Greenhouse gas emissions* factor~~ *global warming potential* for ~~*industrial*~~*process gas* type 2, kg$CO_2$e/kgPG2

**6.5.4.2.5.2.2 *As-built Compliance Path***. *GHG emissions* shall be calculated in accordance with Section 6.5.4.2.5.2.1 ~~except that~~ using the actual ~~rather than estimated~~ quantities of gases purchased deterimined in Section 6.5.4.2.5.1.~~ during the assessment~~reference study period shall be used.

~~**6.5.4.2.6 Fire Suppression System Emissions**~~

~~**6.5.4.2.6.1** *As-built* and operated emissions shall be calculated in accordance with Section 6.5.4.2.4.~~

~~**6.5.4.2.7 Industrial~~Process~~ Gas Emissions**~~

~~**6.5.4.2.7.1** *As-built* and operated emissions shall be calculated in accordance with Section 6.5.4.2.5 except that actual rather than estimated quantities of gases purchased during the assessment~~reference study~~ period shall be used.~~

**6.5.5 Maintenance Emissions (*B2*)** GHG emissions associated with the *building* or site maintenance shall be calculated ~~excluded from calculations except~~ where a calculation procedure is specified and required by the *AHJ*.

Informative Note: *Module B2* includes all emissions arising from planned activities required for regular validity of warranties, continued efficiency, cleanliness, and good appearance of *building elements* with the exception of operational emissions already accounted for in *Module B6*.

**6.5.6 Repair Emissions (*B3)*** GHG emissions associated with the *building* or *site* repairs shall be calculated ~~excluded from calculations except~~ where a calculation procedure is specified and required by the *AHJ* ~~at this time.~~

**Informative Note:** *Module B3* ~~shall~~ includes all emissions associated with the mending, renewal or partial replacement of worn, damaged or degraded components or elements. Emissions estimates for *B3* include emissions from all activities associated with repair, including production of products, transportation to *site*, installation and transportation and disposal of waste.

~~**6.5.6.1 *As- Designed* Compliance Path:** Reserved for future use.~~

~~**6.5.6.2 *As-Built Compliance Path*:** Reserved for future use.~~

**6.5.7 Replacement Emissions (*B4*)** ~~shall include all~~ GHG emissions associated with the anticipated need to replace *building elements* shall be calculated in accordance with Section 6.5.7.1 or Section 6.5.7.2, including all like-for-like, whole-number replacements of products, components, and systems over the *reference study period*. ~~*B4*~~ Calculations shall include all emissions arising from production, transportation to *site*, installation, and transportation and disposal of waste of said products.

**6.5.7.1 *As-Designed* Compliance Path:** GHG emissions shall be calculated for applicable material or product replacement in accordance with the GHG emissions calculations in Sections 6.5.1 and 6.5.1.1 and with Equation 6.5.7.1. *Building element service life* default value shall ~~be~~ correspond to the applicable material or product.~~as shown in~~ ~~assumed as depicted in Table A.1.~~ ~~Informative~~ Normative Appendix A Table A.1 Omniclass Building Elements. ~~Where available, p~~ Product or material *service life* shall be adjusted to match the industry ~~wide~~average applicable PCR or product-specific *EPD* where available. Service lives for products contained within larger assemblies shall be adapted to match the expected *service life* of the assembly for the *project*.

~~Emissions shall be calculated for applicable material or product replacement by multiplying the expected integer number of material or equipment replacements by the results of Equation 6.5.1 from section 6.5.1.~~

$$E_L \text{ ~~} EEEE_{LLLLLL} \text{ ~~} \times n = LE \qquad (6.5.7.1)$$

where
~~$EEEE_{LLLLLL}$~~ $E_L$ are the *greenhouse gas emissions* for the relevant *life cycle stage* for a given material or product
n is the integral number of material or equipment replacements (e.g. if the replacement value is 2.3 the integral replacement number is 3 as one will not procure 0.3 of an item)
LE is the resultant lifetime replacement emissions of a given material or product.

Replacement emissions calculations shall ~~must be considered~~ use~~d~~ the same data for materials and products as ~~was~~ used in Sections 6.5.1 through 6.5.3 (*Modules A1–A5)* for installation and Sections 6.5.9 through 6.5.12 (*Modules C1–C4)* for their end of life. Any loads and benefits beyond the *system boundary* from the recovery of materials from *Module A5* or *Modules C1– C4* and calculated in accordance with Section 8 ~~will also~~ shall be used for the recovery of any materials covered by this section ~~in *B4,*~~ reported in *D1.* The treatment of *biogenic carbon* for replacement of biobased materials during the *RSP* should be in accordance with Section 6.5.13.1.

***6.5.7.2 As-Built Compliance Path***: *GHG emissions* shall be calculated for applicable material or product replacement in accordance with the *GHG emissions* calculations in Sections 6.5.1 and 6.5.1.1 and with Equation 6.5.7.1. Measured service lives shall be used according to maintenance reports or other facility tracking where~~n~~ available. Where~~n~~ not available, default values shall be used from Table A.1 in Normative Appendix A. ~~Emissions shall be calculated for applicable materials and products by multiplying the number of documented material or equipment replacements by the results of Equation 6.5.1 from Section 6.5.1.~~

Where a new product or assembly is used to replace a previous product or assembly (ex. a new carpet product is used with a different backing and underpad system), the associated *Module B4* emissions shall match the new product.

**6.5.8 Refurbishment Emissions (*B5*).** The assessment ~~S~~shall include all *GHG emissions* associated with *alterations* or improvements to the *building* or *site* for it to meet a planned change in function or performance. ~~This~~ *GHG emissions* shall be calculated in accordance with Sections 6.5.1 through 6.5.3. ~~be considered a new *project*follow~~

~~include all emissions requiring calculations forfrom~~ (*Modules A1-A5)* for all added products ~~or~~ and materials.

***Informative note*:** Refurbishment activities that shall be treated as a new *project* include but are not limited to: major changes to the layout of the interior space of the *building* to meet an anticipated use change or tenant change, the anticipated fit-out of a space that was shelled in the original construction process*,* the changing of HVAC systems to meet an anticipated change in fuel source or efficiency, a change to the number of stories of a *building*, or a planned extension of the *building* footprint. For a new *project*, existing material that is remaining in place may exclude the original *Module A1-A5* impacts associated with that material.

**6.5.9 *Deconstruction* and *Demolition* (*C1*).** The assessment ~~S~~shall include all *GHG emissions* associated with *deconstruction* or *demolition*.

**6.5.9.1 *As-Designed* Compliance Path.** *GHG emissions* calculations shall include ~~Environmental impacts for~~ all *site* activities associated with *deconstruction* and *demolition* of the *building* or *site* (*Module C1)* ~~shall be included.~~ ~~The~~ e Environmental impact data used in *GHG emissions* calculations shall ~~follow~~ comply with Section 6.3.

**Exception to 6.5.91:** Where environmental impact data complying with Section 6.3 for *Module C1* is not available for a product or material *GHG emissions* calculations in accordance with the following shall be permitted:

**(i.)** Where the *project* does not document *design for deconstruction* practices and the *AHJ* does not require *design for deconstruction* practices, the *GHG emissions* shall be permitted to be calculated at 30% of the *GHG Emissions* calculated in accordance with Section 6.5.3.2 (*Module A5*-2)

**(ii.)** Where the *project* documents *design for deconstruction* practices or the *AHJ* requires *design for deconstruction practices*, the *GHG emissions*, shall be permitted to be calculated ~~if known or be based upon 30% of the emissions in *A5*-2 or~~as 50% of the GHG emissions calculated in in accordance with Section 6.5.3.2 (*Module A5*-2). ~~if the *project* explicitly documents *design for deconstruction* practices or if *deconstruction* is required by the jurisdiction.~~

**6.5.9.2 *As-Built* Compliance Path.** GHG emissions shall be calculated in accordance with Follow the procedure for *A5-1* according to Section 6.5.3.1.2 *(Module A5-1).*

**6.5.10 Waste Transportation Emissions (*C2*)**

GHG emissions shall be calculated in accordance with Section 6.5.10.1 or Section 6.5.10.2 ~~Calculations~~ for ~~C2 shall include~~ the transportation of all materials and products from the demolished or deconstructed *project* to the *site* of disposal or transfer of ownership beyond the *project*, including but not limited to ~~(~~recycling, reuse, and sorting.~~, etc.)~~.

**6.5.10.1 *As-Designed* Compliance Path.**

GHG emissions associated with waste transportation shall be calculated using the following default factor applied to the weight of all materials and products: 13kg$CO_2$~~E~~/ton.

**6.5.10.2 *As-Built* Compliance path.**~~-~~

*GHG emissions* calculations shall be calculated in accordance with Section 6.5.2 and the following:

1.Transportation distances shall be based on current waste and recovery facility locations in the *project* jurisdiction: and

2. Material quantities shall be separated based upon their intended disposal pathway and transportation distance shall be calculated per disposal pathway using the relevant facility, including but not limited to ~~(e.g~~. landfill pathway, or appropriate *recycling* facility~~, etc~~.).

**Exception to 6.5.10.2:** Where data are not available for end-of-life disposal practices, emissions shall be permitted to be calculated for all materials and assemblies ~~using~~ in accordance with Equation 6.5.1 from Section 6.5.1. with *GHG emissions factors* for C2 from ~~a~~ *harmonized LCA dataset* or *industry-average EPD* as an allowable data source per Section 6.3.~~1~~2. ~~Transportation emissions shall be measured according to the requirements for *A4*, according to Section 6.5.2.2.~~

**6.5.11 Waste Processing for Reuse, Recycling, or Recovery (*C3*).**

GHG emissions shall be calculated in accordance with Section 6.5.11.1 or Section 6.5.11.2 for all ~~his stage shall include emissions associated with~~ material processing for reuse, recovery, and *recycling*. For the purposed *GHG emissions* calculations in this section, ~~P~~ processing of materials for reuse and recovery shall include collection, basic processing, crushing, chipping, coating and adhesive removal, and bundling.

~~When~~ Where materials are combusted for energy recovery, the *GHG emissions* from the activity shall be included in GHG emissions calculations in this section. ~~reported under *C3*.~~ Where materials are combusted ~~Combustion w~~ithout energy recovery, the activity shall be included in *GHG* calculations in Section 6.5.11.~~reported under~~ (*Module C4*).

**6.5.11.1 *As-Designed* Compliance Path.**
*GHG emissions* shall be calculated for all materials and assemblies using Equation 6.5.1 from Section 6.5.1. with *GHG emissions factor*s for *C3* from ~~a *harmonized LCA dataset* or *industry-average EPD* as~~ an allowable data source per Section 6.3.~~12 or from reported *EPD* as per Section 6.3.12~~. For bulk materials in jurisdictions with known waste diversion rates, such rates shall ~~should~~ be used. ~~to reflect the jurisdictional practices where available.~~ Where jurisdiction diversion rates are not known, ~~none exist,~~ national averages shall be used.

**6.5.11.2 *As-Built* Compliance Path.**
*GHG emissions* shall be calculated using jurisdiction reports and data to reflect typical waste treatment practices, or official maintenance manuals outlining waste processing practices from the *project* owner. Where none exist, *GHG emissions* shall be calculated for all materials and assemblies using Equation 6.5.1 from Section 6.5.1. with *GHG emissions factors* for C3 from reported *EPD* data as per Section 6.3.4.

**6.5.12 Waste Disposal (*C4*).**
*GHG emissions* associated with *building elements* sent to landfill shall be calculated in accordance with Section 6.5.11.1. or Section 6.5.12.2 ~~reported under C4. This includes all landfill emissions and incineration without energy recovery~~. Where materials are combusted without energy recovery, the *GHG emissions* from the activity shall be included in *GHG emissions* calculations in this section. Where materials are combusted for energy recovery, the *GHG emissions* from the activity shall be included in *GHG emissions* calculations in Section 6.5.11.

**6.5.12.1 *As-Designed* Compliance Path.**
*GHG emissions* shall be calculated for all materials and assemblies using Equation 6.5.1 from Section 6.5.1 with *GHG emissions factors* for C4 from ~~a *harmonized LCA dataset* or *industry-average EPD* as~~ an allowable data source per Section 6.3.~~12 or from reported *EPD* as per Section 6.3.12~~. For bulk materials~~,~~ in jurisdictions with known waste diversion rates, such rates ~~that reflect the jurisdictional practices~~ shall be used. ~~where available.~~ Where jurisdiction waste diversion rates are unkown ~~none exist~~, national averages shall be used.

**6.5.12.2 *As-Built* Compliance Path.**
*GHG emissions* shall be calculated using jurisdiction reports and data to reflect waste treatment practices, or official maintenance manuals outlining waste processing practices from the project owner. Where none exist, *GHG emissions* shall be calculated for all materials and assemblies using Equation 6.5.1 from Section 6.5.1 with *GHG emissions factors* for C3 from reported *EPD* data as per Section 6.3.1.

~~**6.5.13.1 Treatment of *Carbon Sequestration* and Storage.**~~
~~Carbon sequestered or stored using any method that is included in the environmental impact data shall be reported separately, noting the relevant life cycle stage(s) of the product when carbon is sequestered.~~

**6.6 Treatment of Special Topics.** *GHG emissions* shall be calculated in accordance with Section 6.6.1 through 6.6.6.

~~**6.5.13.1.1**~~**6.6.1 Biogenic Carbon.**
*GHG* calculations shall comply with all of the following:

1. *Biogenic* carbon accounting shall be treated in accordance with ISO 21930:2017 section 7.2.7,

*Accounting of biogenic carbon uptake and emissions during the life cycle,* with the following clarifications and limitations: ~~uptake and emissions shall be balanced between nature and the product system for any sustainably sourced timber or biobased products~~.

i. The sequestered *biogenic* carbon ~~may~~ shall be reported as a removal of *biogenic* carbon from the biosphere ~~nature~~ when the *biomass* is harvested in accordance with Section 6.5.1 (Modules (*A1~~-A3~~*) and must be reported as emitted when combusted, decomposed, or degraded in the *life cycle stage* where the emissions occurs in accordance with Section 6.5.11 (*Module C3*) or Section 6.5.12 (Module C4), as applicable. ~~at end of life (*C3* or *C4*). Timber or biobased products that are not sustainably sourced shall not include any *biogenic* carbon uptake.~~

ii. For sustainably sourced forest products, reclaimed wood, or rapidly-renewable agricultural fibers, ~~biogenic carbon may be characterized with~~ a –1 kg CO2e/kg CO2 *biogenic carbon* flow shall be permitted when entering the product system. *Biogenic carbon* uptake for all other forest products shall not be included. National reporting under the United Nations Framework Convention on Climate Change (UNFCCC), ~~or other evidence used to identify forests with stable or increasing forest carbon stocks for the purpose of assessing land use change,~~ shall not be used to determine supply-chain specific sourcing claims.

2. *Biogenic carbon emissions* must be reported separately from fossil emissions, per *life-cycle stage*.

3. Where this standard is used only to calculate ~~Any use of this standard only requiring~~ upfront ~~carbon~~ *GHG emissions* in accordance with Section 6.5.1 through 6.5.3 (*Modules ~~(~~A1-A5*) and ~~shall require a net *biogenic* carbon balance~~ where any *biogenic carbon* uptake is included ~~reported~~ as stored within the *project*, , the *GHG emissions* calculation shall include ~~accounts for~~ end-of-life emissions in accordance with Section 6.5.11 (*Module C3*) or Section 6.5.12 (*Module C4*), as applicable. ~~(C3 or C4)~~.

*Biogenic carbon* stored in *building* materials during the *building*'s life may be reported as an inventory metric and shall not be combined with biogenic or fossil carbon emissions. ~~shall be reported separately and shall not be combined with fossil emissions~~.

**~~6.5.13.2~~ 6.6.2 Carbonation.**

GHG emissions calculations shall include ~~The *carbonation* process~~ that occurs over the life of concrete and cementitious elements ~~and shall be accounted for~~ in the life cycle stage in which it occurs, in accordance with the following:

1. Section 6.5.1 for ~~including~~ Manufacturing (*Modules A1-A3*),
2. Section 6.5.4 for Use (Module *B1~~; see Section 6.4.4.1~~*) and
3. Section 6.5.11 and 6.5.12 for End-of-Life (Modules *C3-C4~~; see Sections 6.4.5.3 and 6.4.5.4~~*) ~~stages where applicable~~.
4. Section 8.3 for Recovery, Reuse and Recycling ~~*Carbonation* may also occur in~~ (*Module D*) where the *system boundary* includes *Module D1*.~~if recycled concrete aggregate is stockpiled before use~~. Data from *EPDs* or equivalent sources shall be permitted for *GHG emissions* calculation under this section ~~can be used to account for the impact of *carbonation* in m~~*Modules A1-A3*, *B1,* and *C3,* and *C4*, or *D1* provided that the conditions in the scenario selected in the data source coincide with the anticipated project-specific ones, particularly in relation to surface area exposure.

~~**6.5.13.3 Delayed Emissions.** Reserved for future use.~~

~~**6.5.13.4**~~ **6.6.4 Treatment of Recycled Content.**
Carbon impacts associated with recycled material shall be allocated according to the "polluter pays principle". No burden associated with the original manufacturing of a recycled material shall be allocated to the user of the recycled material.

~~***6.5.13.5***~~ ***6.6.5 Decarbonization* of the Energy Grid or Other Energy During Manufacturing Phases.**
To limit the uncertainty in factors impacting assessment results, no projected *decarbonization* shall be included within the minimum required calculations for embodied emissions.

~~**6.5.13.6**~~ **6.6.6 Land Use Change.**
Both direct and ~~induced~~ indirect *land use change* impacts shall not be included. ~~are considered out of scope under this standard.~~

## 7. Quantifying Operational Greenhouse Gas Emissions

**7 ~~General~~**

~~i.**Scope**. Section 7 specifies requirements for quantifying the operational *greenhouse gas emissions* in the *greenhouse gas emissions* assessment.~~

**7.1 ~~Compliance Paths~~ General.** The *greenhouse gas emissions* assessment shall comply with ~~Section 7.2.1 and either Section 7.2.2 or Section 7.2.3 **Requirements for all Compliance Paths.** The *greenhouse gas emissions* assessment shall comply with~~ all of items a. though e. below. Where specified by the *AHJ*, compliance with items f. and g. shall also be required.

a. Section 7.1, "General"
b. Section 7.3.1.1, "General Data Requirements – Operational Energy Usage"
c. Section 7.3.2, "Greenhouse Gas *Emissions Factors* – Operational Energy Usage"
d. Section 7.3.3, "Greenhouse Gas Emissions Quantification – Operational Energy Usage"
e. Section 7.5.1, "Data Requirements – *Fugitive Emissions*"
f. Section 7.4.1.1, "General Data Requirements – Operational Water"
g. Section 7.4.2, "Greenhouse Gas Emissions Quantification – Operational Water"

**7.1.1 Requirements for *As-Designed* Path.** Where compliance Is shown using the "*As-Designed* Path," the *project* shall comply with all the following:

a. Section 7.3.1.3, "*As-Designed* Data Requirements – Operational Energy Usage"
b. Section 7.5.2, "Quantifying Greenhouse Gas Emissions from *Fugitive Emissions* – *As-Designed*"

**7.1.2 Requirements for *As-Built* Path.** Where compliance is shown using the "*As-Built* Path," the *project* shall comply with all the following:

a. Section 7.3.1.4, "*As-Built* Data Requirements – Operational Energy Usage"
b. Section 7.5.3, "Quantifying Greenhouse Gas Emissions from *Fugitive Emissions* – *As-Built*"

**7.1.3 *EPD* Data.** Operational energy and emissions values from *EPD*s shall not be permitted to show compliance with Section 7.

### 7.3 Operational Energy Usage (*B6*)

**7.3.1 Operational Energy Usage Data Requirements.** The *greenhouse gas emissions* assessment shall comply with Sections 7.3.1.1 and 7.3.1.2 and with either Section 7.3.1.3 or Section 7.3.1.4.

**7.3.1.1 Data Time Resolution.** *Imported energy* usage shall be determined on an annual basis for each energy source. Where the *AHJ* requires a *greenhouse gas* assessment using time periods other than one year for any *imported energy* source, the energy usage shall be determined for time periods as required by the *AHJ* for each applicable *imported energy* source.

**7.3.1.2 End Use Data.** Energy usage for all of the following shall be determined individually in compliance with Section 7.3.1.1 for the corresponding energy source:

1. All *imported energy.*
2. Electricity usage for *electric vehicle supply equipment* within the *system boundary*.
3. *Imported energy* usage by any *equipment* or *system* that produces *exported energy*.
4. Energy usage for any *equipment*, *system* or end use specified by the *AHJ*.
5. All energy usage for non-electric vehicle refueling within the *system boundary*.

~~Operational energy values from EPDs shall not be used when complying with this section.~~

**Exception to 7.3.1.2:** Where the *project* complies with Section 7.3.1.4 and the end use is not separately metered.

***7.3.1.3 As-Designed* Data Requirements – Operational Energy Usage.** Where the *energy code* applicable to the *project* includes a methodology for a whole *building* simulated performance-based compliance option, all *imported energy* usage shall be computed in accordance with the requirements for the *proposed design* in that methodology. Where an *energy code* is not applicable or the applicable *energy code* does not have a whole *building* simulated performance-based compliance option, all *imported energy* usage shall be computed in accordance with the requirements for the *proposed design* in the Performance Rating Method of ANSI/ASHRAE/IES Standard 90.1 for *buildings* other than *low-rise residential buildings*, *of* ICC IECC Residential for *low-rise residential buildings*, or of ANSI/ASHRAE/IES Standard 90.2 for *residential buildings*.

**Exception to 7.3.1.3:***Alterations* for which the *AHJ* approves an alternative computation method for *imported energy* usage and by which no *exported energy* is produced.

***7.3.1.4 As-Built* Data Requirements – Operational Energy Usage.**

**7.3.1.4.1 Historical Operational Energy Usage.** On-site usage of each *imported energy* source shall be measured and recorded annually and at any additional interval required by the *AHJ*.

**Exceptions to 7.3.1.4.1**

1. Where usage of a *bulk fuel* is not metered, the *AHJ* does not require an energy usage interval other than annual for the *bulk fuel*, and the annual usage of the *bulk fuel* is estimated based on the sum of the measured on-site stored fuel at the beginning of a 12-month period and the total documented amount of fuel delivered in the same 12-month period, minus the measured on-site stored fuel at the end of the same 12-month period.
2. Where energy usage measurements include energy usage outside the *system boundary,* the *AHJ* approves a method to compute the *imported energy* from the total measurement of the energy source, and the computed values are recorded annually and at any additional interval required by the *AHJ*.

**7.3.1.4.2 Typical Annual Operational Energy.** An average annual energy usage for each *imported energy* source shall be calculated based on ~~the lesser of~~ all available data for the energy source, not to exceed ~~and~~ the five most recent years of energy usage data, quantified in accordance with Section 7.3.1.4.1.

**Exception to 7.3.1.4.2** Where the *AHJ* approves the use of measured *imported energy* usage for a period no less than one year as better representing the future *imported energy* usage.

***7.3.2 Greenhouse Gas Emissions*** **Factors – Operational Energy Usage.** *Emissions factors* for all *imported energy* shall include:

a. both c*ombustion greenhouse gas emissions* and *precombustion greenhouse gas emissions*,
b. *carbon dioxide* (*CO2*), nitrous oxide ($N_2O$) and methane ($CH_4$), and
c. where applicable, electricity transmission and distribution losses.

Where the *AHJ* does not require or approve *emissions factors* for an *imported energy* source the *emissions factors* shall comply with Section 7.3.2.1 for *imported energy* sources other than electricity and shall comply with Section 7.3.2.2 for *imported electricity*.

***Informative note:*** See Informative Appendix C for recommended sources for *emissions factors* that may be most appropriate for a particular *jurisdiction* or *project*.

**7.3.2.1Default Greenhouse Gas Emissions Factors – Energy Sources Other Than Electricity.** *Emissions factors* for all *imported energy* other than electricity shall be taken from Table 7.3.2.1 for a 100~~20~~-year *global warming potential* basis.

**Exceptions to 7.3.2.1:**

1.Where the *AHJ* requires a *greenhouse gas assessment* using a 20~~100~~-year *global warming potential* basis and *emissions factors* for all *imported energy* other than electricity are taken from Table 7.3.2.1 for a 20~~100~~-year *global warming potential* basis.

*2. Emissions factors* for alternative fuels not included in Table 7.3.2.1, approved by the *AHJ*, and calculated in accordance with the California Air Resources Board Low Carbon Fuel Standard or the U.S. Environmental Protection Agency Renewable Fuel Standard.

*3. Emissions factors* for chilled water, steam or hot water approved by the *AHJ* and accounting for all of the following:

a. Input fuel and electricity *emissions factors* in accordance with Tables 7.3.2.1, Table

7.3.2.2(1) or Table 7.3.2.2(2).

b. Conversion efficiency of the heating or cooling plant.

c. Auxiliary equipment and distribution losses associated with delivery of thermal energy to the *building*.

**Table 7.3.2.1 Greenhouse Gas *Emissions Factors* for Energy Sources Other Than Electricity**

| Fuel | *CO2e*(20-year) *emissions factor*, kg/MWh | *CO2e*(100-year) *emissions factor*, kg/MWh |
|---|---|---|
| *Bulk Fuels* | | |
| Fuel Oil (residual) | 334 | 313 |
| Fuel Oil (distillate) | 324 | 303 |
| Liquefied Petroleum Gas or Propane | 295 | 275 |
| Gasoline | 337 | 312 |
| Coal | 382 | 353 |
| Liquefied Natural Gas | 330 | 266 |
| Other *bulk fuels* | 382 | 353 |
| *Energy Utilities* | | |
| Natural Gas | 277 | 228 |
| Chilled Water | 131 | 117 |
| Steam | 466 | 383 |
| Hot Water | 440 | 362 |
| Other utility-supplied Gases | 277 | 228 |

***Informative Note**: Emissions factors in Table 7.3.2.1 include combustion values from the U.S. Environmental Protection Agency and precombustion values from NREL's "U.S. Life Cycle Inventory Database," with two exceptions. Precombustion values for natural gas are taken from NETL's "Life Cycle Analysis of Natural Gas Extraction and Power Generation" (2019). Liquefied Natural Gas includes greenhouse gas emissions associated with liquefaction taken from NETL's "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update" (2019).*

**7.3.2.2 Default Greenhouse Gas *Emissions Factors* – Electricity.** *Emissions factors* for electricity shall correspond to the appropriate year of the *reference study period* and the grid region of the *building* or *site* and shall be taken from Table 7.3.2.2(1) for a *greenhouse gas assessment* using a 100~~20~~-year *global warming potential* basis. Where the year of the *reference study period (RSP)* is before the earliest year in Table 7.3.2.2(1) for the grid region, the value for the earliest year shall be used. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(1) for the grid region, the value for the latest year shall be used.

**Exception to 7.3.2.2** Where the *AHJ* requires a *greenhouse gas assessment* using a 20~~100~~-year *global warming potential* basis, and *emissions factors* for electricity correspond to the appropriate year of the *RSP* and the grid region of the *building* or *site* in Table 7.3.2.2(2). Where the year of the *RSP* is before the earliest year in Table 7.3.2.2(2) for the grid region, the value for the earliest year shall be used. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(2) for the grid region, the value for the latest year shall be used.

**Table 7.3.2.2(2)~~(1)~~ Greenhouse Gas *Emissions Factors* for Electricity, 20-year Global Warming Potential, kg/MWh [a]**

| Grid Region | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AKGD | 687.6 | 693.4 | | | | | | | | | | | | | | |
| AKMS | 369.0 | 336.5 | | | | | | | | | | | | | | |
| AZNM | 515.0 | 495.9 | 438.5 | 381.2 | 323.9 | 299.3 | 274.7 | 228.5 | 182.3 | 167.8 | 153.2 | 141.4 | 129.7 | 118.0 | 106.2 | 94.5 |
| CAMX | 376.7 | 379.1 | 311.4 | 243.8 | 176.1 | 166.6 | 157.0 | 132.3 | 107.6 | 87.8 | 67.9 | 62.5 | 57.1 | 51.6 | 46.2 | 40.7 |
| ERCT | 528.2 | 520.1 | 452.9 | 385.7 | 318.6 | 272.3 | 226.1 | 178.4 | 130.7 | 110.8 | 90.9 | 85.4 | 79.9 | 74.4 | 68.9 | 63.4 |
| FRCC | 586.2 | 589.5 | 533.7 | 477.9 | 422.0 | 380.6 | 339.1 | 312.7 | 286.3 | 264.0 | 241.7 | 226.2 | 210.8 | 195.4 | 179.9 | 164.5 |
| HIMS | 875.7 | 798.5 | | | | | | | | | | | | | | |
| HIOA | 1085.2 | 1078.2 | | | | | | | | | | | | | | |
| MORE | 888.3 | 921.6 | 726.2 | 530.8 | 335.4 | 304.4 | 273.4 | 239.6 | 205.8 | 183.2 | 160.6 | 153.6 | 146.6 | 139.6 | 132.6 | 125.6 |
| MROW | 556.2 | 573.6 | 491.2 | 408.8 | 326.4 | 271.8 | 217.2 | 167.6 | 118.0 | 98.9 | 79.7 | 75.6 | 71.4 | 67.2 | 63.0 | 58.8 |
| NEWE | 405.7 | 417.0 | 341.5 | 266.0 | 190.6 | 188.0 | 185.4 | 177.2 | 169.0 | 156.9 | 144.8 | 139.5 | 134.2 | 128.8 | 123.5 | 118.2 |
| NWPP | 360.6 | 385.6 | 339.1 | 292.5 | 246.0 | 216.9 | 187.8 | 165.1 | 142.4 | 133.2 | 124.1 | 118.5 | 112.8 | 107.1 | 101.4 | 95.8 |
| NYCW | 441.3 | 576.1 | 412.6 | 329.8 | 247.0 | 211.4 | 175.9 | 164.8 | 153.8 | 140.9 | 128.1 | 122.9 | 117.8 | 112.6 | 107.5 | 102.3 |
| NYLI | 653.4 | 676.7 | 610.9 | 488.3 | 365.7 | 313.1 | 260.4 | 244.1 | 227.7 | 208.7 | 189.7 | 182.0 | 174.4 | 166.7 | 159.1 | 151.5 |
| NYUP | 182.3 | 180.7 | 170.4 | 136.2 | 102.0 | 87.3 | 72.6 | 68.1 | 63.5 | 58.2 | 52.9 | 50.8 | 48.6 | 46.5 | 44.4 | 42.3 |
| RFCE | 438.8 | 451.5 | 417.8 | 384.1 | 350.4 | 338.7 | 327.0 | 314.2 | 301.3 | 293.0 | 284.6 | 276.8 | 269.1 | 261.3 | 253.5 | 245.7 |
| RFCM | 708.6 | 726.8 | 681.1 | 635.4 | 589.8 | 549.5 | 509.2 | 483.3 | 457.4 | 425.4 | 393.4 | 389.1 | 384.8 | 380.5 | 376.2 | 371.9 |
| RFCW | 603.2 | 635.3 | 622.7 | 610.2 | 597.6 | 578.4 | 559.2 | 498.5 | 437.7 | 391.0 | 344.3 | 331.1 | 318.0 | 304.8 | 291.6 | 278.4 |
| RMPA | 619.6 | 642.7 | 648.8 | 655.0 | 661.1 | 585.0 | 508.9 | 374.2 | 239.5 | 168.2 | 97.0 | 93.3 | 89.7 | 86.1 | 82.5 | 78.8 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPNO | 539.2 | 572.5 | 536.8 | 501.1 | 465.4 | 357.7 | 250.1 | 183.0 | 115.9 | 99.1 | 82.2 | 79.2 | 76.2 | 73.2 | 70.2 | 67.2 |
| SPSO | 552.5 | 595.9 | 444.3 | 292.8 | 141.2 | 118.4 | 95.5 | 73.0 | 50.4 | 42.6 | 34.9 | 32.6 | 30.4 | 28.1 | 25.8 | 23.6 |
| SRMV | 522.0 | 541.5 | 536.7 | 531.8 | 526.9 | 507.0 | 487.1 | 439.4 | 391.7 | 347.1 | 302.6 | 283.5 | 264.4 | 245.3 | 226.1 | 207.0 |
| SRMW | 866.7 | 916.3 | 834.4 | 752.5 | 670.5 | 638.5 | 606.4 | 427.9 | 249.4 | 204.9 | 160.4 | 154.2 | 147.9 | 141.6 | 135.4 | 129.1 |
| SRSO | 577.8 | 600.7 | 550.8 | 500.9 | 451.0 | 426.8 | 402.5 | 358.2 | 313.9 | 304.4 | 295.0 | 281.8 | 268.6 | 255.4 | 242.2 | 229.0 |
| SRTV | 523.2 | 566.6 | 605.4 | 644.1 | 682.9 | 638.0 | 593.0 | 518.4 | 443.9 | 413.6 | 383.3 | 363.4 | 343.4 | 323.4 | 303.5 | 283.5 |
| SRVC | 426.0 | 431.0 | 401.9 | 372.8 | 343.7 | 323.4 | 303.0 | 259.7 | 216.4 | 195.0 | 173.6 | 160.8 | 148.0 | 135.2 | 122.4 | 109.6 |
| All Other | 520.6 | 539.1 | 489.9 | 440.8 | 391.6 | 358.8 | 326.0 | 278.4 | 230.8 | 207.0 | 183.2 | 174.7 | 166.1 | 157.5 | 148.9 | 140.4 |

***Informative note:*** Values for Years 2020 and 2021 are computed using the method of *ASHRAE 189.1-2020, Addendum m*, applied to EPA eGRID data. Values for Years 2024, 2026, 2028, 2030, 2035, 2040, 2045 and 2050 are average emissions values taken from NREL's Cambium 2022 Mid-Case Scenario. The EPA eGRID map can be found at: https://www.epa.gov/system/files/images/2023-05/eGRID2021_subregion_map.png. The NREL Cambium map can be found at: https://www.nrel.gov/docs/fy23osti/84916.pdf.

a. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(2) for the grid region, the value for the latest year shall be used.

**Table 7.3.2.2(2)~~(1)~~ Greenhouse Gas *Emissions Factors* for Electricity, 20-year Global Warming Potential, kg/MWh (cont.) [a]**

| Grid Region | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AKGD | | | | | | | | | | | | | | | |
| AKMS | | | | | | | | | | | | | | | |
| AZNM | 87.3 | 80.2 | 73.0 | 65.8 | 58.6 | 55.6 | 52.6 | 49.6 | 46.6 | 43.6 | 44.8 | 46.0 | 47.2 | 48.4 | 49.5 |
| CAMX | 37.1 | 33.4 | 29.8 | 26.1 | 22.5 | 21.2 | 20.0 | 18.7 | 17.5 | 16.2 | 17.3 | 18.3 | 19.3 | 20.3 | 21.4 |
| ERCT | 62.0 | 60.6 | 59.2 | 57.7 | 56.3 | 56.1 | 55.8 | 55.6 | 55.3 | 55.1 | 54.3 | 53.6 | 52.8 | 52.1 | 51.3 |
| FRCC | 161.0 | 157.5 | 154.0 | 150.5 | 147.0 | 143.6 | 140.2 | 136.8 | 133.4 | 129.9 | 134.6 | 139.3 | 144.0 | 148.7 | 153.4 |
| HIMS | | | | | | | | | | | | | | | |
| HIOA | | | | | | | | | | | | | | | |
| MROE | 119.4 | 113.2 | 107.0 | 100.9 | 94.7 | 100.4 | 106.2 | 112.0 | 117.8 | 123.5 | 131.6 | 139.7 | 147.8 | 155.9 | 164.0 |
| MROW | 54.7 | 50.7 | 46.6 | 42.5 | 38.4 | 38.1 | 37.7 | 37.4 | 37.0 | 36.7 | 35.4 | 34.2 | 32.9 | 31.7 | 30.4 |
| NEWE | 119.1 | 119.9 | 120.8 | 121.7 | 122.6 | 125.9 | 129.1 | 132.4 | 135.7 | 139.0 | 138.6 | 138.2 | 137.8 | 137.4 | 137.0 |
| NWPP | 91.2 | 86.6 | 82.0 | 77.4 | 72.8 | 69.8 | 66.8 | 63.9 | 60.9 | 57.9 | 55.7 | 53.5 | 51.3 | 49.1 | 46.9 |
| NYCW | 102.1 | 101.9 | 101.7 | 101.5 | 101.3 | 104.0 | 106.8 | 109.5 | 112.3 | 115.0 | 118.1 | 121.3 | 124.4 | 127.5 | 130.6 |
| NYLI | 151.2 | 150.9 | 150.6 | 150.3 | 150.0 | 154.0 | 158.1 | 162.2 | 166.3 | 170.3 | 174.9 | 179.5 | 184.1 | 188.7 | 193.3 |
| NYUP | 42.2 | 42.1 | 42.0 | 41.9 | 41.8 | 43.0 | 44.1 | 45.2 | 46.4 | 47.5 | 48.8 | 50.1 | 51.4 | 52.6 | 53.9 |
| RFCE | 243.2 | 240.8 | 238.3 | 235.8 | 233.4 | 234.7 | 236.0 | 237.3 | 238.6 | 239.9 | 242.3 | 244.7 | 247.2 | 249.6 | 252.1 |
| RFCM | 367.1 | 362.3 | 357.6 | 352.8 | 348.0 | 343.6 | 339.2 | 334.7 | 330.3 | 325.9 | 323.8 | 321.6 | 319.5 | 317.4 | 315.2 |
| RFCW | 260.6 | 242.7 | 224.9 | 207.1 | 189.2 | 188.4 | 187.6 | 186.8 | 186.0 | 185.2 | 190.2 | 195.2 | 200.1 | 205.1 | 210.1 |
| RMPA | 74.0 | 69.3 | 64.5 | 59.7 | 54.9 | 48.3 | 41.7 | 35.0 | 28.4 | 21.8 | 22.5 | 23.3 | 24.0 | 24.7 | 25.5 |
| SPNO | 63.3 | 59.4 | 55.5 | 51.6 | 47.7 | 43.9 | 40.0 | 36.2 | 32.4 | 28.5 | 27.7 | 26.9 | 26.1 | 25.4 | 24.6 |
| SPSO | 22.0 | 20.4 | 18.9 | 17.3 | 15.8 | 15.8 | 15.8 | 15.8 | 15.8 | 15.8 | 17.3 | 18.8 | 20.3 | 21.8 | 23.3 |
| SRMV | 192.7 | 178.5 | 164.2 | 149.9 | 135.6 | 135.8 | 135.9 | 136.1 | 136.3 | 136.5 | 145.3 | 154.2 | 163.1 | 171.9 | 180.8 |
| SRMW | 120.7 | 112.3 | 103.9 | 95.4 | 87.0 | 82.8 | 78.5 | 74.2 | 69.9 | 65.7 | 58.3 | 50.9 | 43.6 | 36.2 | 28.8 |
| SRSO | 217.3 | 205.6 | 193.9 | 182.2 | 170.6 | 164.6 | 158.7 | 152.7 | 146.8 | 140.8 | 137.3 | 133.8 | 130.2 | 126.7 | 123.1 |
| SRTV | 265.6 | 247.7 | 229.8 | 211.9 | 194.0 | 185.9 | 177.7 | 169.6 | 161.5 | 153.3 | 152.9 | 152.5 | 152.1 | 151.7 | 151.3 |
| SRVC | 105.7 | 101.8 | 97.9 | 94.1 | 90.2 | 81.3 | 72.5 | 63.6 | 54.8 | 45.9 | 46.1 | 46.3 | 46.4 | 46.6 | 46.7 |
| All Other | 134.4 | 128.5 | 122.5 | 116.6 | 110.7 | 108.4 | 106.1 | 103.8 | 101.5 | 99.2 | 99.8 | 100.3 | 100.9 | 101.5 | 102.1 |

***Informative note:*** Values for Years 2020 and 2021 are computed using the method of ASHRAE 189.1-2020, Addendum m, applied to EPA eGRID data. Values for Years 2024, 2026, 2028, 2030, 2035, 2040, 2045 and 2050 are average emissions values taken from NREL's Cambium 2022 Mid-Case Scenario. The EPA eGRID map can be found at: https://www.epa.gov/system/files/images/2023-05/eGRID2021_subregion_map.png. The NREL Cambium map can be found at: https://www.nrel.gov/docs/fy23osti/84916.pdf.

a. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(2) for the grid region, the value for the latest year shall be used.

**Table 7.3.2.2(1)~~(2)~~ Greenhouse Gas *Emissions Factors* for Electricity, 100-year Global Warming Potential, kg/MWh [a]**

| Grid Region | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AKGD | 609.2 | 611.9 | | | | | | | | | | | | | | |
| AKMS | 334.1 | 304.9 | | | | | | | | | | | | | | |
| AZNM | 453.1 | 436.7 | 384.3 | 331.8 | 279.4 | 258.5 | 237.5 | 197.7 | 157.9 | 145.6 | 133.3 | 123.0 | 112.7 | 102.5 | 92.2 | 81.9 |
| CAMX | 328.1 | 329.9 | 268.3 | 206.6 | 144.9 | 137.1 | 129.2 | 108.9 | 88.6 | 72.3 | 55.9 | 51.4 | 46.9 | 42.5 | 38.0 | 33.5 |
| ERCT | 464.9 | 459.0 | 396.7 | 334.5 | 272.2 | 232.1 | 191.9 | 151.0 | 110.0 | 93.4 | 76.7 | 72.1 | 67.5 | 62.9 | 58.3 | 53.7 |
| FRCC | 508.3 | 511.8 | 459.0 | 406.1 | 353.3 | 318.6 | 283.8 | 261.1 | 238.3 | 219.7 | 201.0 | 188.0 | 175.0 | 161.9 | 148.9 | 135.9 |
| HIMS | 801.7 | 731.9 | | | | | | | | | | | | | | |
| HIOA | 997.4 | 988.7 | | | | | | | | | | | | | | |
| MROE | 806.5 | 837.6 | 653.2 | 468.7 | 284.3 | 258.0 | 231.6 | 202.3 | 172.9 | 154.0 | 135.0 | 129.1 | 123.2 | 117.2 | 111.3 | 105.4 |
| MROW | 508.8 | 524.8 | 447.0 | 369.1 | 291.2 | 242.4 | 193.5 | 149.3 | 105.1 | 88.2 | 71.2 | 67.5 | 63.7 | 60.0 | 56.2 | 52.5 |
| NEWE | 355.1 | 363.5 | 294.8 | 226.0 | 157.3 | 155.1 | 152.9 | 146.1 | 139.3 | 129.4 | 119.4 | 115.0 | 110.6 | 106.2 | 101.8 | 97.4 |
| NWPP | 325.0 | 347.0 | 303.5 | 260.1 | 216.7 | 190.9 | 165.0 | 145.2 | 125.3 | 117.4 | 109.4 | 104.4 | 99.4 | 94.3 | 89.3 | 84.3 |
| NYCW | 376.8 | 491.4 | 350.0 | 278.6 | 207.3 | 176.6 | 146.0 | 136.6 | 127.3 | 116.7 | 106.0 | 101.7 | 97.3 | 93.0 | 88.6 | 84.2 |
| NYLI | 569.8 | 587.4 | 529.2 | 421.3 | 313.4 | 267.1 | 220.7 | 206.6 | 192.5 | 176.4 | 160.3 | 153.8 | 147.2 | 140.6 | 134.0 | 127.4 |
| NYUP | 157.8 | 156.1 | 146.6 | 116.7 | 86.8 | 74.0 | 61.1 | 57.2 | 53.3 | 48.9 | 44.4 | 42.6 | 40.8 | 38.9 | 37.1 | 35.3 |
| RFCE | 383.4 | 395.3 | 361.1 | 327.0 | 292.9 | 282.7 | 272.5 | 261.4 | 250.2 | 243.3 | 236.3 | 229.8 | 223.4 | 216.9 | 210.5 | 204.0 |
| RFCM | 636.0 | 657.3 | 610.5 | 563.6 | 516.8 | 477.8 | 438.7 | 414.8 | 390.9 | 362.1 | 333.2 | 328.6 | 324.0 | 319.4 | 314.8 | 310.2 |
| RFCW | 543.6 | 573.9 | 556.2 | 538.5 | 520.8 | 503.5 | 486.1 | 430.5 | 374.9 | 334.4 | 293.8 | 282.0 | 270.2 | 258.4 | 246.6 | 234.8 |
| RMPA | 558.9 | 582.8 | 584.9 | 587.0 | 589.1 | 521.1 | 453.1 | 333.2 | 213.3 | 150.0 | 86.6 | 83.4 | 80.2 | 77.1 | 73.9 | 70.7 |
| SPNO | 492.2 | 523.9 | 488.2 | 452.5 | 416.8 | 320.2 | 223.5 | 163.5 | 103.4 | 88.5 | 73.5 | 70.8 | 68.1 | 65.5 | 62.8 | 60.1 |
| SPSO | 489.7 | 534.2 | 396.3 | 258.3 | 120.4 | 100.8 | 81.1 | 61.7 | 42.3 | 35.9 | 29.4 | 27.5 | 25.6 | 23.8 | 21.9 | 20.0 |
| SRMV | 453.6 | 473.7 | 465.2 | 456.7 | 448.2 | 430.2 | 412.2 | 370.4 | 328.6 | 290.9 | 253.1 | 237.1 | 221.1 | 205.2 | 189.2 | 173.2 |
| SRMW | 793.0 | 840.5 | 760.9 | 681.3 | 601.7 | 572.9 | 544.1 | 383.9 | 223.7 | 183.9 | 144.1 | 138.5 | 132.9 | 127.3 | 121.7 | 116.1 |
| SRSO | 511.3 | 533.8 | 485.1 | 436.5 | 387.8 | 367.0 | 346.2 | 307.4 | 268.6 | 260.6 | 252.5 | 241.3 | 230.1 | 218.9 | 207.7 | 196.5 |
| SRTV | 470.6 | 511.5 | 542.1 | 572.7 | 603.3 | 563.0 | 522.7 | 455.6 | 388.5 | 361.8 | 335.0 | 317.3 | 299.6 | 281.9 | 264.2 | 246.5 |
| SRVC | 377.3 | 382.0 | 353.1 | 324.1 | 295.2 | 277.6 | 260.0 | 222.0 | 183.9 | 165.5 | 147.1 | 136.1 | 125.1 | 114.1 | 103.1 | 92.1 |
| All Other | 463.0 | 480.9 | 433.4 | 386.0 | 338.6 | 309.7 | 280.8 | 239.0 | 197.1 | 176.7 | 156.3 | 148.9 | 141.4 | 134.0 | 126.5 | 119.1 |

***Informative note:*** Values for Years 2020 and 2021 are computed using the method of ASHRAE 189.1-2020, Addendum m, applied to EPA eGRID data. Values for Years 2024, 2026, 2028, 2030, 2035, 2040, 2045 and 2050 are average emissions values taken from NREL's Cambium 2022 Mid-Case Scenario. The EPA eGRID map can be found at: https://www.epa.gov/system/files/images/2023-05/eGRID2021_subregion_map.png. The NREL Cambium map can be found at: https://www.nrel.gov/docs/fy23osti/84916.pdf.

a. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(1) for the grid region, the value for the latest year shall be used.

**Table 7.3.2.2(1)~~(2)~~ Greenhouse Gas *Emissions Factors* for Electricity, 100-year Global Warming Potential, kg/MWh (cont.)** [a]

| Grid Region | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AKGD | | | | | | | | | | | | | | | |
| AKMS | | | | | | | | | | | | | | | |
| AZNM | 75.7 | 69.5 | 63.3 | 57.1 | 50.9 | 48.3 | 45.7 | 43.2 | 40.6 | 38.0 | 39.0 | 45.0 | 46.0 | 47.0 | 43.0 |
| CAMX | 30.5 | 27.5 | 24.5 | 21.5 | 18.5 | 17.5 | 16.5 | 15.4 | 14.4 | 13.4 | 14.2 | 19.3 | 20.1 | 21.0 | 17.6 |
| ERCT | 52.5 | 51.3 | 50.0 | 48.8 | 47.6 | 47.3 | 47.1 | 46.8 | 46.6 | 46.3 | 45.7 | 41.8 | 41.2 | 40.5 | 43.1 |
| FRCC | 133.0 | 130.0 | 127.1 | 124.1 | 121.2 | 118.4 | 115.6 | 112.7 | 109.9 | 107.1 | 111.0 | 134.3 | 138.1 | 142.0 | 126.5 |
| HIMS | | | | | | | | | | | | | | | |
| HIOA | | | | | | | | | | | | | | | |
| MROE | 100.1 | 94.8 | 89.6 | 84.3 | 79.0 | 83.8 | 88.6 | 93.4 | 98.2 | 103.0 | 109.7 | 150.2 | 156.9 | 163.7 | 136.7 |
| MROW | 48.9 | 45.2 | 41.6 | 37.9 | 34.3 | 34.0 | 33.6 | 33.3 | 32.9 | 32.6 | 31.4 | 24.5 | 23.3 | 22.2 | 26.8 |
| NEWE | 98.1 | 98.8 | 99.6 | 100.3 | 101.0 | 103.7 | 106.4 | 109.0 | 111.7 | 114.4 | 114.1 | 112.2 | 111.8 | 111.5 | 112.8 |
| NWPP | 80.2 | 76.2 | 72.1 | 68.1 | 64.0 | 61.3 | 58.7 | 56.0 | 53.4 | 50.7 | 48.7 | 36.7 | 34.7 | 32.7 | 40.7 |
| NYCW | 84.0 | 83.7 | 83.4 | 83.2 | 82.9 | 85.1 | 87.4 | 89.6 | 91.8 | 94.1 | 96.5 | 111.1 | 113.6 | 116.0 | 106.2 |
| NYLI | 127.0 | 126.6 | 126.2 | 125.8 | 125.4 | 128.7 | 132.1 | 135.5 | 138.9 | 142.2 | 145.9 | 168.0 | 171.7 | 175.4 | 160.7 |
| NYUP | 35.2 | 35.1 | 34.9 | 34.8 | 34.7 | 35.7 | 36.6 | 37.5 | 38.5 | 39.4 | 40.4 | 46.5 | 47.6 | 48.6 | 44.5 |
| RFCE | 201.8 | 199.7 | 197.5 | 195.4 | 193.2 | 194.2 | 195.2 | 196.2 | 197.2 | 198.2 | 200.1 | 211.5 | 213.4 | 215.3 | 207.7 |
| RFCM | 306.1 | 302.0 | 297.8 | 293.7 | 289.6 | 286.0 | 282.4 | 278.8 | 275.2 | 271.6 | 269.2 | 254.8 | 252.4 | 250.0 | 259.6 |
| RFCW | 219.5 | 204.2 | 188.9 | 173.6 | 158.3 | 157.6 | 156.9 | 156.3 | 155.6 | 154.9 | 158.9 | 182.6 | 186.6 | 190.5 | 174.7 |
| RMPA | 66.4 | 62.1 | 57.8 | 53.5 | 49.2 | 43.3 | 37.3 | 31.4 | 25.4 | 19.5 | 20.2 | 24.3 | 24.9 | 25.6 | 22.9 |
| SPNO | 56.6 | 53.2 | 49.7 | 46.3 | 42.8 | 39.3 | 35.9 | 32.4 | 29.0 | 25.5 | 24.7 | 20.2 | 19.4 | 18.7 | 21.7 |
| SPSO | 18.7 | 17.3 | 16.0 | 14.6 | 13.3 | 13.3 | 13.3 | 13.2 | 13.2 | 13.2 | 14.5 | 22.4 | 23.8 | 25.1 | 19.8 |
| SRMV | 161.2 | 149.2 | 137.1 | 125.1 | 113.1 | 113.1 | 113.2 | 113.2 | 113.3 | 113.3 | 120.8 | 165.8 | 173.3 | 180.8 | 150.8 |
| SRMW | 108.5 | 100.9 | 93.3 | 85.7 | 78.1 | 74.2 | 70.3 | 66.3 | 62.4 | 58.5 | 51.8 | 11.6 | 4.9 | -1.8 | 25.0 |
| SRSO | 186.3 | 176.1 | 165.9 | 155.7 | 145.5 | 140.3 | 135.1 | 130.0 | 124.8 | 119.6 | 116.4 | 97.2 | 94.0 | 90.8 | 103.6 |
| SRTV | 230.8 | 215.1 | 199.4 | 183.7 | 168.0 | 160.9 | 153.9 | 146.8 | 139.8 | 132.7 | 132.2 | 129.2 | 128.7 | 128.2 | 130.2 |
| SRVC | 88.8 | 85.5 | 82.1 | 78.8 | 75.5 | 68.1 | 60.8 | 53.4 | 46.1 | 38.7 | 38.7 | 39.0 | 39.0 | 39.1 | 38.9 |
| All Other | 114.0 | 108.8 | 103.7 | 98.5 | 93.4 | 91.4 | 89.4 | 87.5 | 85.5 | 83.5 | 83.9 | 86.0 | 86.4 | 86.7 | 85.3 |

***Informative note:*** Values for Years 2020 and 2021 are computed using the method of ASHRAE 189.1-2020, Addendum m, applied to EPA eGRID data. Values for Years 2024, 2026, 2028, 2030, 2035, 2040, 2045 and 2050 are average emissions values taken from NREL's Cambium 2022 Mid-Case Scenario. The EPA eGRID map can be found at: https://www.epa.gov/system/files/images/2023-05/eGRID2021_subregion_map.png. The NREL Cambium map can be found at: https://www.nrel.gov/docs/fy23osti/84916.pdf.

a. Where the year of the *RSP* is after the latest year in Table 7.3.2.2(2) for the grid region, the value for the latest year shall be used.

**7.3.3 Greenhouse Gas Emissions Quantification – Operational Energy Usage.** The general form of calculating *greenhouse gas emissions* associated with operational energy usage for the *RSP* shall be in accordance with Equation 7.3.3:

$$GHG_{OE} = \sum_{s} \sum_{t=1}^{T} E_{s,t} \times e_{s,l,t} \tag{7.3.3}$$

where

$GHG_{OE}$ = total operational energy greenhouse gas emissions of the *RSP*
$t$ = timestep
$T$ = total timesteps of the *RSP*
$E_{s,t}$ = energy usage for *imported energy* source *s*, at timestep, *t,* as calculated in accordance with Section 7.3.1
$e_{s,l,t}$ = *emissions factor* for *imported energy* source, *s*, at location, *l*, at timestep, *t*as determined in accordance with Section 7.3.2

Where the *AHJ* does not specify a required method for calculating *greenhouse gas emissions* associated with operational energy usage, the *project* shall comply with Section 7.3.3.1 or Section 7.3.3.2.

***7.3.3.1As-Designed* Path Minimum Quantification Requirements.** Where the *project* documents compliance in accordance with the "*As-Designed* Path," the *greenhouse gas emissions* associated with operational energy usage for the *RSP* shall be calculated in accordance with Equation 7.3.3.1:

$$GHG_{OE} = Y \times \left( \sum_{s} A_s \times e_s \right) + \sum_{y=y_1}^{y_Y} A_{elec} \times e_{elec,l,y} \tag{7.3.3.1}$$

where

$GHG_{OE}$ = total operational energy greenhouse gas emissions of the *RSP*, kg
$Y$ = number of years of the *RSP*
$A_S$ = annual energy usage for non-electric *imported energy* source *s*, as calculated in accordance with Section 7.3.1.3, MWh
$e_S$ = *emissions factor* for non-electric *imported energy* source, *s*, in accordance with Section 7.3.2, kg/MWh
$y_1$ = the first year of the *RSP*
$y_Y$ = the last year of the *RSP*
$A_{elec}$= annual electricity usage, as calculated in accordance with Section 7.3.1.3, MWh
$e_{elec,l,y}$
$ee_{eelleeee,ll,yye_{elec,l,y}}$ = greenhouse gas emissions factor for electricity for *project* location, *l*, and year, *y*, in accordance with Section 7.3.2, kg/MWh

**Exception to 7.3.3.1:** *Project*s for which the operational energy usage-related *greenhouse gas emissions* for the *RSP* are calculated in accordance with a method approved by the *AHJ*.

***7.3.3.2 As-Built* Path Minimum Quantification Requirements.** Where the *project* documents compliance in accordance with the "*As-Built* Path", the *greenhouse gas emissions* associated with operational energy usage for the *RSP* shall be calculated in accordance with Equation 7.3.3.2:

$$GHG_{OE} = \sum_{s} \sum_{y=y_1}^{y_s} E_{s,y} \times e_s + \sum_{s} (y_Y - y_s) \times (A_s \times e_s) + \sum_{y=y_1}^{y_{elec}} E_{elec,y} \times e_{elec,l,y} + \sum_{y=y_{elec}+1}^{y_Y} A_{elec} \times e_{elec,l,y} \quad (7.3.3.2)$$

where

$GHG_{OE}$ = total operational energy *greenhouse gas emissions* of the *RSP*, kg

$y_1$ = the first year of the *RSP*

$y_s$ = the most recent year of the *RSP* for which complete energy usage data is available for *imported energy* source, *s*, as measured in accordance with Section 7.3.1.4.1

$y_Y$ = the last year of the *RSP*

$E_{s,y}$ = energy usage for non-electric *imported energy* source *s*, in year, *y*, as measured in accordance with Section 7.3.1.4.1

$e_s$ = *emissions factor* for non-electric *imported energy* source, *s*, in accordance with Section 7.3.2, kg/MWh

$A_S$ = annual energy usage for non-electric *imported energy* source *s*, as calculated in accordance with Section 7.3.1.4.2, MWh

$E_{elec,y}$ = electricity usage in year, *y*, as measured in accordance with Section 7.3.1.4.1

$e_{elec,l,y}$ = *greenhouse gas emissions* factor for electricity for *project* location, *l*, and year, *y*, in accordance with Section 7.3.2, kg/MWh

$y_{elec}$ = the most recent year of the *RSP* for which complete electricity usage data is available, as measured in accordance with Section 7.3.1.4.1

$A_{elec}$ = annual electricity usage, as calculated in accordance with Section 7.3.1.4.1, MWh

**Exception to 7.3.3.2:** *Project*s for which the operational energy usage-related *greenhouse gas emissions* for the *RSP* are calculated in accordance with a method approved by the *AHJ*.

**7.4 Operational Water Usage (B7)** Compliance with the requirements of Section 7.4 shall not be required except where specifically required by the *AHJ*.

***Informative note:*** *For most buildings, the emissions related to water and wastewater are expected to be very small relative to other emissions. Exceptions may occur where water is supplied by a desalination process, for buildings with exceptionally high water consumption, and for buildings that are part of the water supply or wastewater treatment systems.*

**7.4.1 Operational Water Data Requirements.** The *greenhouse gas emissions assessment* shall comply with Sections 7.4.1.1 and 7.4.1.2 and either Section 7.4.1.3 or Section 7.4.1.4.

**7.4.1.1 General Data Requirements – Water usage.** All water usage shall be determined on an annual basis. Where the *AHJ* requires a *greenhouse gas assessment* using a temporal resolution other than one

year for water usage, the water usage shall be determined at the same temporal resolution required by the *AHJ*.

**7.4.1.2 General Data Requirements – Wastewater generation.** All wastewater generation shall be determined on an annual basis. Where the *AHJ* requires a *greenhouse gas assessment* using a temporal resolution other than one year for wastewater generation, the wastewater generation shall be determined at the same temporal resolution required by the *AHJ*.

**7.4.1.3 *As-Designed* Data Requirements – Operational Water.** Water consumption and wastewater generation shall be determined based on the characteristics of the *building* including number of occupants, occupant activity and schedules, water fixture flow rates, and any other relevant factors.

***Informative Note***: The US DOE provides guidance on estimating water consumption at https://www.energy.gov/eere/femp/estimating-methods-determining-end-use-water-consumption.

**7.4.1.4 *As-Built* and Operated Data Requirements – Operational Water.** The water usage shall be determined in accordance with Section 7.4.1.4.1. The wastewater generation shall be determined in accordance with Section 7.4.1.4.2.

**7.4.1.4.1 *As-Built* and Operated Data Requirements – Water Usage.** Where an *existing building* has not less than one complete year of metered water consumption data, the consumption shall be that of the most recent 12-month period. Where the *building* has water supplied from multiple sources with individual meters (for example, potable water and recycled water), water consumption for each source shall be determined separately.

**Exception to 7.4.1.4.1:** Where a 12-month period of metered water consumption other than the most recent 12-month period is approved by the *AHJ* as better representing future consumption, consumption data from such period shall be used.

**7.4.1.4.2 *As-Built* and Operated Data Requirements – Wastewater.** Where an existing *building* has not less than one complete year of metered wastewater data, the generation shall be that of the most recent 12-month period.

**Exception to 7.4.1.4.2:** Where a 12-month period of metered wastewater generation other than the most recent 12-month period is approved by the *AHJ* as better representing future generation, generation data from such period shall be used.

**7.4.2 Greenhouse Gas Emissions Quantification – Operational Water.** The *greenhouse gas emissions* associated with water usage shall be determined in accordance with Section 7.4.2.1. The *greenhouse gas emissions* associated with wastewater generation shall be determined in accordance with Section 7.4.2.2.

**7.4.2.1 Greenhouse Gas Emissions Quantification – Water Usage.**

**7.4.2.1.1 Water Supply-Related Energy Usage.** The energy needed for the supply of water across the analysis boundary shall be determined and shall be expressed as an energy per unit of water volume. The water-related energy consumption shall be the energy per unit water volume multiplied by the water consumption determined in accordance with Section 7.4.1. Where a *building* has multiple water supplies, the energy consumption per unit water volume shall be determined separately for each supply.

The energy per unit water volume shall include energy needed for sourcing, treatment, and transport. Data used shall be provided by the local water utility or as otherwise acceptable to the *AHJ*. Where data for the local water utility are not available, a value of 0.75 kWh/m³ of electricity shall be used. Locations not served by a water utility shall include the energy consumption of local *equipment*, such as well pumps, where such *equipment* is not included in the energy consumption of the *building* as determined in accordance with Section 7.3.

***Informative notes**:*

1. Sourcing energy includes well pumps, desalination plants, and any other electric and non-electric energy needed to provide water to a treatment plant delivering water to the *site*.
2. Treatment energy includes the electric and non-electric energy consumption of water treatment plants in the process of filtration and chemical treatment as necessary to make the water potable or otherwise useable on the *site*.
3. Transport energy includes electric and non-electric energy used by pumps necessary to transport the water from the treatment plant to the *site* including energy needed to provide pressure to the *site*.

**7.4.2.1.2 Water Supply-Related Energy Emissions.** Water supply-related *greenhouse gas emissions* shall be calculated in accordance with Section 7.3.3 by replacing the operational energy consumption values with the water supply-related energy usage determined in accordance with Section 7.4.1.

**7.4.2.2 Greenhouse Gas Emissions Quantification – Wastewater Generation.**

**7.4.2.2 Wastewater-Related Energy Usage.** The energy needed for the pumping of wastewater from the analysis boundary to a wastewater treatment plant shall be determined and shall be expressed as an energy per unit of water volume. Data used shall be provided by the local wastewater utility or as otherwise acceptable to the *AHJ*. Where data for the local water utility are not available, values of 0.56 kWh/m³ of electricity plus 0.23 kWh/m³ of natural gas shall be used. The wastewater-related energy consumption shall be the energy per unit wastewater volume multiplied by the wastewater generation determined in accordance with Section 7.4.1.

**7.4.2.2.2 Wastewater-Related Energy Emissions.** Wastewater energy-related *greenhouse gas emissions* shall be calculated in accordance with Section 7.3.3 by replacing the operational energy consumption values with the wastewater energy usage determined in accordance with Section 7.4.1.

**7.4.2.2.3 Wastewater-Related Non-Energy Emissions.** Non-energy *emissions factor* from wastewater treatment processes shall be determined from the local wastewater treatment system on an emissions per unit of wastewater volume basis. Data used shall be provided by the local wastewater utility or as otherwise acceptable to the *AHJ*. The non-energy wastewater *CO2e* emissions shall be the non-energy *emissions* factor multiplied by the wastewater volume determined in accordance with Section 7.4.1.

**7.4.2.2.4 Total Wastewater-Related Emissions.** The total wastewater *CO2e emissions* shall be the sum of the wastewater energy related *CO2e emissions* determined in accordance with Section 7.4.2.2.2 and the non-energy wastewater *CO2e emissions* determined in accordance with Section 7.4.2.2.3.

**8. Quantifying Greenhouse Gas Emissions Associated with Benefits and Loads Beyond the *System Boundary***

## 8.1 General

**8.1.1 Scope.** Section 8 specifies requirements for quantifying the *greenhouse gas emissions* beyond the *system boundary* in the *greenhouse gas emissions assessment*.

**8.2 Compliance Paths**. The *greenhouse gas emissions assessment* shall comply with Section 8.2.1 and either Section 8.2.2 or Section 8.2.3.

**8.2.1 Requirements for all Compliance Paths**. The *greenhouse gas emissions assessment* shall comply with all of the following:

**a.** Section 8.1, "General"
**b.** Section 8.3, "Recovery, Reuse and Recycling Potential (*D1*)
**c.** Section 8.4.1.1, "Data Time Resolution"
**d.** Section 8.4.1.2, "Specific Exported Energy Sources"

**8.2.2 Requirements for As-Designed Compliance Path**

a. Section 8.4.1.3, "*As-Designed* Data Requirements – Exported Energy"

**8.2.3 Requirements for As-Designed Compliance Path**

a. Section 8.4.1.4, "*As-Built* and Operated Data Requirements – Exported Energy"

**8.3 Recovery, Reuse and Recycling Potential (*D1*)**. The *greenhouse gas emission*s associated with recovery, reuse and recycling potential of each product in the *material inventory* shall be the appropriate value from the same environmental impact data source as used for Section ~~6.5.7~~ 6.2.2. Where the environmental impact data source used for the product does not include information on recovery, reuse and recycling potential, the *greenhouse gas emissions* for the product's recovery, reuse and recycling potential shall be zero.

**Exception to 8.3:** Where compliance is shown using the "*As-Designed* Path" and the *construction documents* include all information necessary for *design for deconstruction* of the product or compliance is shown using the "*As-*~~Measured~~ *Built* Compliance Path" and the *record documents* include all information necessary for *design for deconstruction* of the product, and the *greenhouse gas emissions* for the product's recovery, reuse and recycling potential are assigned a value equal to the *product stage* calculated in accordance with Section 6.5.9~~1~~.

## 8.4 Exported Energy (*D2*)

**8.4.1 Exported Energy Data Requirements.** The *greenhouse gas emissions assessment* shall comply with Section 8.4.1.1 and Section 8.4.1.2 and with either Section 8.4.1.3 or Section 8.4.1.4.

**8.4.1.1 Data Time Resolution.** All *exported energy* shall be computed at the same time resolution as the data used to comply with Section 7.3.1.2. ~~on an annual basis for each energy source. Where the *authority having jurisdiction* requires a *greenhouse gas assessment* using a temporal resolution other than one year for any *exported energy* source, the exported energy shall be computed at the same temporal~~

~~resolution required by the *authority having jurisdiction* for each applicable *exported energy* source.~~

**8.4.1.2 Specific Exported Energy Sources.** All the following specific *exported energy* sources shall be determined individually:

1. Electricity usage for *electric vehicle supply equipment* computed in accordance with Section 7.3.1.2.
2. Any *exported energy* source specified by the *AHJ*.

**Exception to 8.4.1.2:** Where the *project* complies with Section 8.5.1.4 and the specific *exported energy* source is not separately metered.

**8.4.1.3 *As-Designed* Data Requirements – Exported Energy.** *Exported energy* shall be computed using the same model used to comply with Section 7.3.1.3.

**8.4.1.4 *As-Built* Data Requirements – Exported Energy.** Historical *exported energy* shall be computed in accordance with Section 8.4.1.4.1, and typical annual *exported energy* shall be computed in accordance with Section 8.4.1.4.2 for each *exported energy* source.

**Exception to 8.4.1.4:** Where an *exported energy* source is not separately metered.

**8.4.1.4.1 Historical Exported Energy.** Each *exported energy* source shall be measured and recorded annually and at any additional interval required by the *AHJ*.

**8.4.1.4.2 Typical Annual Exported Energy.** An average annual *exported energy* for each *exported energy* source shall be calculated based on ~~the lesser of~~ all available data for the energy source, not to exceed ~~and~~the five most recent years of *exported energy* data quantified in accordance with Section 8.4.1.4.1.

**Exception to 8.4.1.4.2** Where the *AHJ* approves the use of measured *exported energy* usage for a period no less than one year as better representing the future *imported energy* usage.

## 9. Documentation of *Greenhouse Gas Emissions*

**9.1 Compliance.** The ~~estimated~~ calculated ~~*as-designed*~~ embodied ~~carbon~~ *GHG emissions* and removals, operational ~~carbon~~ *GHG emissions*, and total ~~*greenhouse gas*~~ *GHG emissions* of the *building* and *building site* or portion thereof shall be documented and made available to the *AHJ*. Where the assessment includes *as-designed* and *as-built* calculations emissions shall be documented separately for each.

~~The *as-built* embodied carbon emissions of the *building* and *building site* or portion thereof shall be made available to the *authority having jurisdiction,* if requested.~~

**9.2 Minimum *Project* Assessment Identification Parameters.** The following *Project* Assessment Identification Parameters shall be documented ~~collected~~:

~~a. Unique identifier.~~
a~~b~~. *Project* Name.
~~c~~b. *Project Street Address*

C. ~~Date of Submission.~~
~~d~~c. *Project* City.
ed. *Project* Country.
fe. *Project* Postal Code.
~~g. *Project* Data Has Been Anonymized (yes/no).~~
~~h. *Project* Units (IP or SI).~~
~~i.~~f Building *Gross Floor Area*.
~~j.~~g *Project Site* Area.
~~k~~h. Year of reporting data.
~~l~~i. *Project* phase at time of assessment.
j. *Project* Construction Type: New Construction or *Existing Building* Modification.
~~M~~k. . Embodied Carbon Tool used, including software and database version
~~n. Applicable life cycle stages.~~
~~o. Scope Included in Assessment~~.
~~p~~.l. Operational Energy calculation methodology ~~Included (yes/no). If operational energy is included, the referenced calculation methodology shall be stated.~~
~~q. *Biogenic* Embodied carbon Included (yes/no).~~
m. *GWP* Time Horizons Used
1. Embodied Carbon (materials):
2. Embodied Carbon (*fugitive emissions*):
3. Operational Carbon (fuel sources other than electricity):
4. Operational Carbon (electricity):

**9.3 Object of Assessment.** The Object of Assessment shall be documented in accordance with ~~Fields per~~ Sections 9.3.1 through 9.3.5. ~~shall be included~~.

**9.3.1. Physical Limit.** Text description that includes the physical limits of the study as defined by Section 5.2.

**9.3.2 *System Boundary*.** Text description to identify which building *life cycle stage* modules are excluded and why.

**9.3.3 Exclusions of Required Processes, Flows and Activities.** Text description to identify which *building life-cycle stage* modules are excluded and why.

**9.3.4 *Reference Study Period.*** A single value representing the number of years.

**9.3.5 Spatial Boundary.** Text description to identify unusual or non-standard conditions that are or are not included in the scope of the assessment.

9.4 ~~**Carbon**~~ **Greenhouse Gas Emissions.** The following *GHG emissions* shall be documented, in units of mass of CO2e~~.~~:
a. Total embodied *GHG emissions* calculated in accordance with Section 6.6.1.
b. Embodied *GHG emissions* calculated in accordance with Section 6.6.1.
c. Operational *GHG emissions* calculated in accordance with Section 7.
d. *GHG emissions* associated with benefits and loads beyond the *system boundary* calculated in accordance with Section 8, where required by the *AHJ*.
d. Total net *GWP* emissions

**9.4 Embodied Carbon.** Where required by the ~~*AHJ,*~~ the embodied *GHG* ~~*greenhouse gas emissions associated with embodied carbon*~~ shall be documented as the sum of results from the following *building element* categories as described in Table A1: OmniClass Building Elements (L1-3) and calculated in accordance with Section 6:

a. *Substructure*.
b. *Superstructure* (*Structure*).
c. *Superstructure* (*Enclosure*).
d. Interiors.
e. Services.
g. Special Construction and *Demolition*.
h. Sitework. Elements beyond the minimum required scope for the *building* as noted in the sections above shall be reported independently as *greenhouse gas emissions* for the *building site* and not included within the calculation of the *greenhouse gas emissions for the building*. This shall include documenting Sitework as an independent category separate from other *building element* categories.
i. Other voluntarily reported elements beyond the minimum required scope for the *building* and the *building site* shall be reported independently as two separate categories and shall not be included within the calculation of the *greenhouse gas emissions for the building* and the *building site*.
j. ~~Other voluntarily reported elements beyond the minimum required scope for the *building site* shall be reported independently and shall not be included within the calculation of the *greenhouse gas emissions for the building site*~~.

**9.4.1 *Life Cycle Stages*.** Documentation shall include emissions for the following *life-cycle stages* per *building element* category:

a. *Product stages A1-A3* calculated in accordance with Section 6.5.1.
b. *Construction stage A4* for the transportation of all materials and products to the construction *site* calculated in accordance with Section 6.5.2.
c. *Construction stage A5* for the construction processes and installation of materials calculated in accordance with Section 6.5.3.
d. *Use stage B1* for in-use emissions calculated in accordance with Section 6.5.4.
e. Maintenance stage calculated in accordance with Section 6.5.5, where required by the *AHJ*.
f. Repair stage calculated in accordance with Section 6.5.6, where required by the *AHJ*.
~~e~~g. *Use stage B4* for the replacement of components in their entirety at the end of their *service life* calculated in accordance with Section 6.5.7.
h. *Use stage B5* for any refurbishment or retrofit calculated in accordance with Section 6.5.8.
i. *Deconstruction and end-of-life stage C1* for the *deconstruction* and *demolition* of a *project* calculated in accordance with Section 6.5.9.
j. *Deconstruction and end-of-life stage C2* for the transportation of materials to and from intermediate storage or waste processing locations calculated in accordance with Section 6.5.10.
k. *Deconstruction and end-of-life stage C3* for the processing of materials for reuse, recovery, or recycling calculated in accordance with Section 6.5.11.
l. *Deconstruction and end-of-life stage C4* for the treatment and disposal of materials calculated in accordance with Section 6.5.12.
m. Benefits and loads beyond the *system boundary* stage *D1* for recovery, reuse and recycling potential, calculated in accordance with Section 8.3, where required by the *AHJ*.
n. Benefits and loads beyond the *system boundary* stage *D2* for *exported energy*, calculated in accordance with Section 8.3, where required by the *AHJ*.

**9.4.2 Carbon Emissions per Stage.** The ~~required~~ documentation of ~~carbon~~ *GHG emissions* per stage shall include:

a. *GWP* Fossil (kgCO2e).
b. *GWP Biogenic* (kgCO2e).
c. *GWP* Captured and stored (kgCO2e).

**9.5 Operational ~~Carbon~~GHG**. Where required by the A*HJ,* the operational *GHG ~~greenhouse gas~~ emissions ~~associated with operational carbon~~* shall be documented as the sum of results from the following sources:

a. *GHG emissions* associated with ~~E~~energy usage ~~consumption~~ calculated in accordance with Section 9.5.1.

b. *GHG emissions* associated with ~~W~~water~~/~~andwastewater calculated in accordance with Section 9.5.5.

**9.5.1 Greenhouse Gas Emissions from Energy Use.** Documentation ~~for~~ of the operational ~~carbon~~ GHG emissions associated with energy usage shall include the first year and ~~sixty-year~~ *reference study period* projections of ~~*greenhouse gas*~~ *GHG emissions* from all of the following applicable to the assessment ~~sources~~:

a. Electricity usage calculated ~~consumption~~ in accordance with Section 9.5.2.
b. Fuel usage calculated ~~consumption~~ in accordance with Section 9.5.3.
c. Thermal energy usage calculated ~~consumption~~ in accordance with Section 9.5.4.

**9.5.1.1 Global Warming Potential of Energy Sources.** The documentation shall state whether the basis of the *global warming potential* for energy sources is determined on a 20-year or 100-year basis.

**9.5.1.2 Energy Model Criteria.** The documentation shall include the following key energy model criteria:

a. A text description naming the energy modeling methodology reference standard used.
b. The name and version of software used for energy modeling.
c. The *building* or *building site* location's weather data information based on the information available in ASHRAE's Weather Data Viewer (for details, see https://www.ashrae.org/technical-resources/bookstore/weather-data-center). The documentation shall state the weather station name and the World Meteorological Organization (WMO) station identifier, the latitude, longitude, and ASHRAE Climate Zone of the *building* or *building site* per ASHRAE Standard 169, year of accessing the weather file, and hyperlink if file is available in a public domain. The documentation shall state whether the weather file is derived from statistical assessment of historical data or projected weather data files downscaled from global climate models. Projected weather data file documentation shall include source, downscaling methodology, emissions scenarios, projected time period, and associated Climate Model Intercomparison Project (CMIP).

**9.5.1.3 ~~Exported Energy Not Applicable~~ Specific Energy End Uses.** ~~Only consumed energy shall be tracked for compliance with this Standard. Exports of renewable energy to the utility or another user shall not be counted as deductions in the calculation of the greenhouse gas emissions under this standard.~~ *GHG emissions* associated with end use data complying with Section 7.3.1.2 and calculated in accordance with Sections 9.5.2 through 9.5.4 shall be documented separately for each applicable end use.

**9.5.2 Electricity usage.** Documentation of *greenhouse gas emissions* associated with source electricity use shall include:

a. Name of Electricity Source Provider.

b. The type of electricity source selected from one of the following: "*imported from a utility*," "*on-site electricity generation*," or "direct-wired from dedicated offsite source."
c. ~~Carbon~~ *Emissions factor* (in kgCO2e/MWh) stated as either a single annualized value or as a list of sub-annual schedule-based values, with a text description of the source of the data.
d. Basis of future ~~carbon~~ *emissions factor* projections if applied to the *RSP* calculations, the basis of such projections shall be documented along with the source of the assumption. Default requirement is the number of years within the *RSP* multiplied by the emissions associated with the first year of operation.
e. First year *as-designed* consumption (in MWh/year).
f. First year *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e).
g. Total life-cycle *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e) based on the *RSP*.

**9.5.3 Fuel Usage ~~consumption~~.** *Greenhouse gas emissions* associated with source fuel use shall be documented as follows:
a. Name of Fuel.
b. Name of Fuel Source Provider.
c. Type of Fuel Source. To be selected from "Piped source" or "Bulk-delivery source."
d. ~~Carbon~~ *Emissions factor* (in kgCO2e/MWh). To be stated as a single annualized value, with a text description of the source of the data.
e. First Year *as-designed* consumption (in MWh/year).
f. First Year *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e).
g. Total life-cycle *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e) based on the *RSP*.

**9.5.4 Thermal Energy usage ~~consumption~~**. Documentation of *Greenhouse gas emissions* associated with source thermal energy shall include:
a. Name of Thermal Energy Source Provider.
b. The type of Fuel Source for cooling ~~and/~~or heating, of *conditioned spaces* where cooling refers to chilled water or condenser water and heating refers to heating water or steam.
c. ~~Carbon~~ *Emissions factor* (in kgCO2e/MWh of thermal energy) stated as a single annualized value, with a text description of the source of the data.
d. First Year *as-designed* consumption (in MWh of thermal energy/year).
e. First Year *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e/year).
f. Total life-cycle *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e) based on the *RSP*. 1

**9.5.5 Greenhouse Gas Emissions from Water/Wastewater.** Documentation of the operational *GHG* ~~carbon~~ *emissions* associated with water shall include the first year and *reference study period* ~~sixty-year~~ projections of *GHG* ~~*greenhouse gas*~~ *emissions* associated with all of ~~for~~ the following sources and products:
a. Potable water.
b. Reclaimed water.
c. Wastewater ~~when where required by the *Authority Having Jurisdiction*~~

**9.5.5.1 Water/Wastewater Calculation Criteria.** The documentation shall include a text description describing the derivation of the consumption values for each water source or wastewater product and specify:
a. Name of Water source provider or Wastewater handling utility.
b. The type of Water/Wastewater. To be selected from potable, reclaimed, or wastewater.
c. Energy Intensity factor (in kWh/$m^3$) for electricity used in sourcing, treatment, and transport as a single annualized value, and a text description of the source of the data.

d. Energy Intensity factor (in kWh/$m^3$) for fuel used in sourcing, treatment, and transport as a single annualized value, and a text description of the source of the data.
e. First year *as-designed* water or wastewater volume (in $m^3$/year).
f. First year *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e/year) from electricity and fuel use.
g. Total life-cycle *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e) from electricity and fuel use based on the *RSP*.

**9.6 Total Greenhouse Gas Emissions Summary Results.** Where required by the *AHJ,* the total *greenhouse gas emissions* for the *building* and building *site* shall be separately stated as follows:

a. The total *greenhouse gas emissions* is represented by the sum for each *life-cycle stage*, with operational energy and operational water total life-cycle *greenhouse gas emissions* inserted into stages *B6* & *B7*.
b. For each stage other than *B6* & *B7*, results shall be reported for *GWP* Fossil Fuel (kgCO2e), GWP *Biogenic* (kgCO2e), and area normalized *GWP* Fossil Fuel (kgCO2e/$m^2$), GWP *Biogenic* (kgCO2e/$m^2$) using the building *gross floor area* or the *project site* area, respectively for building and *site* emissions, where areas are as described in Section 5.
c. For *B6* and *B7*, results shall be reported as *GWP* Fossil Fuel (kgCO2e) and area normalized GWP Fossil Fuel (kgCO2e/$m^2$).
d. A totalizing sum of *Modules A* through *C* for the *building* shall be provided in GWP Fossil Fuel (kgCO2e), GWP *Biogenic* (kgCO2e), and area normalized GWP Fossil Fuel (kgCO2e/$m^2$), GWP *Biogenic* (kgCO2e/$m^2$) using the building *gross floor area*.
e. As appropriate, a totalizing sum of *Modules A* through *C* for the building *site* shall be provided in GWP Fossil Fuel (kgCO2e), GWP *Biogenic* (kgCO2e), and area normalized GWP Fossil Fuel (kgCO2e/$m^2$), GWP *Biogenic* (kgCO2e/$m^2$) using the using the project site area." where project site area is a defined term.

**9.7 *Module D* Documentation requirements.** Where required by the *AHJ* ~~*Authority Having Jurisdiction,*~~ the benefits and loads beyond the *system boundary* shall be reported as follows:

a. *GHG emissions* associated with *Module D1* (recovery, reuse, and recycling potential) and calculated iin accordance with Section 8.3 shall be documented ~~(~~in kgCO2e~~)~~ for relevant processes and material flows per *building element* category that occur outside of the *system boundary.*
b. Energy usage associated with *Module D2* (*exported energy*) and calculated in accordance with Section 8.4 shall be documented ~~(~~in MWh/year~~)~~ for all specific *exported energy* sources complying with Section 8.4.1.2. ~~energy serving *electric vehicle supply equipment*.~~
c. *GHG emissions* associated with ~~For each *exported energy* source as specified by the *authority having jurisdiction,* independent documentation of~~ *Module D2* (*exported energy*) and calculated in accordance with Section 8.4 shall be documented in kgCO2e for all specific *exported energy* sources complying with Section 8.4.1.2~~per export type (in MWh/year) shall be provided~~.

**9.8 Environmental Impact Data Disclosure per Product or Material.** Where required by the *AHJ,* documentation of data source per product or material shall include:

a. Name of Product or Material.
b. Associated *building element* category
c. Type of Allowable Data Source. The allowable data source shall be selected from one of the following: “Product-specific *EPD*”, “Facility-specific or supply-chain specific *EPD*”, “Industry-~~wide~~ average *EPD*”, “regional dataset of generic environmental impact figures”, “background datasets”, or “MEP lifecycle assessments” as described under Section 6.3.1. Documentation shall include:
d. The publisher’s name.
e. The publication date.

f. Environmental impact results by *life cycle stage* for GWP Fossil and GWP *Biogenic* (in kgCO2e).
g. *Functional Unit.*
h. Total ~~carbon~~ data uncertainty score as derived from the calculations ~~noted~~ in Section 6.4.

## 10 NORMATIVE REFERENCES

| Reference | Title |
|---|---|
| ASHRAE | ASHRAE 2020. ANSI/ASHRAE Standard 169, Climatic Data for Building Design Standards. Atlanta: ASHRAE. |
| ASHRAE | ASHRAE. 2022. ANSI/ASHRAE/IES Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P edition. Atlanta: ASHRAE. |
| ASHRAE | ASHRAE. 2018. ANSI/ASHRAE Standard 209, Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings, I-P edition. Atlanta: ASHRAE. |
| ASHRAE | ASHRAE 2021. Handbook (Fundamentals) , SI edition. Atlanta: ASHRAE |
| ASHRAE | ASHRAE 2018. ANSI/ASHRAE/IES Standard 90.1, Energy Efficient Design of Low-Rise Residential Buildings, I-P edition. Atlanta: ASHRAE. |
| ASHRAE | ASHRAE 2021. ASHRAE Weather Data Viewer. https://www.ashrae.org/technical-resources/bookstore/weather-data-center Atlanta: ASHRAE |
| CIBSE | CIBSE Technical Memorandum 65, Embodied carbon in building services: A calculation methodology (2021)TM65. |
| CIBSE | CIBSE. (2022). TM65LA Embodied carbon in building services: Using TM65 outside the UK. |
| CIBSE | CIBSE. (2022). TM65ANZ Embodied carbon in building services: A methodology for ANZ. |
| CIBSE | CIBSE. (2022). Embodied Carbon Manufacturer Form (Beta 2) |
| ~~Structural Engineering Institute (SEI) Sustainability Committee~~ | ~~*Calculation Methodology for Structural Systems in Whole-Building Life Cycle Assessment*, a publication of the Structural Engineering Institute (SEI) Sustainability Committee.~~ |
| Intergovernmental Panel on Climate Change (IPCC) | Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) |
| EPA | EPA Snap Refrigerants Blends http://www.epa.gov/ozone/snap/refrigerants/refblend.html |
| EPA | Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2021 (https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021) |

| | |
|---|---|
| ICC | ICC 2021. International Energy Conservation Code. Washington D.C.: ICC. |
| ISO | International Organization Standardization [IS0 ~~2020~~ 2016] ISO 14025:~~2020~~ 2016~~–~~ Type III environmental declarations – Principles and procedures ~~Environment labels and declarations.~~ |
| ISO | International Organization Standardization [IS0 2006] ISO 14040:2006 Environmental management Life cycle assessment Principles and framework. |
| ISO | International Organization Standardization [ISO 2006] ISO 14044, Environmental management – Life cycle assessment – Requirements and guidelines |
| ISO | International Organization Standardization [IS0 2017] ISO 21930:2017, Sustainability in buildings and civile engineering works- Core rules for environmental product declarations of construction products and services |
| EN | ~~EN 2012. EN Standard 15804-2012, Sustainability of construction works, Environmental declarations, Core rules for the product category of construction products plus amendment 2~~European Committee for Standardization (CEN). "EN 15804:2012+A2:2019: Sustainability of Construction Works - Environmental Product Declarations - Core Rules for the Product Category of Construction Products," 2019. https://www.en-standard.eu/bs-en-15804-2012-a2-2019-sustainability-of-construction-works-environmental-product-declarations-core-rules-for-the-product-category-of-construction-products/. |
| EN | European Committee for Standardization (CEN)"EN Standard 50693:2019, Product category rules for life cycle assessments of electronic and electrical products and systems" |
| RICS | Royal Institution of Charter Surveyors (RICS). (2023). Whole life carbon assessment for the built environment, 2nd edition. London. RICS, ~~2023~~ |

***Informative note:*** The most recent versions of reference TM 65 documents for the UK, Australia and New Zealand, and the use of TM 65 methodologies outside the UK can be found at https://www.cibse.org/tm65, with reference documents at time of publishing as follows:

CIBSE. (2021). TM65 Embodied carbon in building services: A calculation methodology.
CIBSE. (2022). TM65LA Embodied carbon in building services: Using TM65 outside the UK.
CIBSE. (2022). TM65ANZ Embodied carbon in building services: A methodology for ANZ.
CIBSE. (2022). Embodied Carbon Manufacturer Form (Beta 2)]k
CIBSE. (2024). TM65NA Embodied Carbon in building services: A calculation methodology for North America.

~~**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**~~

## ~~INFORMATIVE~~ NORMATIVE APPENDIX A

### A.1 Building Elements

Informative Note: All *buildings* are made up of discreet *building elements* which can be grouped into consistent categories such as *structure*, envelope, interiors, and services. A Whole Life Cycle Analysis report ~~format will follow a common~~commonly follows an elemental *structure* based on **OmniClass Table 21 – Building Elements**. OmniClass is designed to provide a standardized basis for classifying information created and used by the North American architectural, engineering, and construction (AEC) industry, and can be used throughout the full facility and asset life cycle. Table A.1 is arranged by OmniClass Table 21 (L1-3) with added commentary.

It is natural for the granularity of reporting and modeling to increase as a design develops, with the greatest level of detail and certainty about material estimates occurring after *project* completion. Increasing the specificity of model data should improve the accuracy of the WLCA and reduce uncertainty, however, it should not result in increased scope.

~~All *building elements* referenced in the table below that are within the scope of the *building project* must be included in any compliant WLCA, whatever the *project* phase. While the granularity of reporting and modeling may increase as a design develops with the greatest level of detail and certainty about material estimates after project completion. Increasing the specificity of model data should improve the accuracy of the WLCA and reduce uncertainty, however, it should not result in increased scope.~~

**Table A.1 O~~mniClass *Building Elements* (L1-3)~~Building Element Categories**

| | | | | Years |
|---|---|---|---|---|
| **OmniClass Number** | **Element Category** | **Required** | **Exclude** | **Default *Service Life*** |
| **21-01 00 00** | **Substructure** | | | |
| 21-01 10 | **Foundations** | X | | Life of *building* |
| 21-01 10 10 | – Standard Foundations | -Including sheeting, shoring and blind side waterproofing elements. Only includes permanently installed components. | X | | Life of *building* |
| 21-01 10 20 | – Special Foundations | | X | | Life of *building* |
| 21-01 20 | **Subgrade Enclosures** | X | | Life of *building* |
| 21-01 20 10 | – Walls for Subgrade Enclosures | Including retaining walls, foundation walls, below-grade insulation, and waterproofing. | X | | Life of *building* |
| 21-01 40 | **Slabs-On-Grade** | X | | Life of *building* |
| 21-01 40 10 | – Standard Slabs-on-Grade | X | | Life of *building* |
| 21-01 40 20 | – Structural Slabs-on-Grade | X | | Life of *building* |
| 21-01 40 30 | – Slab Trenches | X | | Life of *building* |
| 21-01 40 40 | – Pits and Bases | X | | Life of *building* |

 

| | | | | | |
|---|---|---|---|---|---|
| 21-01 40 90 | – Slab-On-Grade Supplementary Components | | X | | Life of building |
| 21-01 60 | **Water and Gas Mitigation** | | X | | |
| 21-01 60 10 | – *Building* Subdrainage | Including sheeting, shoring and blind side waterproofing elements. Only includes permanently installed components. | X | | |
| 21-01 60 20 | – Off-Gassing Mitigation | | | X | n/a |
| 21-01 90 | – **Substructure Related Activities** | | | X | n/a |
| 21-01 90 10 | – Substructure Excavation | | | X | n/a |
| 21-01 90 20 | – Construction Dewatering | | | X | n/a |
| 21-01 90 30 | – Excavation Support<br>– Only materials left in place after construction shall be included | | | X | n/a |
| 21-01 90 40 | – Soil Treatment | | | X | n/a |
| 21-02 10 | **Superstructure** | | | | Life of *building* |
| 21-02 10 10 | – Floor Construction | Including elements of:<br>• Gravity systems - columns, bearing walls, beams, joists, girders, floor plate, roof plate, topping slabs, ledgers, blocking, deck edge angles, and kickers<br>• Lateral systems - bracing and frames, shear walls, and diaphragms.<br>Connections & Attachments - primary connections (framing to framing), secondary connections (sheathing and nailing), and diaphragm connections, secondary reinforcement (drag bars, opening reinforcement, add bars).<br>• Thermal and water vapor layers. | X | | Life of *building* |
| 21-02 10 20 | – Roof Construction | | X | | Life of *building* |
| 21-02 10 80 | – Stairs | Including stringers, treads, and railing | X | | Life of *building* |
| | – **Enclosure** | | | | |
| 21-02 20 | – **Exterior Vertical Enclosures** | | X | | 35 |
| 21-02 20 10 | – *Exterior Walls* | | X | | 35 |

| | | | | |
|---|---|---|---|---|
| 21-02 20 20 | – Exterior Windows | X | | 30 |
| 21-02 20 50 | – Exterior Doors and Grilles | X | | 30 |
| 21-02 20 70 | – Exterior Louvers and Vents | X | | 30 |
| 21-02 20 80 | – *Exterior Wall* Appurtenances | X | | 30 |
| 21-02 20 90 | – *Exterior Wall* Specialties | X | | 30 |
| 21-02 30 | – **Exterior Horizontal Enclosures** | X | | |
| 21-02 30 10 | – Roofing | X | | 20 |
| 21-02 30 20 | – Roof Appurtenances | | X | n/a |
| 21-02 30 40 | – Traffic Bearing Horizontal Enclosures | X | | 20 |
| 21-02 30 60 | – Horizontal Openings | X | | 20 |
| 21-02 30 80 | – Overhead Exterior Enclosures | X | | 20 |
| **21-03 00 00** | – **Interiors** | | | |
| 21-03 10 | – **Interior Construction** | X | | |
| 21-03 10 10 | – Interior Partitions Including walls | X | | 25 |
| 21-03 10 20 | – Interior Windows | X | | 25 |
| 21-03 10 30 | – Interior Doors | X | | 25 |
| 21-03 10 40 | – Interior Grilles and Gates | | X | n/a |
| 21-03 10 60 | – Raised Floor Construction | X | | 25 |
| 21-03 10 70 | – Suspended Ceiling Construction | X | | ( Refer to Interior Finishes below; 21-03 20 50 ) |
| 21-03 10 90 | – Interior Specialties | | X | n/a |
| 21-03 20 | – **Interior Finishes** | X | | |
| 21-03 20 10 | – Wall Finishes | X | | |
| | - Epoxy (Two part) | | | 15 |
| | - Fabric | | | 5 |
| | - Glazed Wall Tile | | | 50 |
| | - Paint | | | 5 |
| | - Plastic Laminate | | | 10 |
| | - Vinyl Wall Covering | | | 10 |
| | - Wall base | | | 5 |
| | - Wallpaper | | | 4 |
| | - Wood Finishes | | | |
| | - Finish | | | 10 |
| | - Substrate | | | 50 |
| 21-03 20 20 | – Interior Fabrications Including permanently installed interior components not included elsewhere. | X | | 12 |

 

| | | | | | |
|---|---|---|---|---|---|
| 21-03 20 30 | – Flooring | | X | | |
| | - Carpet | | | | |
| | - Broad Loom | | | | 5 |
| | - Carpet Tiles | | | | 5 |
| | - Loop Pile | | | | 15 |
| | - Concrete | | | | 50 |
| | - Epoxy Coating (Two Part) | | | | 10 |
| | - Hardwood | | | | |
| | - Finish | | | | 10 |
| | - Substrate | | | | 50 |
| | - Laminate | | | | 10 |
| | - Linoleum | | | | 5 |
| | - Mosaic Tile | | | | 50 |
| | - Porcelain Tile | | | | 50 |
| | - Rubber Tile | | | | 5 |
| | - Stone | | | | |
| | - Granite | | | | 75 |
| | - Marble | | | | 50 |
| | - Terrazzo | | | | 50 |
| | - Vinyl | | | | |
| | - Sheet | | | | 12 |
| | - Tile | | | | 12 |
| 21-03 20 40 | – Stair Finishes | | X | | See flooring. |
| 21-03 20 50 | – Ceiling Finishes | | X | | |
| | - Drywall / Plaster | | | | 30 |
| | - Metal | | | | 25 |
| | - Suspended | | | | |
| | - Ceiling Tiles | | | | 13 |
| | - Lay-in systems | | | | 25 |
| | - Spline Systems | | | | 20 |
| 21-04 | – **Services** | | | | |
| 21-04 10 | – **Conveying** | | | X | |
| 21-04 10 10 | – Vertical Conveying Systems | | | X | 15 |
| 21-04 10 30 | – Horizontal Conveying | | | X | 20 |
| 21-04 10 50 | – Material Handling | | | X | n/a |
| 21-04 10 80 | – Operable Access Systems | | | X | n/a |
| 21-04 20 | – **Plumbing** | Including equipment, piping, and fixtures for domestic hot and cold water, storm water, | X | | |

| | | | | | |
|---|---|---|---|---|---|
| | | natural gas, sanitary, waste systems; and specialty gas systems, such as potable water systems, non-potable water systems, hot water heaters, water closet fixtures, grease traps, gray water systems, black water systems, medical gases and their insulation. | | | |
| 21-04 20 10 | – Domestic Water Distribution | | X | | |
| | - Copper Pipe | | | | 30 |
| | - Pex Water Pipe | | | | 30 |
| | - PVC / CPVC Pipe | | | | 30 |
| | - Stainless Steel Pipe | | | | 30 |
| 21-04 20 20 | – Sanitary Drainage | | X | | |
| | - Cast Iron Pipe | | | | 30 |
| | - PVC / CPVC Pipe | | | | 30 |
| 21-04 20 30 | – *Building* Support Plumbing Systems | | X | ~~X~~ | |
| 21-04 20 50 | – General Service Compressed-Air | | X | ~~X~~ | |
| 21-04 20 60 | – Process Support Plumbing Systems | | X | ~~X~~ | |
| 21-04 30 | – **Heating, Ventilation, and Air Conditioning (HVAC)** | Including terminals that provide, either collectively or individually, the process of HVAC to a *building* or portion of a *building*, such as ducts and pipes serving mechanical equipment and their insulation, chillers, cooling towers, air cooled condensers, roof top units, air handlers, heat pumps, boilers, chilled beams, VRF systems, heat exchangers, air conditioners, and unitary systems. | X | | |
| 21-04 30 10 | – Facility Fuel Systems | | X | | |
| 21-04 30 20 | – Heating Systems | | X | | |
| | - Heat Pump | | | | 15 |
| | - Ground Source Heat Pump | | | | 40 |
| | - Boiler | | | | 15 |
| 21-04 30 30 | – Cooling Systems | | X | | |
| | - Air Conditioner | | | | 10 |
| | - Heat Pump | | | | 15 |

 

| | | | | | |
|---|---|---|---|---|---|
| | - Ground Source Heat Pump | | | | 40 |
| | - Cooling Tower | | | | 15 |
| | - Chiller | | | | 15 |
| 21-04 30 50 | – Facility HVAC Distribution Systems | | X | | |
| | - Flexible Ductwork | | | | 10 |
| | - Metal Ductwork | | | | 20 |
| | - Pumps | | | | 10 |
| | - Variable Refrigerant Flow (VRF) | | | | 15 |
| | - Variable Air Volume (VAV) Air Handling Unit (AHU) or single duct | | | | 15 |
| | - VAV Terminals with electric or fan coil | | | | 15 |
| 21-04 30 60 | – Ventilation | | X | | |
| | - Dedicated Outside Air with Electric Heat | | | | 15 |
| | - Dedicated Outside Air with Heat Recovery | | | | 15 |
| 21-04 30 70 | – Special Purpose HVAC Systems | | X | | |
| 21-04 40 | – **Fire Protection** | | | X | |
| 21-04 40 10 | – Fire Suppression | | X | ~~X~~ | |
| 21-04 40 30 | – Fire Protection Specialties | | X | ~~X~~ | n/a |
| 21-04 50 | – **Electrical** | including electrical equipment and their distribution systems, such as lamps and luminaires, power supply and distribution; and power management systems, including batteries, uninterruptible power supplies, switchgears, panel boards, transformers, and power generation systems. | X | | |
| 21-04 50 10 | – Facility Power Generation | | X | | |
| | - Backup Generator | | | | 20 |
| | - Photovoltaic Collector Panels | | | | 20 |
| 21-04 50 20 | – Electrical Service and Distribution | | X | | |
| | - Switchgear | | | | 30 |
| | - Transformer | | | | 30 |
| 21-04 50 30 | – General Purpose Electrical Power | | X | | |
| | - Battery Backup | | | | 5 |
| | - Uninterruptable Power Supply | | | | 10 |
| 21-04 50 40 | – Lighting | | X | | |
| | - Light Fixtures | | | | 20 |
| 21-04 50 80 | – Miscellaneous Electrical Systems | | | X | |
| 21-04 60 | – **Communications** | | | X | |

| | | | | | |
|---|---|---|---|---|---|
| 21-04 60 10 | – Data Communications | | | X | |
| 21-04 60 20 | – Voice Communications | | | X | |
| 21-04 60 30 | – Audio-Video Communication | | | X | |
| 21-04 60 60 | – Distributed Communications and Monitoring | | | X | n/a |
| 21-04 60 90 | – Communications Supplementary Components | | | X | n/a |
| 21-04 70 | – **Electronic Safety and Security** | Including electrical low voltage systems such as fire alarm systems, IT systems, security systems, and other control systems | | X | n/a |
| 21-04 70 10 | – Access Control and Intrusion Detection | | X | ~~X~~ | n/a |
| 21-04 70 30 | – Electronic Surveillance | | X | ~~X~~ | n/a |
| 21-04 70 50 | – Detection and Alarm | | X | ~~X~~ | n/a |
| 21-04 70 70 | – Electronic Monitoring and Control | | X | ~~X~~ | n/a |
| 21-04 70 90 | – Electronic Safety and Security Supplementary Components | | X | ~~X~~ | n/a |
| 21-04 80 | – **Integrated Automation** | | | X | |
| 21-04 80 10 | – Integrated Automation Facility Controls | | | X | |
| 21-05 | – **Equipment and Furnishings** | | | | |
| 21-05 10 | – **Equipment** | | | X | ~~n/a~~ |
| 21-05 10 10 | – Vehicle and Pedestrian Equipment | | | X | n/a |
| 21-05 10 30 | – Commercial Equipment | | | X | n/a |
| 21-05 10 40 | – Institutional Equipment | | | X | n/a |
| 21-05 10 60 | – Residential Equipment | | | X | n/a |
| 21-05 10 70 | – Entertainment and Recreational Equipment | | | X | n/a |
| 21-05 10 90 | – Other Equipment | | | X | n/a |
| 21-05 20 | – **Furnishings** | Including permanently installed furnishings, such as casework | | X | n/a |
| 21-05 20 10 | – Fixed Furnishings | | | X | n/a |
| 21-05 20 50 | – Movable Furnishings | | | X | n/a |
| 21-06 | – **Special Construction and *Demolition*** | | | | |
| 21-06 10 | – **Special Construction** | | X | | |
| 21-06 10 10 | – Integrated Construction | | ~~X~~ | X | |
| 21-06 10 20 | – Special Structures | | X | | |
| 21-06 10 30 | – Special Function Construction | | ~~X~~ | X | |
| 21-06 10 50 | – Special Facility Components | | X | | |
| 21-06 10 60 | – Athletic and Recreational Special Construction | | ~~X~~ | X | |
| 21-06 10 80 | – Special Instrumentation | | | X | n/a |
| 21-06 20 | – **Facility Remediation** | | | X | n/a |

 

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|---|---|---|---|---|
| 21-06 20 10 | – Hazardous Materials Remediation | | X | n/a |
| 21-06 30 | – ***Demolition*** | X | | |
| 21-06 30 10 | – *Structure Demolition* | ~~X~~ | X | |
| 21-06 30 30 | – Selective *Demolition* | ~~X~~ | X | |
| 21-06 30 50 | – *Structure* Moving | ~~X~~ | X | |
| 21-07 | – **Sitework** | | | |
| 21-07 10 | – ***Site* Preparation** | ~~X~~ | X | |
| 21-07 10 10 | – *Site* Clearing | ~~X~~ | X | |
| 21-07 10 20 | – *Site* Elements *Demolition* | ~~X~~ | X | |
| 21-07 10 30 | – *Site* Element Relocations | ~~X~~ | X | |
| 21-07 10 50 | – *Site* Remediation | | X | |
| 21-07 10 70 | – *Site* Earthwork | ~~X~~ | X | |
| 21-07 20 | – ***Site* Improvements** | X | | |
| 21-07 20 10 | – Roadways | X | | |
| 21-07 20 20 | – Parking Lots | X | | |
| 21-07 20 30 | – Pedestrian Plazas and Walkways | X | | |
| 21-07 20 40 | – Airfields | X | | |
| 21-07 20 50 | – Athletic, Recreational, and Playfield Areas | X | | |
| 21-07 20 60 | – *Site* Development | | X | |
| 21-07 20 80 | – Landscaping | | X | n/a |
| 21-07 30 | – **Liquid and Gas *Site* Utilities** | X | | |
| 21-07 30 10 | – Water Utilities | X | | |
| 21-07 30 20 | – Sanitary Sewerage Utilities | X | | |
| 21-07 30 30 | – Storm Drainage Utilities | X | | |
| 21-07 30 50 | – *Site* Energy Distribution | X | | |
| 21-07 30 60 | – *Site* Fuel Distribution | X | | |
| 21-07 30 90 | – Liquid and Gas *Site* Utilities Supplementary Components | | X | |
| 21-07 40 | – **Electrical *Site* Improvements** | X | | |
| 21-07 40 10 | – *Site* Electric Distribution Systems | X | | |
| 21-07 40 50 | – *Site* Lighting | X | | |
| 21-07 50 | – ***Site* Communications** | | X | |
| 21-07 50 10 | – *Site* Communications Systems | | | |
| 21-07 90 | – **Miscellaneous *Site* Construction** | X | | |
| 21-07 90 10 | – Tunnels | X | | |

**(This is a normative appendix and is part of the standard.)**

## Normative Appendix B Data Representativeness

### Table B.1: Data representativeness evaluation table

| ***Quality*** | ***Geographic Representativeness*** | ***Technological Representativeness*** | ***Product Representativeness*** | ***Temporal Representativeness*** | ***Data Granularity*** | ***Verifiability*** |
|---|---|---|---|---|---|---|
| *Very Good* | *Region is representative (e.g. NYC and Northeast US) -* ***10*** | *Reflects the identical technology and characteristics (e.g. BF/BOF steel with 40% recycled content) -* ***6*** | *Data for actual product used -* ***6*** | *Year of data ~~collection~~ publication less than 3 years from year of construction -* ***8*** | *Site-specific data (factory-specific) -* ***5*** | *Third-party verified to EN 15804+A2 or ISO 21930 -* ***5*** |
| *Good* | *Region is geographically similar (e.g. NYC and Quebec) -* ***7*** | *Partially reflects technology and technical characteristics (e.g. BOF steel with incorrect recycled content) -* ***4*** | *Representative or average product adapted by relevant characteristic (e.g. data per $m^2$ adapted by scaling factor) -* ***5*** | *<5 years from year of construction -* ***6*** | *Manufacturer-specific (actual manufacturer used and averaged across factories or different factory site) -* ***4*** | *Independently verified to ISO 14025 -* ***4*** |
| *Fair* | *Much larger region or global dataset (e.g. NYC and NAM) -* ***4*** | *Does not reflect specifics of the technology (e.g. steel generally) -* ***3*** | *Average data for product group of actual product used* | *<10 years from year of construction -* ***4*** | *Regional Sector Data -* ***3*** | *Peer reviewed to ISO 14044 -* ***3*** |
| *Poor* | *Totally different context (e.g. China for EU) -* ***2*** | *Totally different technology (EAF steel for BOF steel) -* ***1*** | *Proxy data or data extrapolated from a group of datasets -* ***2*** | *Less than 15 years from year of construction -* ***2*** | *Global sector data -* ***2*** | *Not peer reviewed or not verified -* ***0*** |
| *Not Accepted* | | | | *>15 years from construction* | | |

Based on the value of *US*, the following datum uncertainty factor shall be assigned in accordance with Table 6.4.3.

 

**(This is a normative appendix and is part of the standard.)**

**Normative Appendix C Fugitive Emissions Data**

**Table C1: Global Warming Potentials for Refrigerants and other gases**

| ~~**Common Name**~~ **Refrigerant Designation** | ~~**Formula**~~ **Refrigerant Composition (Mass %)** | **GWP-100** | **GWP-20** |
|---|---|---|---|
| *Carbon Dioxide* (R-744) | CO2 | 1 | 1 |
| Methane (R-50) | CH4 | ~~25~~ (27.9) | 81.2 |
| Nitrous Oxide (R-744A) | N20 | ~~298~~ (273) | 273 |
| Sulfur hexaflouride | SF6 | 22,800 | |
| Nitrogen trifluoride | NF3 | 17,200 | |
| ~~HFC-23~~ | ~~CHF3~~ | ~~14,800~~ | |
| ~~HFC-32~~ | ~~CH2 F2~~ | ~~675~~ | |
| ~~HFC-41~~ | ~~CH3F~~ | ~~92~~ | |
| **Chlorofluorocarbons** | | | |
| CFC-11 | $CCl_3F$ | 6230 | 8320 |
| CFC-12 | $CCl_2F_2$ | 12500 | 12700 |
| CFC-13 | $CClF_3$ | 16200 | 12400 |
| CFC-112 | $CCl_2FCCl_2F$ | 4620 | 5620 |
| CFC-112a | $CCl_3CClF_2$ | 3550 | 4740 |
| CFC-113 | $CCl_2FCClF_2$ | 6520 | 6860 |
| CFC-113a | $CCl_3CF_3$ | 3930 | 5110 |
| CFC-114 | $CClF_2CClF_2$ | 9430 | 8260 |
| CFC-114a | $CCl_2FCF_3$ | 7420 | 7510 |
| CFC-115 | $CClF_2CF_3$ | 9600 | 7410 |

 

| | | | |
|---|---|---|---|
| E-R316c | trans cyc (-$CClFCF_2CF_2CClF$-) | 4320 | 4810 |
| Z-R316c | cis cyc (-$CClFCF_2CF_2CClF$-) | 5660 | 5590 |
| CFC 1112 | CClF=CClF | 0.126 | 0.454 |
| CFC 1112a | $CCl_2=CF_2$ | 0.021 | 0.076 |
| **Hydrochlorofluorocarbons** | | | |
| HCFC-21 | $CHCl_2F$ | 160 | 575 |
| HCFC-22 | $CHClF_2$ | 1960 | 5690 |
| HCFC-31 | $CH_2ClF$ | 79.4 | 286 |
| HCFC-121 | $CHCl_2CCl_2F$ | 58.3 | 210 |
| HCFC-122 | $CHCl_2CClF_2$ | 56.4 | 203 |
| HCFC-122a | $CHClFCCl_2F$ | 245 | 879 |
| HCFC-123 | $CHCl_2CF_3$ | 90.4 | 325 |
| HCFC-123a | $CHClFCClF_2$ | 395 | 1410 |
| HCFC-124 | $CHClFCF_3$ | 597 | 2070 |
| HCFC-124a | $CHF_2CClF_2$ | 2070 | 5110 |
| HCFC-132 | CHClFCHClF | 122 | 440 |
| HCFC-132a | $CHCl_2CHF_2$ | 70.4 | 253 |
| HCFC-132c | $CH_2FCCl_2F$ | 342 | 1220 |
| HCFC-133a | $CH_2ClCF_3$ | 388 | 1370 |
| HCFC-141 | $CH_2ClCHClF$ | 46.6 | 168 |
| HCFC-141b | $CH_3CCl_2F$ | 860 | 2710 |
| HCFC-142b | $CH_3CClF_2$ | 2300 | 5510 |
| HCFC-225ca | $CHCl_2CF_2CF_3$ | 137 | 491 |
| HCFC-225cb | $CHClFCF_2CClF_2$ | 568 | 1960 |
| HCFO-1233zd(E) | (E)-$CF_3CH$=CHCl | 3.88 | 14 |
| HCFO-1233zd(Z) | (Z)-$CF_3CH$=CHCl | 0.454 | 1.64 |

 

| | | | |
|---|---|---|---|
| (e)-1-chloro-2-fluoroethene | (E/Z)-CHCl=CHF | 0.004 | 0.13 |
| **Hydrofluorocarbons** | | | |
| HFC-23 | $CHF_3$ | 14600 | 12400 |
| HFC-32 | $CH_2F_2$ | 771 | 2690 |
| HFC-41 | $CH_3F$ | 135 | 485 |
| HFC-125 | $CHF_2CF_3$ | 3740 | 6740 |
| HFC-134 | $CHF_2CHF_2$ | 1260 | 3900 |
| HFC-134a | $CH_2FCF_3$ | 1530 | 4140 |
| HFC-143 | $CH_2FCHF_2$ | 364 | 1300 |
| HFC-143a | $CH_3CF_3$ | 5810 | 7840 |
| HFC-152 | $CH_2FCH_2F$ | 21.5 | 77.6 |
| HFC-152a | $CH_3CHF_2$ | 164 | 591 |
| HFC-161 | $CH_3CH_2F$ | 4.84 | 17.4 |
| HFC-227ca | $CF_3CF2CHF_2$ | 2980 | 5370 |
| HFC-227ea | $CF_3CHFCF_3$ | 3600 | 5850 |
| HFC-236cb | $CH_2FCF_2CF_3$ | 1350 | 3750 |
| HFC-236ea | $CHF_2CHFCF_3$ | 1500 | 4420 |
| HFC-236fa | $CF_3CH_2CF_3$ | 8690 | 7450 |
| HFC-245ca | $CH_2FCF_2CHF_2$ | 787 | 2680 |
| HFC-245cb | $CF_3CF_2CH_3$ | 4550 | 6970 |
| HFC-245ea | $CHF_2CHFCHF_2$ | 255 | 912 |
| HFC-245eb | $CH_2FCHFCF_3$ | 325 | 1160 |
| HFC-245fa | $CHF_2CH_2CF_3$ | 962 | 3170 |
| HFC-263fb | $CH_3CH_2CF_3$ | 74.8 | 269 |
| HFC-272ca | $CH_3CF_2CH_3$ | 599 | 1910 |
| HFC-329p | $CHF_2CF_2CF_2CF_3$ | 2890 | 5010 |
| HFC-365mfc | $CH_3CF_2CH_2CF_3$ | 914 | 2920 |

| | | | |
|---|---|---|---|
| HFC-43-10mee | $CF_3CHFCHFCF_2CF_3$ | 1600 | 3960 |
| **Hydrofluoroolefin** | | | |
| HFO-1123 | $CHF=CF_2$ | 0.005 | 0.017 |
| HFO-1132a | $CH_2=CF_2$ | 0.052 | 0.189 |
| HFO-1141 | $CH_2=CHF$ | 0.024 | 0.088 |
| HFO-1225ye(Z) | (Z)-$CF_3CF=CHF$ | 0.344 | 1.24 |
| HFO-1225ye(E) | (E)-$CF_3CF=CHF$ | 0.118 | 0.426 |
| HFO-1234ze(Z) | (Z)-$CF_3CH=CHF$ | 0.315 | 1.13 |
| HFO-1234ze(E) | (E)-$CF_3CH=CHF$ | 1.37 | 4.94 |
| HFO-1234yf | $CF_3CF=CH_2$ | 0.501 | 1.81 |
| HFO-1336mzz(E) | (E)-$CF_3CH=CHCF_3$ | 17.9 | 64.3 |
| HFO-1336mzz(Z) | (Z)-$CF_3CH=CHCF^3$ | 2.08 | 7.48 |
| HFO-1243zf | $CF_3CH=CH_2$ | 0.261 | 0.94 |
| HFO-1345zfc | $CF_3CF_2CH=CH_2$ | 0.182 | 0.656 |
| 3,3,4,4,5,5,6,6, 6-nonafluorohex- 1-ene | n-$C_4F_9CH=CH_2$ | 0.204 | 0.734 |
| | | | |
| **Methane Series** | | | |
| CFC-11 | | 6 410 | 8 560 |
| CFC-12 | | 12 500 | 12 700 |
| BCFC-12B1 | | 1 990 | 5 080 |
| CFC-13 | CClF3 | 16 300 | 12 400 |
| BFC-13B1 | CBrF3 | 7 430 | 8 580 |
| IFC-13I1 | CF3I | <1 | 1 |
| PFC-14 | CF4 | 7 490 | 5 380 |
| HCFC-21 | CHCl2F | 161 | 578 |
| HCFC-22 | CHClF2 | 1 910 | 5 610 |

 

| | | | |
|---|---|---|---|
| HFC-23 | CHF3 | 14 700 | 12 400 |
| HCC-30 | CH2Cl2 | 11 | 39 |
| HCFC-31 | CH2ClF | 85 | 307 |
| HFC-32 | CH2F2 | 749 | 2 620 |
| HCC-40 | CH3Cl | 6 | 20 |
| HFC-41 | CH3F | 137 | 492 |
| HC-50 | CH4 | 29.8 | 82.5 |
| **Ethane Series** | | | |
| CFC-113 | CCl2FCClF2 | 6 530 | 6 870 |
| CFC-114 | CClF2CClF2 | 9 450 | 8 280 |
| CFC-115 | CClF2CF3 | 9 630 | 7 430 |
| PFC-116 | CF3CF3 | 12 600 | 9 040 |
| HCFC-123 | CHCl2CF3 | 91 | 329 |
| HCFC-124 | CHClFCF3 | 596 | 2 060 |
| HFC-125 | CHF2CF3 | 3 820 | 6 790 |
| HFC-134a | CH2FCF3 | 1 470 | 4 060 |
| HCFC-141b | CH3CCl2F | 808 | 2 590 |
| HCFC-142b | CH3CClF2 | 2 190 | 5 400 |
| HFC-143a | CH3CF3 | 5 900 | 7 900 |
| HFC-152a | CH3CHF2 | 153 | 550 |
| HFC-161b | CH3CH2F | 5 | 17 |
| HC-170 | CH3CH3 | <1 | 3 |
| **Ethers** | | | |
| HE-E170 | CH3OCH3 | 0.015 | 1 |
| **Propane Series** | | | |
| PFC-218 | CF3CF2CF3 | 2.6 | 9 500 |
| HFC-227ea | CF3CHFCF3 | 35.8 | 3 580 |

 

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|---|---|---|---|
| HFC-236fa | CF3CH2CF3 | 213 | 9 120 |
| HFC-245fa | CHF2CH2CF3 | 7.74 | 966 |
| HC-290 | CH3CH2CH3 | 15 days | <<1 |
| **Cyclic Organic Compounds** | | | |
| PFC-C318 | -(CF2)4- | 3.2 | 10 600 |
| **Hydrocarbons** | | | |
| HC-600 | CH3CH2CH2CH3 | 6.5 days | <<1 |
| HC-600a | CH(CH3)2CH3 | 7.0 days | <<1 |
| HC-601 | CH3CH2CH2CH2CH3 | 4.0 days | <<1 |
| HC-601a | CH(CH3)2CH2CH3 | 3.9 days | <<1 |
| **Oxygen Compounds** | | | |
| HE-610 | CH3CH2OCH2CH3 | | |
| R-611 | HCOOCH3 | 86 days | 13 |
| **Nitrogen Compounds** | | | |
| R-630 | CH3NH2 | | |
| R-631 | CH3CH2(NH2) | | |
| **Inorganic Compounds** | | | |
| R-702 | H2 | | |
| R-704 | He | | |
| R-717 | NH3 | days | <<1 |
| R-718 | H2O | | |
| R-720 | Ne | | |
| R-728 | N2 | | |
| R-732 | O2 | | |
| R-740 | Ar | | |
| R-744 | CO2 | | 1 |
| R-744A | N2O | 109 | 273 |

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|---|---|---|---|
| R-764 | SO2 | | |
| **Unsaturated Organic Compounds** | | | |
| HCC-1130(E) | CHCl=CHCl | 5.5 days | <<1 |
| HFO-1132(E) | CHF=CHF | 1.3 days | <<1 |
| HFO-1132a | CF2=CH2 | 4.6 days | <<1 |
| HC-1150 | CH2=CH2 | 1.7 days | <<1 |
| HCFO-1224yd(Z) | CF3CF=CHCl | 12 days | <1 |
| HCFO-1233zd(E) | CF3CH=CHCl | 41.9 days | 4 |
| HFO-1234yf | CF3CF=CH2 | 12 days | <1 |
| HFO-1234ze(E) | CF3CH=CHF | 19 days | 1 |
| HC-1270 | CH3CH=CH2 | 0.4 days | <<1 |
| HFO-1336mzz(E) | CF3CH=CHCF3 | 121 days | 26 |
| HFO-1336mzz(Z) | CF3CH=CHCF3 | 27 days | 2 |
| **400 Series** | | | |
| R-400 | R-12/114 (50.0/50.0) | 10 975**In** | 10 490 |
| R-400 | R-12/114 (60.0/40.0) | 11 280 | 10 932 |
| R-401A | R-22/152a/124 (53.0/13.0/34.0) | 1 235 | 3 745 |
| R-401B | R-22/152a/124 (61.0/11.0/28.0) | 1 349 | 4 059 |
| R-401C | R-22/152a/124 (33.0/15.0/52.0) | 963 | 3 005 |
| R-402A | R-125/290/22 (60.0/2.0/38.0) | 3 018 | 6 206 |
| R-402B | R-125/290/22 (38.0/2.0/60.0) | 2 598 | 5 946 |
| R-403A | R-290/22/218 (5.0/75.0/20.0) | 3 333 | 5 592 |
| R-403B | R-290/22/218 (5.0/56.0/39.0) | 4 775 | 5 840 |
| R-404A | R-125/143a/134a (44.0/52.0/4.0) | 4 808 | 7 258 |

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|---|---|---|---|
| R-405A | R-22/152a/142b/C318 (45.0/7.0/5.5/42.5) | 5 496 | 6 150 |
| R-406A | R-22/600a/142b (55.0/4.0/41.0) | 1 948 | 5 300 |
| R-407A | R-32/125/134a (20.0/40.0/40.0) | 2 266 | 4 864 |
| R-407B | R-32/125/134a (10.0/70.0/20.0) | 3 043 | 5 827 |
| R-407C | R-32/125/134a (23.0/25.0/52.0) | 1 892 | 4 411 |
| R-407D | R-32/125/134a (15.0/15.0/70.0) | 1 714 | 4 254 |
| R-407E | R-32/125/134a (25.0/15.0/60.0) | 1 642 | 4 110 |
| R-407F | R-32/125/134a (30.0/30.0/40.0) | 1 959 | 4 447 |
| R-407G | R-32/125/134a (2.5/2.5/95.0) | 1 511 | 4 092 |
| R-407H | R-32/125/134a (32.5/15.0/52.5) | 1 588 | 4 002 |
| R-407I | R-32/125/134a (19.5/8.5/72.0) | 1 529 | 4 011 |
| R-408A | R-125/143a/22 (7.0/46.0/47.0) | 3 879 | 6 746 |
| R-409A | R-22/124/142b (60.0/25.0/15.0) | 1 624 | 4 691 |
| R-409B | R-22/124/142b (65.0/25.0/10.0) | 1 610 | 4 702 |
| R-410A | R-32/125 (50.0/50.0) | 2 285 | 4 705 |
| R-410B | R-32/125 (45.0/55.0) | 2 438 | 4 914 |
| R-411A | R-1270/22/152a (1.5/87.5/11.0) | 1 688 | 4 969 |

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| R-411B | R-1270/22/152a (3.0/94.0/3.0) | 1 800 | 5 290 |
| R-412A | R-22/218/142b (70.0/5.0/25.0) | 2 360 | 5 623 |
| R-413A | R-218/134a/600a (9.0/88.0/3.0) | 2 149 | 4 196 |
| R-414A | R-22/124/600a/142b (51.0/28.5/4.0/16.5) | 1 505 | 4 339 |
| R-414B | R-22/124/600a/142b (50.0/39.0/1.5/9.5) | 1 396 | 4 121 |
| R-415A | R-22/152a (82.0/18.0) | 1 594 | 4 699 |
| R-415B | R-22/152a (25.0/75.0) | 592 | 1 815 |
| R-416A | R-134a/124/600 (59.0/39.5/1.5) | 1 103 | 3 209 |
| R-417A | R-125/134a/600 (46.6/50.0/3.4) | 2 515 | 5 194 |
| R-417B | R-125/134a/600 (79.0/18.3/2.7) | 3 287 | 6 107 |
| R-417C | R-125/134a/600 (19.5/78.8/1.7) | 1 903 | 4 523 |
| R-418A | R-290/22/152a (1.5/96.0/2.5) | 1 837 | 5 399 |
| R-419A | R-125/134a/E170 (77.0/19.0/4.0) | 3 221 | 6 000 |
| R-419B | R-125/134a/E170 (48.5/48.0/3.5) | 2 558 | 5 242 |
| R-420A | R-134a/142b (88.0/12.0) | 1 556 | 4 221 |
| R-421A | R-125/134a (58.0/42.0) | 2 833 | 5 643 |
| R-421B | R-125/134a (85.0/15.0) | 3 468 | 6 381 |
| R-422A | R-125/134a/600a (85.1/11.5/3.4) | 3 420 | 6 245 |

 

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| R-422B | R-125/134a/600a (55.0/42.0/3.0) | 2 718 | 5 440 |
| R-422C | R-125/134a/600a (82.0/15.0/3.0) | 3 353 | 6 177 |
| R-422D | R-125/134a/600a (65.1/31.5/3.4) | 2 950 | 5 699 |
| R-422E | R-125/134a/600a (58.0/39.3/2.7) | 2 793 | 5 534 |
| R-423A | R-134a/227ea (52.5/47.5) | 2 472 | 4 901 |
| R-424A | R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6) | 2 620 | 5 337 |
| R-425A | R-32/134a/227ea (18.5/69.5/12) | 1 590 | 4 006 |
| R-426A | R-125/134a/600/601a (5.1/93.0/1.3/0.6) | 1 562 | 4 122 |
| R-427A | R-32/125/143a/134a (15.0/25.0/10.0/50.0) | 2 392 | 4 911 |
| R-427B | R-32/125/143a/134a (20.6/25.6/19.0/34.8) | 2 765 | 5 192 |
| R-427C | R-32/125/143a/134a (25.0/25.0/10.0/40.0) | 2 320 | 4 767 |
| R-428A | R-125/143a/290/600a (77.5/20.0/0.6/1.9) | 4 141 | 6 842 |
| R-429A | R-E170/152a/600a (60.0/10.0/30.0) | 16 | 56 |
| R-430A | R-152a/600a (76.0/24.0) | 117 | 418 |
| R-431A | R-290/152a (71.0/29.0) | 45 | 160 |
| R-432A | R-1270/E170 (80.0/20.0) | 1 | 1 |
| R-433A | R-1270/290 (30.0/70.0) | 1 | 1 |
| R-433B | R-1270/290 (5.0/95.0) | 1 | 1 |

 

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| R-433C | R-1270/290 (25.0/75.0) | 1 | 1 |
| R-434A | R-125/143a/134a/600a (63.2/18.0/16.0/2.8) | 3 711 | 6 363 |
| R-435A | R-E170/152a (80.0/20.0) | 31 | 111 |
| R-436A | R-290/600a (56.0/44.0) | 1 | 1 |
| R-436B | R-290/600a (52.0/48.0) | 1 | 1 |
| R-436C | R-290/600a (95.0/5.0) | 1 | 1 |
| R-437A | R-125/134a/600/601 (19.5/78.5/1.4/0.6) | 1 899 | 4 511 |
| R-438A | R-32/125/134a/600/601a (8.5/45.0/44.2/1.7/0.6) | 2 432 | 5 073 |
| R-439A | R-32/125/600a (50.0/47.0/3.0) | 2 170 | 4 501 |
| R-440A | R-290/134a/152a (0.6/1.6/97.8) | 173 | 603 |
| R-441A | R-170/290/600a/600 (3.1/54.8/6.0/36.1) | 1 | 1.1 |
| R-442A | R-32/125/134a/152a/227ea (31.0/31.0/30.0/3.0/5.0) | 2 041 | 4 443 |
| R-443A | R-1270/290/600a (55.0/40.0/5.0) | 1 | 1 |
| R-444A | R-32/152a/1234ze(E) (12.0/5.0/83.0) | 98 | 346 |
| R-444B | R-32/1234ze(E)/152a (41.5/48.5/10) | 327 | 1 145 |
| R-445A | R-744/134a/1234ze(E) (6.0/9.0/85.0) | 133 | 370 |
| R-446A | R-32/1234ze(E)/600 (68.0/29.0/3.0) | 510 | 1 783 |
| R-447A | R-32/125/1234ze(E) (68.0/3.5/28.5) | 643 | 2 021 |

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|---|---|---|---|
| R-447B | R-32/125/1234ze(E) (68.0/8.0/24.0) | 815 | 2 326 |
| R-448A | R-32/125/1234yf/134a/1234ze(E) (26.0/26.0/20.0/21.0/7.0) | 1 497 | 3 300 |
| R-448B | R-32/125/1234yf/134a/1234ze(E) (21.0/21.0/20.0/31.0/7.0) | 1 415 | 3 235 |
| R-449A | R-32/125/1234yf/134a (24.3/24.7/25.3/25.7) | 1 504 | 3 358 |
| R-449B | R-32/125/1234yf/134a (25.2/24.3/23.2/27.3) | 1 519 | 3 419 |
| R-449C | R-32/125/1234yf/134a (20.0/20.0/31.0/29.0) | 1 340 | 3 060 |
| R-450A | R-1234ze(E)/134a (58/42) | 618 | 1 708 |
| R-451A | R-1234yf/134a (89.8/10.2) | 151 | 416 |
| R-451B | R-1234yf/134a (88.8/11.2) | 166 | 456 |
| R-452A | R-1234yf/32/125 (30/11/59) | 2 336 | 4 295 |
| R-452B | R-32/125/1234yf (67.0/7.0/26.0) | 769 | 2 231 |
| R-452C | R-32/125/1234yf (12.5/61.0/26.5) | 2 424 | 4 470 |
| R-453A | R-32/125/134a/227ea/600/601a (20.0/20.0/53.8/5.0/0.6/0.6) | 1 884 | 4 358 |
| R-454A | R-32/1234yf (35.0/65.0) | 263 | 918 |
| R-454B | R-32/1234yf (68.9/31.1) | 516 | 1 806 |
| R-454C | R-32/1234yf (21.5/78.5) | 162 | 565 |
| R-455A | R-744/32/1234yf (3.0/21.5/75.5) | 162 | 565 |
| R-456A | R-32/134a/1234ze(E) | 707 | 1 987 |

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| | (6.0/45.0/49.0) | | |
| R-457A | R-32/1234yf/152a (18.0/70.0/12.0) | 154 | 539 |
| R-457B | R-32/1234yf/152a (35.0/55.0/10.0) | 278 | 973 |
| R-457C | R-32/1234yf/152a (7.5/78.0/14.5) | 79 | 278 |
| R-458A | R-32/125/134a/227ea/236fa (20.5/4.0/61.4/13.5/0.6) | 1 747 | 4 136 |
| R-459A | R-32/1234yf/1234ze(E) (68.0/26.0/6.0) | 510 | 1 782 |
| R-459B | R-32/1234yf/1234ze(E) (21.0/69.0/10.0) | 158 | 552 |
| R-460A | R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0) | 2 282 | 4 415 |
| R-460B | R-32/125/134a/1234ze(E) (28.0/25.0/20.0/27.0) | 1 459 | 3 244 |
| R-460C | R-32/125/134a/1234ze(E) (2.5/2.5/ 46.0/49.0) | 791 | 2 105 |
| R-461A | R-125/143a/134a/227ea/600a (55.0/5.0/32.0/5.0/3.0) | 3 045 | 5 720 |
| R-462A | R-32/125/143a/134a/600 (9.0/42.0/2.0/44.0/3.0) | 2 437 | 5 032 |
| R-463A | R-744/32/125/1234yf/134a (6.0/36.0/30.0/14.0/14.0) | 1 622 | 3 549 |
| R-464A | R-32/125/1234ze(E)/227ea (27.0/ 27.0/40.0/6.0) | 1 449 | 2 893 |
| R-465A | R-32/290/1234yf (21.0/7.9/71.1) | 158 | 552 |
| R-466A | R-32/125/13I1 (49.0/11.5/39.5) | 807 | 2 065 |

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| R-467A | R-32/125/134a/600a (22.0/5.0/72.4/0.6) | 1 420 | 3 855 |
| R-468A | R-1132a/32/1234yf (3.5/21.5/75.0) | 162 | 565 |
| R-468B | R-1132a/32/1234yf (6.0/13.0/81.0) | 98 | 342 |
| R-468C | R-1132a/32/1234yf (6.0/42.0/52.0) | 315 | 1 102 |
| R-469A | R-744/32/125 (35.0/32.5/32.5) | 1 485 | 3 059 |
| R-470A | R-744/32/125/134a/1234ze(E)/227ea (10.0/17.0/19.0/7.0/44.0/3.0) | 1 064 | 2 197 |
| R-470B | R-744/32/125/134a/1234ze(E)/227ea (10.0/11.5/11.5/3.0/57.0/7.0) | 821 | 1 615 |
| R-471A | R-1234ze(E)/227ea/1336mzz(E) (78.7/4.3/17.0) | 159 | 271 |
| R-472A | R-744/32/134a (69.0/12.0/19.0) | 370 | 1 086 |
| R-472B | R-744/32/134a (58.0/10.0/32.0) | 546 | 1 562 |
| R-473A | R-1132a/23/744/125 (20.0/10.0/60.0/10.0) | 1 853 | 1 920 |
| R-474A | R-1132(E)/1234yf (23.0/77.0) | 1 | 1.8 |
| R-475A | R-1234yf/134a/1234ze(E) (45.0/43.0/12.0) | 633 | 1 747 |
| R-476A | R-134a/1234ze(E)/1336mzz(E) (10.0/78.0/12.0) | 151 | 421 |

 

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| R-477A | R-1270/600a (84.0/16.0) | 1 | 1 |
| R-477B | R-1270/600a (38.0/62.0) | 1 | 1 |
| **500 Series** | | | |
| R-500 | R-12/152a (73.8/26.2) | 9 265 | 9 517 |
| R-501 | R-22/12 (75.0/25.0) | 4 558 | 7 383 |
| R-502 | R-22/115 (48.8/51.2) | 5 863 | 6 542 |
| R-503 | R-23/13 (40.1/59.9) | 15 658 | 12 400 |
| R-504 | R-32/115 (48.2/51.8) | 5 349 | 5 112 |
| R-505 | R-12/31 (78.0/22.0) | 9 769 | 9 974 |
| R-506 | R-31/114 (55.1/44.9) | 4 290 | 3 887 |
| R-507A | R-125/143a (50.0/50.0) | 4 860 | 7 345 |
| R-508A | R-23/116 (39.0/61.0) | 13 419 | 10 350 |
| R-508B | R-23/116 (46.0/54.0) | 13 566 | 10 586 |
| R-509A | R-22/218 (44.0/56.0) | 6 160 | 6 344 |
| R-510A | R-E170/600a (88.0/12.0) | 1 | 1 |
| R-511A | R-290/E170 (95.0/5.0) | 1 | 1 |
| R-512A | R-134a/152a (5.0/95.0) | 219 | 726 |
| R-513A | R-1234yf/134a (56/44) | 647 | 1 788 |
| R-513B | R-1234yf/134a (58.5/41.5) | 611 | 1 686 |
| R-514A | R-1336mzz(Z)/1130(E) (74.7/25.3) | 1.7 | 7 |
| R-515A | R-1234ze(E)/227ea (88.0/12.0) | 430 | 704 |
| R-515B | R-1234ze(E)/227ea (91.1/8.9) | 320 | 523 |
| R-516A | R-1234yf/134a/152a (77.5/8.5/14.0) | 147 | 424 |
| R-500 | R-12/152a (73.8/26.2) | 9 265 | 9 517 |

 

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| R-501 | R-22/12 (75.0/25.0) | 4 558 | 7 383 |
| R-502 | R-22/115 (48.8/51.2) | 5 863 | 6 542 |
| R-503 | R-23/13 (40.1/59.9) | 15 658 | 12 400 |
| R-504 | R-32/115 (48.2/51.8) | 5 349 | 5 112 |
| R-505 | R-12/31 (78.0/22.0) | 9 769 | 9 974 |
| R-506 | R-31/114 (55.1/44.9) | 4 290 | 3 887 |
| R-507A | R-125/143a (50.0/50.0) | 4 860 | 7 345 |
| R-508A | R-23/116 (39.0/61.0) | 13 419 | 10 350 |
| R-508B | R-23/116 (46.0/54.0) | 13 566 | 10 586 |
| R-509A | R-22/218 (44.0/56.0) | 6 160 | 6 344 |
| R-510A | R-E170/600a (88.0/12.0) | 1 | 1 |
| R-511A | R-290/E170 (95.0/5.0) | 1 | 1 |
| R-512A | R-134a/152a (5.0/95.0) | 219 | 726 |
| R-513A | R-1234yf/134a (56/44) | 647 | 1 788 |
| R-513B | R-1234yf/134a (58.5/41.5) | 611 | 1 686 |
| R-514A | R-1336mzz(Z)/1130(E) (74.7/25.3) | 1.7 | 7 |
| R-515A | R-1234ze(E)/227ea (88.0/12.0) | 430 | 704 |
| R-515B | R-1234ze(E)/227ea (91.1/8.9) | 320 | 523 |
| R-516A | R-1234yf/134a/152a (77.5/8.5/14.0) | 147 | 424 |
| R-500 | R-12/152a (73.8/26.2) | 9 265 | 9 517 |
| R-501 | R-22/12 (75.0/25.0) | 4 558 | 7 383 |
| R-502 | R-22/115 (48.8/51.2) | 5 863 | 6 542 |
| R-503 | R-23/13 (40.1/59.9) | 15 658 | 12 400 |
| R-504 | R-32/115 (48.2/51.8) | 5 349 | 5 112 |

 

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| R-505 | R-12/31 (78.0/22.0) | 9 769 | 9 974 |
| R-506 | R-31/114 (55.1/44.9) | 4 290 | 3 887 |
| R-507A | R-125/143a (50.0/50.0) | 4 860 | 7 345 |
| R-508A | R-23/116 (39.0/61.0) | 13 419 | 10 350 |
| R-508B | R-23/116 (46.0/54.0) | 13 566 | 10 586 |
| R-509A | R-22/218 (44.0/56.0) | 6 160 | 6 344 |
| R-510A | R-E170/600a (88.0/12.0) | 1 | 1 |
| R-511A | R-290/E170 (95.0/5.0) | 1 | 1 |
| R-512A | R-134a/152a (5.0/95.0) | 219 | 726 |
| R-513A | R-1234yf/134a (56/44) | 647 | 1 788 |
| R-513B | R-1234yf/134a (58.5/41.5) | 611 | 1 686 |
| R-514A | R-1336mzz(Z)/1130(E) (74.7/25.3) | 1.7 | 7 |
| R-515A | R-1234ze(E)/227ea (88.0/12.0) | 430 | 704 |
| R-515B | R-1234ze(E)/227ea (91.1/8.9) | 320 | 523 |
| R-516A | R-1234yf/134a/152a (77.5/8.5/14.0) | 147 | 424 |

~~a.Smith, C., Z.R.J. Nicholls, K. Armour, W. Collins, P. Forster, M. Meinshausen, M.D. Palmer, and M. Watanabe, 2021: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity Supplementary Material. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Available from https://www.ipcc.ch/~~
~~b.For gases not shown in this table, please refer to the tables as found in "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity Supplementary Material" at:~~

~~https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07_SM.pdf~~

 

**Table C.2: Default Leakage Rates for Refrigeration/Air Conditioning Equipment**

| Type of Equipment | Installation Leakage Rate [a] | Annual Operating Leakage Rate | Recovery Efficiency |
|---|---|---|---|
| Room AC-window/wall/portable | NA | 2.0% | 80% |
| Residential AC/HP (ducted) | 1.0% | 5.0% | 80% |
| Small self contained AC/HP (PTAC/HP) | NA | 1.0% | 80% |
| Residential mini-split and multi-split ductless AC/HP | 1.0% | 2.5% | 80% |
| Commercial ductless VRF Systems | 1.0% | 3.0% | 80% |
| Light Commercial Rooftop AC/HP units (5-25 tons) | 1.0% | 8.0% | 80% |
| Large Commercial Rooftop AC/HP units (>25 tons) | 1.0% | 6.0% | 80% |
| Water-cooled Centrifugal & Screw Chillers (all sizes) | 1.0% | 3.0% | 80% |
| Air-cooled Chillers (all sizes) | 1.0% | 6.0% | 80% |
| Residential refrigerators & freezers | 1.0% | 0.5% | 70% |
| Industrial Refrigeration including Food Processing and Cold Storage | 3.0% | 25.0% | 90% |
| Commercial refrigeration (all sizes) | 3.0% | 25.0% | 70% |
| Self-contained refrigeration display cases | 3.0% | 2.5% | 70% |
| Multiplex Rack Systems | 3.0% | 30.0% | 70% |
| Remote Condensing Unit Systems | 3.0% | 15.0% | 70% |

a. For equipment charged at a factory and not connected to field refrigerant piping, use an installation rate of 0.0%.

**(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)**

## INFORMATIVE APPENDIX D Informative References

This informative appendix presents a list of available standards and resources that provide *greenhouse gas emission* factors that could be used in place of the default values provided in this standard. It is recommended that these resources are reviewed in more detail to best determine which resource and which *emissions factor*(s) within them are most appropriate for the proposed application:

### D1. Informative References

- **IGCC-2024,International Green Construction Code powered by ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1,** Standard for the Design of High-Performance Green Buildings
    - **ANSI/ASHRAE Standard 105-2021,** Standard Methods of Determining, Expressing and Comparing Building Energy Performance and Greenhouse Gas Emissions
    - **ANSI/ASHRAE Standard 228-2023,** Standard Method of Evaluating Zero Net Energy and Zero Net Carbon Building Performance
    - International Organization Standardization [ISO 2006] ISO 14044, Environmental management – Life cycle assessment – Requirements and guidelines
    - International Organization Standardization [ISO 2018] ISO 14064-1:201F8, Greenhouse gases – Part: Specification with guidance at the organizational level for quantification and reporting of greenhouse gas emissions and removals
    -

### D2. Informative Resources

- **EFDB IPCC** – Emission factor database, Intergovernmental Panel on Climate Change (COP-2024)
- **IEA** – International Energy Agency Emission Factors, Annual GHG emission factors for World countries from electricity and heat generation, International Energy Agency
- **JRC CoM** - Greenhouse gases emission factors for local emission inventories, Covenant of mayors for Climate and Energy initiative, CoM databases, Joint Research Center, European Commission
- *NETL's "Life Cycle Analysis of Natural Gas Extraction and Power Generation" (2019).*
- *NETL's "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update" (2019)*
- *NREL's "U.S. Life Cycle Inventory Database,"*

 