BSR/ASHRAE/ICC Standard 240P

Quantification of Life Cycle Greenhouse Gas Emissions

Third ISC Public Review (November 2026)

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 https://www.ashrae.org/technical-resources/standards-and-guidelines/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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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 (ISC) draft is the fourth public review of this standard. The first public review was an advisory public review which resulted in over 400 comments, the second public review which resulted in over 700 comments, and the third public review (second ISC) which resulted in 270 comments. The committee would like to thank all the commenters for their comments. During the last year, the committee has reviewed all the comments and based on that review made substantial changes to the draft.

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. Numerous revisions to Chapter 6, *Embodied Greenhouse Emissions*
D. Minor edits to Chapters 7 ad 9
E. Updates to Normatiave Appendix C
F. Updates to Normative and Informative References

NOTE TO REVIEWERS: An independent substantive changes public review means that **only the changes in strikethrough and underline are open for public comment.** A link is provider to the prior public review draft (Second ISC public review) to provide context for the changes made to this draft. 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 be requesting that the document be placed on continuous maintenance once published. This will allow the document to be utilized and updated at a more rapid pace in the future.

3.1 Definitions

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

~~***building 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*.~~

carbonation: *Carbon dioxide* reaction with calcium hydroxide, calcium oxide, or other calcium compounds to produce carbonates. ~~cementitious products to form calcium carbonate.~~

demolition: *t*he controlled and intentional action or process of ~~deconstructing~~, dismantling, or removal by destructive means of a *building* or *building elements.*
emissions factor*:* a representative value that attempts to relate the quantity of a ~~pollutant~~ greenhouse gas (GHG) emissions released to the atmosphere with an activity associated with the release of GHG ~~that pollutant. These~~ This factor~~s are~~ is usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant.

fugitive emissions: the emission, leakage or discharge of gases or vapors from pressure-containing equipment ~~or facilities~~ and components of *buildings* such as valves, piping flanges, pumps, storage tanks, ~~,~~ compressors, etc.
Global warming potential (GWP)**:** an index 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 is ~~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*~~ 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.
~~***product-specific EPD:*** *Environmental Product Declaration (EPD)* developed by a single manufacturer that provides data on a single product or product fam~~ily.
Service life: the period during which a product or *building* is expected to function as intended before needing replacement, refurbishment or disposal.

3.2 Abbreviations and Acronyms

LCA life-cycle ~~analysis~~ assessment
~~WLCA whole life-cycle analysis~~

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

Figure 5 Revised (NEW)

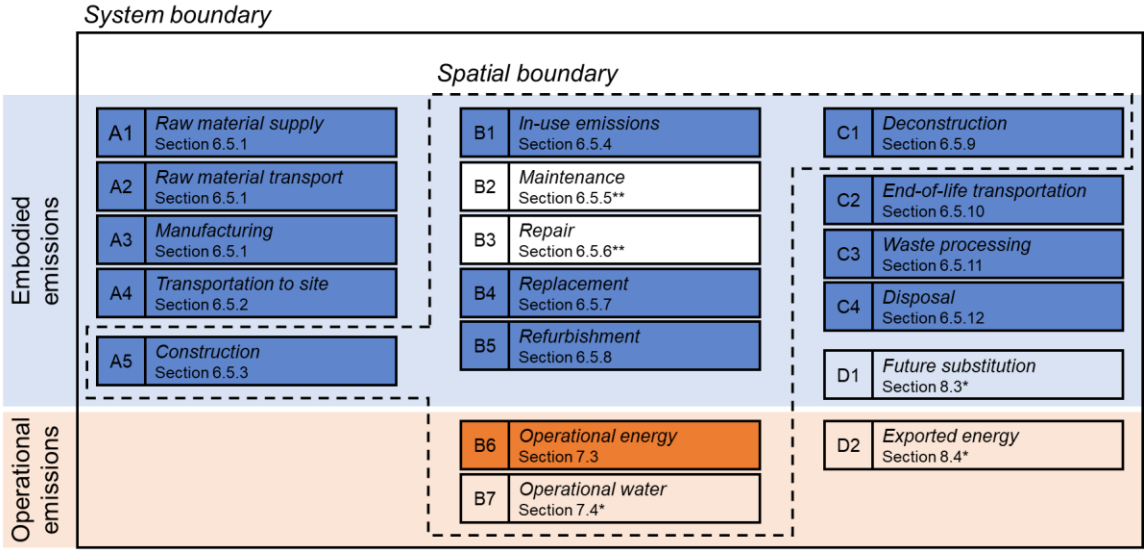


Figure 5: Illustration of *life-cycle stages* included in the *system boundary*

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.

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

a. *Modules A1* through *A5,*
b. Modules B1, B4, B5, and B6,
c. Modules C1 through *C4,*
d. Modules B2, B3, B7, D1, and D2 where required by the AHJ,

6. Quantifying Embodied Greenhouse Gas Emissions

6.1 General The *embodied greenhouse gas emissions* assessment shall comply with all of items a. though p ~~q~~. below. Where ~~specified~~ required by the *AHJ*, ~~compliance~~ the assessment shall also comply with items q., 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, "In-Use ~~Stage~~Emissions" (*B1*)
i. Section 6.5.7, "Replacement Emissions (*B4*)"
j. Section 6.5.8, "Refurbishment Emissions (*B5*)"
k. Section 6.5.9, "Deconstruction and Demolition (*C1*)"
l. Section 6.5.10, "Waste Transportation Emissions (*C2*)"
m. Section 6.5.11, "Waste Processing for Reuse, Recycling, or Recovery (*C3*)"
n. Section 6.5.12. "Waste Disposal (*C4*)"
o. Section 6.6.1 "Biogenic Carbon"
p. Section 6.6.2, "Carbonation"
q. Section 6.4.2.5, "Process Gas Emissions"
r. Section 6.5.5, "Maintenance Emissions (*B2*)"
s. Section 6.5.6, "Repair Emissions (*B3*)"

6.2 Establishing a *Material Inventory*

The assessment shall include a *material inventory* that includes all

1. *building elements* marked as required in Table A.1, *Building Element Categories,* of Appendix A.
   Exception to 6.2: Groups of *building elements* that, in aggregate, constitute less than 5% of the estimated or actual total element Level 3 ~~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 Level 3 ~~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. Refrigerant and *process gases* within the ~~spatial~~ *system boundary* are discussed in Section ~~5.4.2.1.1~~ 6.5.4.2.1.

Table 6.3.1: Types of environmental impact data to be used during different modeling Assessments

Assessment	Greenhouse Gas Emission Data
As-designed	Where a specific product and manufacturer has been ~~selected~~ indicated as the basis of design in the *construction documents:* a. Facility-specific or supply-chain specific *EPD* (where the same specific products/systems are specified) b. Manufacturer-average *EPD* (where products/systems are specified) c. Industry average *EPD* or regionally-appropriate generic values if no manufacturer-average, or facility-specific *EPD* is available

	Once materials have been selected, but no specific product or manufacturer has been specified or purchased: a. Industry average *EPD* b. Regionally-appropriate generic values from national or regional datasets c. Regionally-appropriate generic values from other background datasets For materials and products, if an *EPD* is not available: a. Regionally-appropriate generic values from national or regional datasets b. Regionally-appropriate generic values from other background datasets c. Regionally and technically representative product or material-specific *LCA* d. CIBSE TM 65 product-specific mid-level calculation following local addenda e. CIBSE TM65 product-specific mid-level calculation following original TM65 methodology if local addendum not available f. Proxy *EPD* for similar product type from same manufacturer
As-built	Where a specific product and manufacturer has been purchased or installed: a. Facility-specific or supply-chain specific *EPD* (where the same specific products/systems are specified) b. Manufacturer-average *EPD* (where products/systems are specified) When a type of product has been purchased or installed, but the chosen manufacturer does not have one of the above: a. Industry average *EPD* b. Regionally-appropriate generic values from National or Regional datasets c. Regionally-appropriate generic values from other background Datasets For materials and products, if an *EPD* is not available: a. Regionally and technically representative product or material-specific *LCA* b. CIBSE TM 65 product-specific mid-level calculation following local addenda c. CIBSE TM 65, product-specific mid-level calculation following original TM65 methodology if local addendum not available.

6.3.2.1 Environmental Product Declarations. *EPDs* used shall be valid, 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 EN Standard 50693 shall be accepted. EPDs shall conform to the product category rules (PCR) for the geographical region in which the product is located.

Acceptable *EPD* types are the following:

a. **Industry-average EPD** shall represent the weighted-average environmental impacts product, covering participating manufacturers in a given geographical region, which may be multi-national, national, or sub-national in scope.

b. **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 or supply-chain specific EPD shall ~~be~~ represent a 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 this standard, which is focused on the whole-building scale. ~~*Module B6* and therefore, should not be utilized.~~ The methodology for the Quantification of Operational Greenhouse Gas Emissions ~~shall follow the methodology~~ outlined in Section 7.

6.3.2.2 National and regional datasets of generic environmental impact impacts ~~shall~~ comply ~~be compliant~~ with ISO Standard 21930:2017 Section 7.1.9, ~~or~~ EN Standard 15804 section 6.3.7, ~~plus Amendment 2~~ ISO 14044 clause 4.2.3.6 ~~and represent regional supply chains and regionally-specific manufacturing practices, where available~~ or be a publicly available dataset approved by the *authority having jurisdiction*.

Informative note: Datasets should represent regional supply chains and regionally specific manufacturing practices wherever such data are available. This includes datasets such as US Federal LCA Commons or similar reviewed and published LCA datasets of industry-average production data. This may also include data utilized in a publicly available software or database that is produced following a published, consistent underlying methodology.

6.3.2.3 Life Cycle Assessments. Results from published LCA reports shall be compliant with ISO Standard *14040 and 14044* ~~21930:2017 or EN Standard 15804 -plus Amendment 2-~~. Verified LCA reports shall be critically reviewed by an independent third-party reviewer. Unverified LCA results shall not be permitted.

Informative Note: Results of LCA reports should be communicated as described in ISO 2190:2017 or EN Standard 15804.

6.4.2 Emissions Data ~~Uncertainty~~ Quality Calculation.

Embodied emissions data selection quality shall be calculated as follows:

1. Calculate a datum ~~uncertain~~ selection score, U_S, for each datum, *i*,

For data using the CIBSE TM65 methods, U_S shall be assigned a score of 9. For data from a verified LCA meeting the requirements of Section 6.3.2.3, U_S shall be assigned a score of 12. Where default emissions values provided by this standard are used, U_S shall be assigned a score of 15.

For all other data selections in compliance with Section 6.3 U_S shall be calculated in accordance with Equation 6.4.2.1, where the subscores are determined in accordance with Appendix B Table B.1.

$$U_S = U1 + U2 + U3 + U4 + U5 + U6$$

~~Where the following are determined in accordance with Appendix B Table B.1~~

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~~ selection factor, Q_F ~~U_F~~, for each datum, i, based on the value of U_S computed in (1) 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~~ selection factor

US	<10	10 - <15	15 - <20	20 - <25	25 - <30	30 - <35	35 - <40	40
~~Uncertainty~~ Selection Factor Q_F	~~1~~30%	25 ~~8~~%	20 ~~7~~%	15%	11 ~~4~~%	7~~3~~%	4 ~~2~~%	1%

3. Calculate the whole building ~~uncertainty~~ data representativeness result, Q_R ~~U_R~~ in accordance with Equation 6.4.2.3:

$$Q_R = \sum_{i=1}^{n} [(Q_F)_i * E_i]$$

(6.4.2.3)

where
Q_F ~~U_{datum}~~ is the ~~Uncertainty~~ Data selection factor for environmental datum *i*, determined in (2)
n is the number of materials or products included in the assessment
E_i ~~is~~ are the greenhouse gas emissions calculated for the associated product or material in accordance with Section 6.5 using environmental datum *i*.

4. The ~~uncertainty~~ representativeness result percentage, $QU_{RP,}$ shall be calculated in accordance with Equation 6.4.2.4:

~~$$U_{RP} = \frac{U_R}{E}$$~~

Replace Equation 6.4.2.4 as shown:

$$Q_{RP} = \frac{Q_R}{E}$$

(6.4.2.4)

Where
QU_{RP} is the ~~Uncertainty~~ Data Representativeness Result as a percentage
QU_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.

The total combined uncertainty percentage, $U_{Total,P}$, shall be calculated in accordance with Equation 6.4.3.1

Delete Equation 6.4.3

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

Replace with Revised Equation 6.4.3.1 as shown

$$U_{Total,P}\sqrt{U_{M^2} + Q_{RP^2}} \quad (6.4.3.1)$$

Where

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

$U_{Total,P}$ 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 in accordance with Equation 6.4.3.2.

Equation....

Where
R_E is the final reported Embodied Greenhouse Gas Emissions
E is the total emissions calculated in accordance with Section 6.5
$U_{Total,P}$ is the combined uncertainty percentage calculated by equation 6.4.3.1

Informative Note: This process is meant to provide a mechanism to incentivize ~~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)

The assessment shall calculate emissions associated with the creation of finished physical materials to be permanently installed in the *building* and associated *site* in accordance with Equation 6.5.1,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_2e).
p is a given product or material.
m_p is the quantity of product, *p*, in accordance with Section 6.2.
CF_p is the product's *emissions factor* per Section 6.3 for the relevant *life cycle stage* per Section 5.4.

***Informative note*:** Where the units of m_p and CF_p do not match, the material quantity should be converted to match the units of the *emissions factor* using industry or product-specific density data.

Exception to Section 6.5.1: For any instances of asset reuse, existing material that is remaining in place may exclude the original *Module A1-A3* impacts associated with that material. For any instances of salvaged and reused materials, these materials may exclude the original *Module A1-A3* impacts associated with that material.

6.5.2 Transportation to Site (*Module A4*)

The assessment shall include all emissions arising from the 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. For any instances of asset reuse, existing material that is remaining in place may exclude the original *Module A4* impacts associated with that material.

6.5.2.1 As-Designed Compliance Path.

~~Material or product quantities shall be multiplied by the appropriate emission factor from Table 6.5.2.1.~~ The assessment shall calculate GHG emissions associated with the transportation of products to the building or site in accordance with Equation 6.5.2.1.

$$EM_{A4} = \sum_p m_p \times EF_p \qquad (6.5.2.1)$$

where
p is a given product or material delivered to the *site*
m_p is the quantity of product or material *p* expressed as a mass or a volume
EF_p is the applicable emission factor from Table 6.5.2.1.
EM_{A4} is the greenhouse gas emissions from Module A4

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. 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 *Module A4 GHG emissions* are calculated in accordance with Section 6.5.2.2 using project-specific transportation data.
3. Where *Module A4 GHG emissions* are calculated in accordance with Section 6.5.2.2 using relevant EPD *Module A4* data that is more representative of the transportation scenario than the factors provided in Table 6.5.2.1.

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

Type/Source of product	**Emission factor (EF_p) [$kgCO_2e$/US ton]**
Ready-mixed concrete from a local plant	14.2 ~~9.75~~ ~~$kgCO_2e/yd^3$~~
Manufactured products	
Manufactured locally ~~& sourced~~ (within 100 miles)	81.0 ~~42.2~~ ~~$kgCO_2e$/ton~~
Manufactured regionally ~~& sourced~~ (between 100 and 500 miles)	405 ~~211~~ ~~$kgCO_2e$/ton~~
Manufactured ~~& sourced~~ on same continent as project site (beyond 500 miles)	1,215 ~~422~~ ~~$kgCO_2e$/ton~~
European manufactured to Eastern North America	725 ~~314~~ ~~$kgCO_2e$/ton~~
European manufactured to Western North America	1,332 ~~525~~ ~~$kgCO_2e$/ton~~
Asian manufactured to Eastern North America	1,355 ~~546~~ ~~$kgCO_2e$/ton~~
Asian manufactured to Western North America	748 ~~335~~ ~~$kgCO_2e$/ton~~

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 0.35 is included in the emission factor.~~ The emission factors were established using Equation (6.5.2.2) with the parameters indicated below.*

For ready mix concrete: Concrete mixing truck, d_p = 15 miles, RF_p = 1.0.

For manufactured products:

- *Manufactured locally: Truck, d_p=100 miles, RF_p=0.35.*
- *Manufactured regionally: Truck, d_p=500 miles, RF_p=0.35.*
- *Manufactured on same continent as project site: Truck, d_p=1,500 miles, RF_p=0.35.*
- *European manufactured to Eastern North America:*
  Leg 1: Ocean freighter, d_p=4,500 miles, RF_p=0.00.
  Leg 2: Truck, d_p=750 miles, RF_p=0.35.
- *European manufactured to Western North America:*
  Leg 1: Ocean freighter, d_p=4,500 miles, RF_p=0.00.
  Leg 2: Truck, d_p=1,500 miles, RF_p=0.35.
- *Asian manufactured to Eastern North America:*
- *Leg 1: Ocean freighter, d_p=5,400 miles, RF_p=0.00.*
- *Leg 2: Truck, d_p=1,500 miles, RF_p=0.35.*

- *Asian manufactured to Western North America:*
- *Leg 1: Ocean freighter, d_p=5,400 miles, RF_p=0.00.*
- *Leg 2: Truck, d_p=750 miles, RF_p=0.35.*

6.5.2.2 As-Built Compliance Path

The assessment shall calculate GHG emissions associated with the transportation of products to the *building* or site in accordance with Equation 6.5.2.2. Transportation distance (d_p) 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*.

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

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 to the site
EFO_p is the emission factor for outbound trip based on applicable transportation mode from Table 6.5.2.2.
RF_p is the return trip factor for the applicable mode of transportation from Table 6.5.2.2.
EM_{A4} is the greenhouse gas emissions from *Module A4.*

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_p)		Return trip factor (RF_p) [3]
	[kg CO_2e per metric ton-km]	[kg CO_2e per US ton-mile]	
Concrete mixing truck	0.325	0.474 ~~kgCO_2e/yd^3-mile~~	1.0
Truck	0.411	~~0.281~~ 0.600 ~~kgCO_2e per ton-mile~~	~~0.5~~.0.35 ~~for trips up to 500 miles 0.0 for trips longer than 500 miles~~
Air	1.249	~~0.855~~ 1.824 ~~KgCO2e per ton-mile~~	-
Ocean freighter ~~**Ship or Barge**~~	0.018	~~0.023~~ 0.026 ~~kgCO_2e per ton-mile~~	-

Barge	0.033	0.048	-
Rail	0.022	~~0.015~~ 0.032 ~~kgCO_2e per ton-mile~~	-

Informative note: Transport-specific emissions factors found in this table were compiled using sources listed in Appendix D assuming transportation technology from the year 2026

6.5.3 Construction (A5)
The assessment shall calculate *GHG emissions* associated with preparation activities occurring at the *building* or site until *project* delivery in accordance with Section 6.5.3.1 through 6.5.3.3, and inclusive of materials left in place from the construction process. For any instances of asset reuse, existing material that is remaining in place may exclude the original *Module A5* impacts associated with that material. Worker transportation to and from the site during the construction process shall be excluded.

6.5.3.3 Construction Waste (A5-3)
The assessment shall calculate the GHG emissions associated with manufacturing, transportation, and end-of-life impacts of materials wasted on *site*, inclusive of packaging in accordance with Section 6.5.3.3.1 or Section 6.5.3.3.2. The methodologies in Sections 6.5.1 (*Modules A1-A3), 6.5.2 (Module A4),* 6.5.10 (*Module C2)~~C2~~*, 6.5.11 (*Module C3) and 6.5.1.2 (*Module C4) shall be used to calculate *GHG emissions* associated with materials wasted on site. *Construction waste* quantities estimated for the purpose of this section shall be in addition 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 by multiplying the material quantities determined in accordance to Section 6.2 by the wastage rates in Table 6.5.3.3. 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 30 ~~50~~ lbs/ft^3, 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:

1. Where on-site material wastage rates from an approved ~~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.

Informative note: For prefabricated components, emissions associated with wastage occurring during prefabrication, i.e. prior to transportation to the site, apply to Modules A1 through A3. These emissions are commonly accounted for in product EPDs. They do not need to be accounted for again in Module A5-3.

Table 6.5.3.3: Default on-site material wastage rates

	On-site wastage rate (See Note 1)
Pre-fabricated assemblies (Note4)	
Standardized assemblies~~y~~ ~~and small MEP equipment (400 lbs or less~~) selected from a manufacturer's catalogue. See Notes 2 and 4.	1%
Custom assemblies ~~y~~ made to order.~~ and large MEP equipment (more than 400 lbs).~~ See Notes 3 and 4.	0%
Small MEP equipment (up to 400 lbs)	1%
Large MEP equipment (more than 400 lbs)	0%
Structural components fabricated or manufactured offsite. See Notes 4 and 5.	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%~~5%
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~~6):	
- 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 on-site 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 on site such as cutting or trimming or drilling. For example: standard windows, small appliances. These products are selected from a manufacturer's catalog and susceptible to being ordered in surplus quantities.

3. Applies to custom pre-fabricated assemblies fabricated to meet the specific dimensions and requirements of the project, and shipped to site ready to be installed without any *alterations* resulting in wastage on site such as cutting, trimming, or drilling. ~~meeting all of the following: .~~

~~a. Weighs more than 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 *alterations* resulting in wastage such as cutting or trimming or drilling.~~

For example: unitized curtainwall, volumetric modular construction, ~~structural steel members, glue-laminated members 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 manufactured structural components delivered to the construction site ready to be erected without any anticipated waste (e.g. structural steel members, precast concrete plank or wall panel, engineered wood panels).

6. 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~~ In-Use Emissions (B1)

All material-related GHG *emissions* and 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~~2.

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~~6.2.

6.5.4.2.1.3 Leakage rates. Leakage rates shall be determined in accordance with Section 6.5.4.2.2.2 or Section 6.5.4.2.2.~~3~~4 or Section 6.5.4.2.2.~~4~~5 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 through ~~and~~ 6.5.4.2.2.3

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.~~3~~1 through ~~and~~ 6.5.4.2.2.1.~~5~~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.

6.5.4.2.2.2 Calculate emissions during installation (*Module A5*). GHG emissions associated with *fugitive emissions* from equipment installed during the *reference study period* and charged on-site shall be calculated in accordance with Section 6.5.4.2.2.2.1 or Section 6.5.4.2.2.2.2. *GHG emissions* calculations shall not include *fugitive emissions* from equipment that was pre-charged by the manufacturer.

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 each new piece of equipment, shall be calculated using Equation 6.5.4.2.2.2.2.

$$GHG_{ref,ie} = \sum_{n=1}^{N} REF_{ch,site} \times x_i \times GWP_{ref} ~~GEF_{ref}~~$$

(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, kg CO_2e
$REF_{ch,site}$ = Mass of refrigerant charged within the *site* boundary during installation, kg REF
x_i = Fraction of refrigerant charged within the *site* boundary and leaked during installation, determined based on the compliance path
GWP_{ref} = *Global warming potential* of leaked refrigerant, kg CO_2e/kg REF

6.5.4.2.3 Calculate operating emissions (B1). GHG emissions associated with *fugitive greenhouse gas emissions* associated with equipment leaks, piping leaks, and service losses over the *reference study period* shall be calculated in accordance with Section 6.5.4.2.2.1.4.1~~.3.3.1~~ or Section 6.5.4.2.2.1.4.2 ~~3.2~~.

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 all available annual refrigerant replacement data, not to exceed the five most recent years of refrigerant replacement data. GHG emissions shall be calculated for each piece of equipment, using Equation 6.5.4.2.3.2.

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

(6.5.4.2.2.1.4~~3.2~~)

Where.
t = timestep
T = Total timesteps of the *reference study period*
$GHG_{ref,oe}$ = *Greenhouse gas emissions* of leaked refrigerant during operations, kg CO_2e
$REF_{ch,tot}$ = Mass of pre-charged refrigerant and refrigerant charged onsite (total refrigerant charge), kg REF
x_o = Fraction of total refrigerant charge leaked during operations as determined from Table based on the compliance path

GWP_{ref}= *Global warming potential* of leaked refrigerant, kg CO_2e/kg REF

6.5.4.2.3.3 Calculate disposal emissions (C4). GHG associated with all equipment disposed during the *reference study period* shall be calculated in accordance with Section 6.5.4.2.2.1.5.1 ~~3.1 or Section 6.5.2.3.3.2~~.

6.5.4.2.2.4 Fire Suppression Operating System Emissions (B1). *GHG emissions* associated with permanently installed fire suppression systems shall be calculated in accordance with Section 6.5.2.4.1. 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..2.2.1~~4.1~~.

6.5.4.2.2.2.1~~4.1~~ Calculate total emissions The user shall calculate total GHG emissions in accordance with Equation 6.5.4.2.2.2.1~~4.1~~. Annual emissions from fixed/permanently installed systems shall be assumed to be 2.5 percent (0.025) of the total capacity of the system for each gas. The *global warming potentials* to be used shall be those for the applicable gas in Table C.1.

$GHG_{fs} = \sum_{t=1}^{T} FS_{ch,tot} \times .025_{\times} \text{GWP}_{\text{fs}}$
(6.5.4.2.4.1)
Where
GHG_{fs} = *Greenhouse gas emissions* associated with fixed fire suppression system, kg CO_2e
$FS_{ch,tot}$ = Total capacity of the fixed installed fire suppression system, kg FS
.025 = annual fraction of leaked fire suppression gas
GWP_{fs} = *global warming potential* of the fire suppression gas, kg CO_2e/kg FS

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 appropriate GWP values from Table C-1.~~7.5.1.2(1) or Table 7.5.1.2(2)~~.

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

Where
GHG_{tot} = Total *greenhouse gas emissions* from *process gases, kg CO_2e*
$PG1_{tot}$ = Total *process gas* type 1 total purchased, kg PG1
GWP_{pg1} = *global warming potential* for *process gas* type 1, kg CO_2e/kg PG1
$PG2_{tot}$ = Total *process gas* type 2 total purchased, kg PG2
GWP_{pg2} = *global warming potential* for *process gas* type 2, kg CO_2e/kg PG2

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 correspond to the applicable material or product in Normative Appendix A Table A.1 Omniclass Building Elements~~. Product or material *service life* shall ~~be adjusted to~~ match the industry-average applicable ~~PCR~~ product category rule or product-specific *EPD* where available. Service lives for products or materials contained within larger assemblies shall be adapted to match the expected *service life* of the assembly for the expected use within the *project*. Where the *service life* data is not available, *building element service life* default value shall correspond to the applicable material or product in Normative Appendix A Table A.1 Omniclass Building Elements.

$$E_L \text{ X } n = LE \quad (6.5.7.1)$$

where
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 use the same data for materials and products as 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 shall be used for the recovery of any materials covered by this section, 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.

6.5.8 Refurbishment Emissions (*B5*). The assessment ~~s~~hall 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. *GHG emissions* shall be calculated in accordance with Sections 6.5.1 through 6.5.3.(*Modules A1-A5)* for all added products and materials. For any instances of asset reuse, existing material that is remaining in place may exclude the original *Module A1-A5* impacts associated with that material. For any instances of salvaged and reused materials, these materials may exclude the original *Module A1-A3* impacts associated with that material and shall calculate *Module A4-A5* impacts per Sections 6.5.2 and 6.5.3.

***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.~~

6.5.9.1 *As-Designed* Compliance Path. *GHG emissions* calculations shall include all *site* activities associated with *deconstruction* and *demolition* of the *building* or *site* (*Module C1.)* Environmental impact data used in *GHG emissions* calculations shall 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~~1)

(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 as 50% of the GHG emissions calculated in in accordance with Section 6.5.3.2 (*Module A5*-1~~2~~)

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

6.6.1 Biogenic Carbon.

GHG calculations shall comply with all of the following:

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

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:

    i. ~~The sequestered *b*~~*Biogenic* carbon entering the product system shall be reported at the point of raw material extraction (Module A1) ~~as a removal of *biogenic* carbon from the biosphere when the *biomass* is harvested~~ in accordance with Section 6.5.1 (Modules *A1-A3*) and ~~must~~ shall be reported as emitted when combusted, decomposed, or degraded in the *life cycle stage* where the emissions occurs in accordance with Section 6.5.3 (Module A5), Section 6.5.7 (Module B4), Section 6.5.11 (*Module C3*) or Section 6.5.12 (Module C4), as applicable.

    ii. For sustainably sourced forest products, such as reclaimed wood, salvaged wood products with source-specific evidence to show stable or increasing forest carbon stocks, or rapidly-renewable agricultural fibers, the biogenic carbon flow shall be characterized with a –1 kg CO2e/kg CO2 of *biogenic carbon* ~~flow shall be permitted~~ when entering the product system. *Biogenic carbon* uptake for all other forest products shall ~~not be included,~~ be characterized with 0 kg CO2e/kg CO2 of *biogenic carbon*. National reporting under the United Nations Framework Convention on Climate Change (UNFCCC), shall not be used to determine supply-chain specific sourcing claims. Emissions of *biogenic carbon* shall be characterized with +1 kgCO2e/kg CO2 of *biogenic carbon.*

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

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

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 carbon uptake, biogenic carbon emissions, or fossil carbon emissions.

6.6.2 Carbonation.

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

1. Section 6.5.1 for Manufacturing (*Modules A1-A3)* and A5 pre-construction demolition,
2. Section 6.5.4 for Use (Module *B1*) and
3. Section 6.5.11 and 6.5.12 for End-of-Life (Modules *C3-C4*).
4. Section 8.3 for Recovery, Reuse and Recycling (*Module D*) where the *system boundary* includes *Module D1*. Data from *EPDs* or equivalent sources shall be permitted for *GHG emissions* calculation under this section 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.

7. Quantifying Operational Greenhouse Gas Emissions

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

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.

***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* (*CO_2*), 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~~ Normative ~~Appendix C for recommended sources for *emissions factors* that may be most appropriate for a particular *jurisdiction* or *project*.~~

7.4.2.1.1 Water Supply-Related Energy Usage. The energy needed for the supply of water across the ~~analysis~~ assessment 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.

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~~ assessment 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.

9. Documentation of *Greenhouse Gas Emissions*

9.1 Compliance. The calculated embodied *GHG emissions* and removals, operational *GHG emissions*, and total *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. Any deviation from the methodology included in this standard, with the exception of deviations at the direction of an *AHJ*, would result in noncompliance with this standard.

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

a. *Project* Name.
b. *Project Street Address*
c. *Project* City.
d. *Project* Country.
e. *Project* Postal Code.
~~f Building *Gross Floor Area*.~~
~~g *Project Site* Area.~~
f. Year of reporting data.
g. *Project* phase at time of assessment.
h. *Project* Construction Type: New Construction or *Existing Building* Modification.
~~Embodied Carbon Tool used, including software and database version~~ i. Embodied carbon data source, methodology, or software tool (including version) used.
j. Operational Energy calculation methodology
k. *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):

9.4.2 Carbon Emissions per Stage. The documentation of *GHG emissions* per stage shall include:
a. ~~*GWP*~~ GHG Fossil (kgCO2e).
b. ~~*GWP*~~ GHG *Biogenic* (kgCO2e).
c. ~~*GWP*~~ GHG Captured and stored (kgCO2e).

9.5.1 Greenhouse Gas Emissions from Energy Use. Documentation of the operational GHG emissions associated with energy usage shall include the first year and *reference study period* projections of *GHG emissions* from all of the following applicable to the assessment:
a. Electricity usage calculated in accordance with Section 9.5.2.
b. Fuel usage calculated in accordance with Section 9.5.3.
c. Thermal energy usage calculated ~~consumption~~ in accordance with Section 9.5.4.

9.5.2 Electricity usage. Documentation of *greenhouse gas emissions* associated with source electricity use shall include:
a. Name of ~~Electricity Source Provider.~~ grid region of the building or site.
b. First year of the *RSP.*
c. *RSP* (in number of years).
d. Name of Electricity Source Provider (if known).
e. 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."
f. *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.
g. Basis of future *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.
h. First year *as-designed* consumption (in MWh/year).

i. First year *as-designed* ~~carbon~~ *GHG* emissions (in kgCO2e).
j. First year as-built consumption (in MWh/year).
k. First year as-built carbon emissions (in kgCO2e).
l. Total life-cycle *as-designed and as-built* ~~carbon~~ *GHG* emissions (in kgCO2e) 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* are 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~~ provided for *GHG* Fossil Fuel (kgCO2e) and GHG *Biogenic* (kgCO2e). ~~and area normalized *GWP* Fossil Fuel (kgCO2e/m2), GHG *Biogenic* (kgCO2e/m2) 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~~ provided as *GHG* Fossil Fuel (kgCO2e). ~~and area normalized GHG Fossil Fuel (kgCO2e/m^2).~~

d. A totalizing sum of *Modules A* through *C* for the *building* shall be provided in GHG Fossil Fuel (kgCO2e) and GHG *Biogenic* (kgCO2e), ~~and area normalized GWP Fossil Fuel (kgCO2e/m^2), GHG *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 GHG Fossil Fuel (kgCO2e) and ~~GWP~~ GHG *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~~.

9.8 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-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~~ GHG Fossil and ~~GWP~~ GHG *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 2025~~2020~~. ANSI/ASHRAE Standard 169, *Climatic Data for Building Design Standards*. Atlanta: ASHRAE.
ASHRAE	ASHRAE. 2025~~2022~~. ANSI/ASHRAE/IES Standard 90.1, *Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings*, I-P edition. Atlanta: ASHRAE.

ASHRAE	ASHRAE. 2024. ANSI/ASHRAE Standard 209, *Building Performance Simulation Process*, Atlanta: 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 2025~~2021~~. Handbook (Fundamentals) , SI edition. Atlanta: ASHRAE
ASHRAE	ASHRAE. 2024. ANSI/ASHRAE/IES Standard 90.2, *High-Performance Energy Design of Residential Buildings*. Atlanta: ASHRAE. ~~ASHRAE ANSI/ASHRAE/IES Standard 90.2, *Energy Efficient Design of Low-Rise Residential Buildings*. Atlanta: ASHRAE.~~
EPA	EPA Snap Refrigerants Blends http://www.epa.gov/ozone/snap/refrigerants/refblend.html
ICC	ICC ~~2021~~2024. International Energy Conservation Code. Washington D.C.:ICC.
ISO	ISO. 2026 ISO 14025, *Environmental statements and programmes for products — Environmental product declarations (EPDs)*. Switzerland: International Organization for Standardization. ~~International Organization Standardization [ISO 2016] ISO 14025:2016– Type III environmental declarations – Principles and procedures~~

NORMATIVE APPENDIX A
A.1 Building Elements

Table A.1 Building Element Categories

				Years
OmniClass Number	**Element Category**	**Required**	**Exclude**	**Default *Service Life***
	– **Enclosure**			
21-02 20 10	– *Exterior Walls (non-structured)*	X		35
21-03 00 00	– **Interiors**			
21-03 10	– **Interior Construction**	X		
21-03 10 10	– Interior Partitions | Including non-structural walls	X		25
21-03 20	– **Interior Finishes**	X		
21-03 20 10	– Wall Finishes	X		
	- Epoxy (Two part)			15
	- Fabric			5
	- ~~Glazed Wall Tile~~ Ceramic Tile			50

21-03 20 20	– Interior Fabrications	Including permanently installed interior components not included elsewhere.	X		12
21-03 20 30	– Flooring		X		
	- ~~Mosaic Tile~~ Ceramic Tile				50
	~~- Porcelain Tile~~				~~50~~
21-05	– **Equipment and Furnishings**				
21-05 20	– **Furnishings**	Including permanently installed furnishings, such as casework		X	n/a

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

Normative Appendix B Data Representativeness

Table B.1: Data representativeness evaluation table

Quality	***U1 -Geographic Representativeness***	***U2- Technological Representativeness***	***U30 Product Representativeness***	***U4- Temporal Representativeness***	***U5-Data Granularity***	***U6-Verifiability***
Very Good	*Region is representative (e.g. NYC and Northeast US) -* ***10***	*Reflects the identical manufacturing technology and material characteristics (e. g. BF/BOF steel with 40% recycled content) -* ***6***	*Data for actual product used -* ***6***	*Year of data 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 manufacturing technology and material 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 -3*	*<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

~~Refrigerant Designation~~ Common Name	~~Refrigerant Composition (Mass %)~~ Chemical Formula	GWP-100	GWP-20
~~*Carbon Dioxide* (R-744)~~	~~CO2~~	~~1~~	~~1~~
~~Methane (R-50)~~	~~CH4~~	~~(27.9)~~	~~81.2~~
~~Nitrous Oxide (R-744A)~~	~~N20~~	~~(273)~~	~~273~~
Sulfur hexaflouride	SF6	22,800	
Nitrogen trifluoride	NF3	17,200	
~~**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~~	~~$n\text{-}C_4F_9CH=CH_2$~~	~~0.204~~	~~0.734~~
~~-~~Refrigerant Designation	~~**Refigeration Composition (Mass%)**~~ **Chemical Formula**	**GWP-100**	**GWP-20**
Methane Series			
CFC-11	CCl3F	6 410	8 560
CFC-12	CCl2F2	12 500	12 700
BCFC-12B1	CBrClF2	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	CCl2FCClF2	12 600	9 040
HCFC-123	CClF2CClF2	91	329
HCFC-124	CClF2CF3	596	2 060
HFC-125	CF3CF3	3 820	6 790
HFC-134a	CHCl2CF3	1 470	4 060
HCFC-141b	CHClFCF3	808	2 590
HCFC-142b	CHF2CF3	2 190	5 400
HFC-143a	CH2FCF3	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	1
Propane Series			
PFC-218	CF3CF2CF3	~~2.6~~ 9500	9 ~~500~~ 6920
HFC-227ea	CF3CHFCF3	~~35.8~~ 3580	~~3 580~~ 5830
HFC-236fa	CF3CH2CF3	~~213~~ 9210	~~9 120~~ 7820
HFC-245fa	CHF2CH2CF3	7~~.74~~ 966	~~966~~ 3190
HC-290	CH3CH2CH3	~~15 days~~ <<1	<<1
Cyclic Organic Compounds			
PFC-C318	-(CF2)4-	~~3.2~~ 10600	~~10 600~~ 7740
Hydrocarbons			
HC-600	CH3CH2CH2CH3	~~6.5 days~~ <<1	<<1
HC-600a	CH(CH3)2CH3	~~7.0 days~~ <<1	<<1
HC-601	CH3CH2CH2CH2CH3	~~4.0 days~~<<1	<<1
HC-601a	CH(CH3)2CH2CH3	~~3.9 days~~ <<1	<<1
Oxygen Compounds			
HE-610	CH3CH2OCH2CH3		
R-611	HCOOCH3	~~86 days~~ 13	~~13~~ 46
Nitrogen Compounds			
R-630	CH3NH2		
R-631	CH3CH2(NH2)		
Inorganic Compounds			
R-702	H2		
R-704	He		
R-717	NH3	~~Days~~<<1	<<1
R-718	H2O		
R-720	Ne		

R-728	N2		
R-732	O2		
R-740	Ar		
R-744	CO2	1	1
R-744A	N2O	~~109~~ 273	273
R-764	SO2		
Unsaturated Organic Compounds			
HCC-1130(E)	CHCl=CHCl	~~5.5 days~~ <<1	<<1
HFO-1132(E)	CHF=CHF	~~1.3 days~~<<1	<<1
HFO-1132a	CF2=CH2	~~4.6 days~~ <<1	<<1
HC-1150	CH2=CH2	~~1.7 days~~ <<1	<<1
HCFO-1224yd(Z)	CF3CF=CHCl	~~12 days~~ <1	~~<1~~ 2
HCFO-1233zd(E)	CF3CH=CHCl	~~41.9 days~~ 4	~~4~~ 14
HFO-1234yf	CF3CF=CH2	~~12 days~~ <1	~~<1~~ 2
HFO-1234ze(E)	CF3CH=CHF	~~19 days~~ 1	~~1~~ 5
HC-1270	CH3CH=CH2	~~0.4 days~~ <<1	<<1
HFO-1336mzz(E)	CF3CH=CHCF3	~~121 days~~ 26	~~26~~ 94
HFO-1336mzz(Z)	CF3CH=CHCF3	~~27 days~~ 2	~~2~~ 9
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
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
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	1 396	4 121

	(50.0/39.0/1.5/9.5)		
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
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
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	2 041	4 443

	(31.0/31.0/30.0/3.0/5.0)		
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
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) (6.0/45.0/49.0)	707	1 987
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
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)	633	1 747

	(45.0/43.0/12.0)		
R-476A	R-134a/1234ze(E)/1336mzz(E) (10.0/78.0/12.0)	151	421
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	147	424

	(77.5/8.5/14.0)		
~~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~~
~~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~~

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%

Type of Equipment	Installation Leakage Rate [a]	Annual Operating Leakage Rate	Recovery Efficiency
Light Commercial Rooftop AC/HP units (5-25 tons)	1.0%	5.0 ~~8.0~~%	80%
Large Commercial Rooftop AC/HP units (>25 tons)	1.0%	4.5 ~~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:

D2. Informative Resources

- Building Transparency. *EC3 A4 Transportation Mode Data (Sheet).* EC3 (Embodied Carbon in Construction Calculator). Available: https://docs.google.com/spreadsheets/d/1sviO5qm9bPKSm1biDl9i64yU1_hX17-1Pnduebnj9cc/ Accessed: February 2026.
- NRMCA's "Fleet Benchmarking and Costs Survey" (2022)