



BSR/ASHRAE Standard 228P

Public Review Draft

Standard Method for Evaluating Zero Net Energy and Zero Net Carbon Building Performance

First Public Review (April 2021)

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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

ASHRAE Standard 228P can be used to determine whether a site has achieved “Zero Net Energy” or “Zero Net Carbon,” meaning that the energy or carbon flows coming into a site are less than or equal to those flowing outward during building/site operation.

This standard deals with energy and carbon flows across a site boundary along with their measurement and balance. In that regard, the committee has learned from documents such as ANSI/ASHRAE Standard 105. Allowances are made for sites without the opportunity to produce adequate renewable energy, but the standard puts requirements on that path.

For energy, the committee has chosen to define the calculation in terms of “source.” This is a multiplier on the actual energy crossing the boundary to include energy used or lost getting the measured energy type to the site. While the main energy calculation is in terms of annual average factors, permission is given for a qualified professional to sum the results of individual hours where that data is available.

Carbon was an addition to the committee’s original scope. The actual calculation is being done in terms of carbon dioxide equivalents, valuing related greenhouse causing gases over the 100 years after their release. In some cases, refrigerant leakage can be a substantial contributor to the operational carbon footprint and so the committee has decided to include leakage of refrigerants.

ANSI/ASHRAE standards are reviewed every five years to determine if updating is needed. Future development of this standard may expand beyond operational energy and carbon. For instance, in addition to energy used for operations, the committee weighed whether to include “embodied energy,” the sum of the energy used to create the building or site. While there is valuable work being done on this subject, the decision was made not to include it at this time.

1. PURPOSE

This standard sets requirements for evaluating whether a building or group of buildings meets a definition of “zero net energy” or whether those buildings meet a definition of “zero net carbon.” It provides a consistent method of expressing qualifications for zero net energy and zero net carbon buildings associated with the design of new buildings and the operation of existing buildings.

2. SCOPE

2.1 This standard covers:

- a) existing buildings, new buildings, groups of buildings, or portions of buildings;
- b) determination, including calculation methodology, and expression of the building(s) zero net energy status;
- c) determination, including calculation methodology, and expression of the building(s) zero net carbon status; and
- d) energy and carbon emissions associated with flows across the site boundary and off-site credited flows.

2.2 The provisions of this standard do not apply to:

- a) establishment of building gross energy performance goals or limits;
- b) design guidance or design requirements;
- c) embodied energy or carbon of building materials and systems.

3. DEFINITIONS AND SYMBOLS

3.1 Definitions

adopting authority: the agency or agent that adopts this standard.

authority having jurisdiction (AHJ): the agency or agent responsible for enforcing this standard.

biomass: non-fossilized and biodegradable organic material originating from plants, animals, and/or micro-organisms, including products, by-products, residues, and waste from agriculture, forestry, and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material.

boundary: the demarcation of a defined site across which energy flow characteristics are known or can be calculated.

building: a structure wholly or partially enclosed within exterior walls, or within exterior and party walls, and a roof, affording shelter to persons, animals, or property.

building site: see “site.”

carbon dioxide equivalent (CO_{2e}): a measure used to compare the impact of various greenhouse gases based on their 100-year time horizon global warming potential (GWP). CO_{2e} approximates the time-integrated warming effect of a unit mass of a given greenhouse gas relative to that of carbon dioxide (CO₂).

community renewable energy facility: a facility that produces energy harvested from renewable energy resources and is qualified as a community energy facility under applicable jurisdictional statutes and rules.

energy: the capacity for doing work. Energy takes a number of forms that may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, or chemical. Customary measurement units are British thermal units (Btu), Joules (J), or kilowatt-hours (kWh).

energy form: any thermal, mechanical, electrical, or chemical energy to provide energy services to a site.

existing building: a building or portion thereof that has been in operation and normal use for at least 24 consecutive months following the date of initial occupancy, certificate of occupancy, or occupancy class change, whichever is later.

financial (virtual) renewable energy power purchase agreement (PPA): a financial arrangement between a renewable electricity generator (the seller) and a buyer wherein the buyer pays or guarantees a fixed price to the seller for the project’s generation and associated renewable energy certificate. Also known as a financial power purchase agreement.

global warming potential (GWP): an index for estimating the relative global warming contribution of atmospheric emissions of a particular greenhouse gas compared to emissions of an equal mass of carbon dioxide (CO₂).

greenhouse gas emissions (GHG): The carbon dioxide equivalent emissions from various greenhouse gases based on their 100-year time-integrated global warming potential compared to emissions of an equal mass of carbon dioxide.

gross floor area for nonresidential buildings (GFANR): the sum of the floor areas of all the spaces within the *building* with no deductions for floor penetrations other than atria. It is measured from the exterior faces of exterior walls or from the centerline of walls separating *buildings*, but it excludes covered walkways,

open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, roof overhangs, parking garages, surface parking, and similar features.

gross floor area for residential buildings (GFAR): the sum of the floor areas of all the conditioned (heated and/or cooled) spaces within the *building*, including conditioned garages, conditioned basements, and conditioned attics. It is measured from the exterior faces of exterior walls or from the centerline of walls separating *buildings*. It excludes *crawl spaces*, covered walkways, open roofed-over areas, porches and similar spaces, exterior terraces or steps, and roof overhangs.

imported renewable energy: energy forms that are transacted with or delivered from providers of offsite renewable energy.

new building: a building or portion thereof that has been in operation for less than 24 consecutive months following the date of initial occupancy, certificate of occupancy, or occupancy class change, whichever is later.

off-site: located outside the site boundary.

off-site renewable energy: energy forms derived from renewable energy resources harvested outside of the site boundary.

on-site: located inside the site boundary.

on-site renewable energy: energy forms derived from renewable energy resources harvested inside the site boundary.

physical renewable energy power purchase agreement (PPA): a contract for the purchase of renewable electricity and associated renewable energy certificate from a specific renewable electricity generator (the seller) to a purchaser of renewable electricity.

portion of building: a space within a building that is wholly or partially enclosed by interior walls and with separately metered or sub metered energy flows.

proposed building: a building or portion of building that is in the design or construction phase.

qualified person: a trained person with expertise in building energy-use analysis which includes any of the following:

- a. A licensed professional architect or engineer, or licensed contractor in the jurisdiction where the project is located.
- b. A certified energy auditor or manager.
- c. A person qualified by the adopting authority.

renewable energy: energy forms derived from renewable energy resources.

renewable energy certificate (REC): a market-based instrument that represents and conveys the environmental, social, and other non-power attributes of one megawatt-hour of renewable electricity generation and could be sold separately from the underlying physical electricity associated with renewable energy resources.

renewable energy resources: solar radiation, wind, waves, tides, hydropower, biomass, or extracted from hot fluid or steam heated within the earth.

renewable hydrogen: hydrogen produced using renewable resources both as the source for the hydrogen and the source for the energy input into the production process.

renewable natural gas: pipeline compatible gaseous fuel derived from biomass or from renewable hydrogen.

site: a building, portion of a building, or group of buildings, and surrounding area of land inside the boundary that is contiguous or separated only by public rights-of-way, all of which are under the same ownership or control.

site energy: *commoditized* energy consumed as measured or estimated at the site boundary (E_{site}).

source energy: site energy plus the estimated energy consumed or lost in the extraction, processing, and transportation of primary energy forms such as coal, oil, natural gas, biomass, and nuclear fuel; energy consumed in conversion to electricity; and energy consumed or lost in transmission and distribution to the site.

transportation vehicle energy: energy used to recharge or refuel vehicles that are used for off-site transportation purposes.

zero net energy building: a building that complies in accordance with Section 4.

zero net energy building-portion: a portion of a building that complies with Section 4.

zero net energy portfolio: a collection of building sites owned or leased by a single entity where the sum of the energy use complies in accordance with Section 4.

zero net energy community: a community of building sites within a jurisdictional boundary where the sum of the energy use complies in accordance with Section 4. Jurisdictional boundaries are a collection of legislative, regulatory, political, or administrative boundaries sourced from federal, state, and local authorities.

zero net carbon building: a building that complies in accordance with Section 4.

zero net carbon portfolio: a collection of building sites owned or leased by a single entity where the sum of the energy use complies in accordance with Section 4.

zero net carbon community: a community of building sites within a jurisdictional boundary where the sum of the energy use complies in accordance with Section 4.

3.2 Abbreviations and Acronyms

<i>AHJ</i>	<i>authority having jurisdiction</i>
<i>CO_{2e}</i>	<i>carbon dioxide equivalent</i>
<i>GFANR</i>	<i>gross floor area for non-residential buildings</i>
<i>GHG</i>	<i>greenhouse gas emissions</i>
<i>GRAR</i>	<i>gross floor area for residential buildings</i>
<i>GWP</i>	<i>global warming potential</i>
<i>PPA</i>	<i>financial (virtual) renewable energy power purchase agreement</i>
<i>REC</i>	<i>renewable energy certificate</i>

4 ADMINISTRATION, ENFORCEMENT, AND COMPLIANCE

4.1 Administration and Enforcement

4.1.1 Administrative Requirements. Administrative requirements relating to permit requirements, enforcement by the authority having jurisdiction (AHJ), locally adopted energy standards, interpretations,

claims of exemption, and rights of appeal are to be specified by the AHJ.

4.1.2 Other Laws. The provisions of this standard shall not be deemed to nullify any provisions of local, state, or federal 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.

4.1.3 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.

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

4.1.5 Referenced Standards. The normative referenced standards herein and listed in Section 9 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 E to acknowledge sources and are not part of this standard.

4.2 Compliance

4.2.1 Site Characteristics. Areas within the boundary shall be reported on Appendix A Form 1.

4.2.2 Zero Net Energy and Zero Net Carbon Boundary. The boundary for calculations related to this standard shall be determined as surrounding a site.

4.2.3 Proposed Zero Net Energy and Zero Net Carbon Buildings

4.2.3.1 Proposed annual energy use shall be determined by modeling and reported as required in Section 5.

4.2.3.2 Proposed source energy shall be calculated and reported in accordance with Section 6 and include, if any is to be used, a plan for off-site renewable energy procurement including source, type, and quantity meeting the requirements of Section 8.

4.2.3.3 Zero net energy building and build-portion compliance requirement. For proposed sites, the energy credit, E_{net} , as determined by Section 6 Equation 1, shall be less than or equal to zero.

4.2.3.4 Proposed greenhouse gas emissions (GHG) performance, including typical annual refrigerant leakage, shall be calculated and reported in accordance with Section 7 and include, if any is to be used, a plan for off-site renewable energy procurement including source, type, and quantity meeting the requirements of Section 8.

4.2.3.5 Zero net carbon building and building-portion compliance requirement. For proposed sites, the net greenhouse gas emissions, GHG_{net} , as determined by Section 7 Equation 2, shall be less than or equal to zero.

4.2.4 New Zero Net Energy and Zero Net Carbon Buildings

4.2.4.1 Estimated annual energy use shall be determined by modeling using as-built information and reported as required by Section 5.

4.2.4.2 Modeled source energy shall be calculated and reported in accordance with Section 6 and include any actual qualified off-site renewable energy procurement determined through Section 8.

- 4.2.4.3 Zero net energy building and portion-building compliance requirement. For new sites, the energy credit, E_{net} , as determined by Section 6 Equation 1, shall be less than or equal to zero.
- 4.2.4.4 As-built modeled greenhouse gas emissions performance, including typical annual refrigerant leakage, shall be calculated and reported in accordance with Section 7 and any qualified off-site renewable energy procurement determined through Section 8.
- 4.2.4.5 Zero net carbon building and building-portion compliance requirement. For new sites, the net greenhouse gas emissions, GHG_{net} , as determined by Section 7 Equation 2, shall be less than or equal to zero.

4.2.5 Existing Zero Net Energy and Zero Net Carbon Buildings

- 4.2.5.1 Annual energy use shall be determined and reported as required in Section 5.
- 4.2.5.2 Source energy shall be calculated and reported in accordance with Section 6 and include qualified off-site renewable energy procurement determined through Section 8.
- 4.2.5.3 Zero net energy building or portion of building compliance requirement for existing sites shall be calculated as follows: the sum of energy credit, E_{net} , as determined by Section 6 Equation 1, for the two most recent years of determination shall be less than or equal to zero.

Exception : The first zero net energy building or portion of building compliance for an existing site, at or before 24 months since the granting of the certificate of occupancy, shall be based on the collected energy data for any 12 consecutive month period during the new site's operation. The E_{net} shall be less than or equal to zero.

- 4.2.5.4 GHG performance, including either typical or actual refrigerant leakage, shall be calculated and reported in accordance with Section 7 and any qualified off-site renewable energy procurement determined through Section 8.
- 4.2.5.5 Zero net carbon building and building portion compliance requirement for existing sites shall be calculated as follows: the sum of the net greenhouse gas emissions of the site, GHG_{net} , as determined by Section 7 Equation 2, for the two most recent years of determination shall be less than or equal to zero.

Exception: The first zero net carbon building or portion of building compliance for an existing site, at or before 24 months since the granting of the certificate of occupancy, shall be based on the collected data for any 12 consecutive month period during the new site's operation. The GHG_{net} shall be less than or equal to zero.

4.2.6 Zero Net Energy and Zero Net Carbon Portfolio and Community Compliance.

- 4.2.6.1 The zero net energy credit, E_{net} , of individual sites making up a zero net energy portfolio shall be totaled and the sum shall be less than or equal to zero.
- 4.2.6.2 The net greenhouse gas emission, GHG_{net} , of individual sites making up a zero net carbon portfolio or community shall be totaled and the sum shall be less than or equal to zero.

4.3 Verification of Compliance, Submittals.

4.3.1 Proposed and new sites. A qualified person shall determine if a site meets the modeling and calculation requirements of Sections 4.2.3 for a proposed site and 4.2.4 for a new site and shall submit verification of this modeled compliance to the AHJ using the forms of Appendix A to this standard at the start of construction and at the time the certificate of occupancy is granted. Documentation of specific off-site renewable energy ownership or procurement for new and existing sites shall be submitted to the AHJ.

Exception: For proposed sites, a plan for off-site renewable energy procurement including source, type, and quantity shall be provided with proposed site documentation demonstrating the availability of off-site energy complying with the requirements of Section 8.

4.3.2 Existing sites. A qualified person shall determine from collected data if a site meets the requirements of Section 4.2.5 and shall submit verification of compliance to the AHJ using the forms of Appendix A to this standard starting no later than 24 months after the certificate of occupancy is granted and every two years after that. Documentation of specific off-site energy ownership or procurement for existing sites shall be submitted to the AHJ.

5 ENERGY FLOWS ACROSS THE SITE BOUNDARY

5.1 Scope. This section specifies the variables included in calculating the energy flows crossing the site boundary.

5.2 Measurement. Building, site, and boundary characteristics shall be reported on Appendix A Form 1. Energy across the site boundary shall be reported on Appendix A Form 2.

5.2.1 Proposed Site, New Site, and Generation Within the Boundary. Loads and generation within the proposed project and site boundary shall be determined through modeling in accordance with Sections 5.2.2.1 and 5.2.2.2 and reported on an annual basis.

5.2.1.1 Proposed and New Building Modeling. Modeling for commercial, industrial, and high rise residential proposed buildings and new buildings shall conform with ANSI/ASHRAE/IES Standard 90.1 Section 11.4 and Normative Appendix G for the “Proposed Design.” Modeling for low-rise residential buildings shall conform to ANSI/ASHRAE/IES Standard 90.2 Normative Appendices A and B for the “Proposed Home.”

5.2.1.2 Renewable Generation Modeling. Renewable generation shall be modeled using software approved by the AHJ.

5.2.2 Existing Building Operations. Energy and generation crossing the project and site boundary shall be calculated in accordance with Section 5.3 and ANSI/ASHRAE Standard 105 Sections 5.2, 5.3, and 5.4 and reported on an annual basis.

5.3 Energy Crossing the Site Boundary

5.3.1 Energy to be measured crossing the site boundary and other related energy shall include the following categories. See Figure 1.

Imported Energy

$E_{i,spec}$ = specific off-site energy imported into the site boundary

$E_{i,ren}$ = off-site/grid non-renewable energy imported into the site boundary

$E_{i,v}$ = transportation vehicle energy imported into the site boundary

$E_{i,L}$ = landscape equipment energy imported into the site boundary and used within the boundary

Exported Energy

Ex_{ren} = on-site generated renewable energy exported out of the site boundary

Ex_{nren} = on-site generated non-renewable energy exported out of the site boundary

Ex_v = transportation vehicle energy exported out of the site boundary

Other Measured Energy

EO_{nren} = on-site non-renewable energy used on-site (may include but are not limited to sources such as on-site natural gas, on-site biobased fuels consumed non-sustainable or on-site waste to energy generation within the site boundary)

EO_{ren} = off-site renewable energy

Informative note: Ei_{spec} is intended to be used where grid average source and other factors may not be representative of an energy source, such as electricity purchased from a specific generator. See Sections 6.2.1 and 7.2.1 for further information.

5.3.1.1 Qualified off-site renewable energy shall meet the requirements of Section 8.

5.3.1.2 Transportation Energy. Energy loads from transportation shall be included as being within the site boundary if they are integral to the operation within the boundary and as part of operations within the boundary if they do not leave the boundary. This includes, but is not limited to elevators, people movers, forklifts, landscaping care equipment, and conveyors. Energy to charge, discharge, or refuel vehicles that leave the boundary shall be measured at the point of charging/discharging/refueling and netted from the boundary equation.

5.3.1.3 Landscaping care equipment crossing the boundary. Landscape area shall be calculated as the total site area minus the non-green roof building footprint minus the portion of the site that requires no landscaping maintenance. The annual energy consumption of the landscaping care equipment shall be calculated as either the actual fuel/energy consumption of the landscaping care equipment or a default value of 0.0018 kWh (6 Btu) per landscaped square foot per year.

5.3.2 Hourly Site Energy Conversion Factors. Where site energy is required for hourly source energy calculations, the site energy during that hour shall be recorded for hourly source energy calculations in Section 6.2.2. The annual summary by energy form shall be reported on Appendix A Form 2.

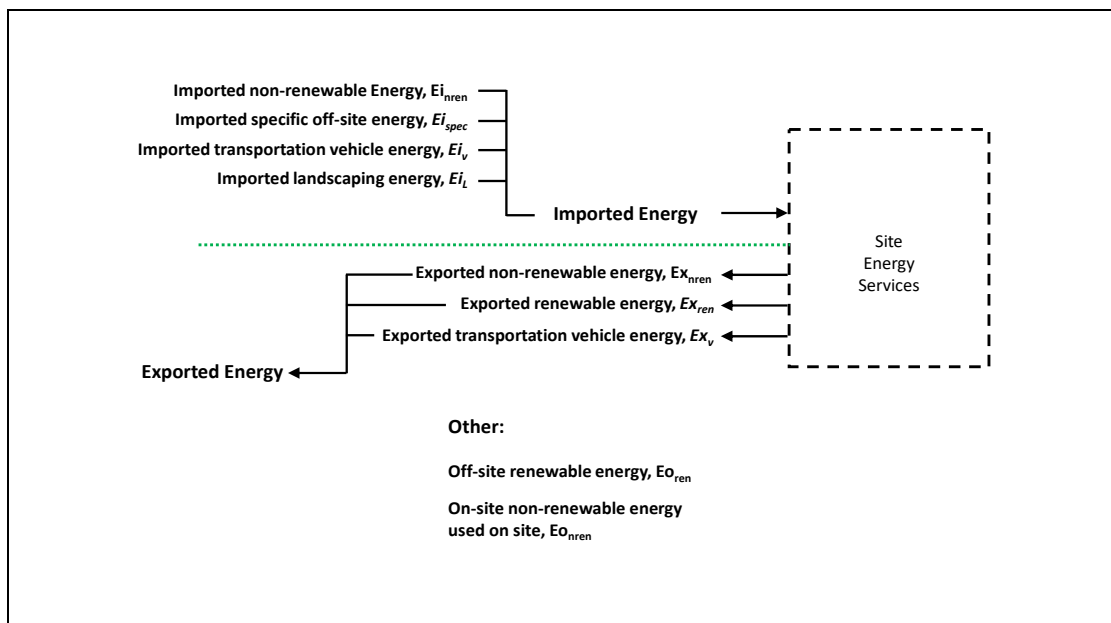


Figure 1 Energy Flows Across Site Boundary.

6 SOURCE ENERGY PERFORMANCE

6.1 Calculation. The annual source energy of a site and additional qualified renewable energy shall be reported using Appendix A Form 3 in accordance with Sections 6.2, 6.3, and Section 8 based on energy flows identified in Sections 5 and 8.

6.2 Source Energy Conversion Factors. Source energy use shall be calculated in accordance with Section 6.2.1 or Section 6.2.2.

6.2.1 Annual Source Energy Conversion Factors. Source energy crossing the site boundary shall be calculated by multiplying the site energy by energy form reported using Appendix A Form 2 by the source energy conversion factors in Table 1. Where a building imports energy from a specific off-site energy provider, the adopting authority shall be permitted to use a source energy conversion factor in Table 4 that is applicable to that energy form.

TABLE 1 Annual Source Energy Conversion Factors for United States and Canada

Form 2 Row	Energy Form (Footnote 3)	Source Energy Conversion Factor (Footnote 1)
1.a	Imported Grid Electricity	Table 2 or Table 3
1.b	Imported Specific Electricity	Footnotes 2 and 3
2.a	Imported Grid Natural Gas	1.09
2.b	Imported Renewable Natural Gas	Footnote 2
3.	Imported Steam	1.83 or note 2
4.	Imported Hot Water	1.73 or note 2
5.	Imported Chilled Water	0.62 or note 2
6.a	Imported Fuel Oil	1.19
6.b	Imported Renewable Fuel Oil	Footnote 2
7	Imported Propane	1.15
8.	Imported Coal or Other	1.05 or Footnote 2
9.	Imported Biomass	Footnote 2
10.	On-Site Non-Renewable Energy	Footnote 2
11.a	Imported Transportation Vehicle Energy	Footnote 2
11.b	Imported Landscaping Energy	Footnote 2
12.	Exported Non-Renewable Electricity	1.00
13.	Exported Renewable Electricity	Table 2 or Table 3
14.	Exported Steam	1.83 or Footnote 2
15.	Exported Hot Water	1.73 or Footnote 2
16.	Exported Chilled Water	0.62 or Footnote 2
17.	Exported other	1.05 or Footnote 2
18.	Exported Transportation Vehicle Energy	Footnote 2

Footnote 1: For locations outside the United States or Canada, the adopting authority shall fill in Table 1 with source energy conversion factors.

Footnote 2: A qualified person shall provide the source energy conversion factor.

Footnote 3: Grid energy forms are from the electric grid or fuel utility or distribution system. Specific renewable energy forms are from a specific provider meeting the requirements of the adopting authority.

TABLE 2 Regional Electricity Source Energy Conversion Factors for the United States

eGRID 2018 Sub-region Acronym	eGRID 2018 Sub-region Name	Source Energy Conversion Factor
AKGD	ASCC Alaska Grid	2.66
AKMS	ASCC Miscellaneous	1.91
ERCT	ERCOT All	2.51
FRCC	FRCC All	2.77
HIMS	HICC Miscellaneous	2.90
HIOA	HICC Oahu	3.51
MROE	MRO East	3.07
MROW	MRO West	2.69
NYLI	NPCC Long Island	3.36
NEWE	NPCC New England	2.77
NYCW	NPCC NYC/Westchester	2.94
NYUP	NPCC Upstate NY	2.23
RFCE	RFC East	2.95
RFCM	RFC Michigan	2.97
RFCW	RFC West	3.08
SRMW	SERC Midwest	3.14
SRMV	SERC Mississippi Valley	2.78
SRSO	SERC South	2.86
SRTV	SERC Tennessee Valley	2.94
SRVC	SERC Virginia/Carolina	2.99
SPNO	SPP North	2.67
SPSO	SPP South	2.61
CAMX	WECC California	2.07
NWPP	WECC Northwest	1.93
RMPA	WECC Rockies	2.59
AZNM	WECC Southwest	2.87

TABLE 3 Regional Electricity Source Energy Conversion Factors for Canada

Abbreviation	Province or Territory	Source Energy Conversion Factor
YT	Yukon	1.21
NT	Northwest Territories	1.95
NU	Nunavut	3.66
BC	British Columbia	1.11
AB	Alberta	2.88
SK	Saskatchewan	2.67
MB	Manitoba	1.05
ON	Ontario	2.63
QC	Quebec	1.07
NB	New Brunswick	2.71
NL	Newfoundland and Labrador	1.15
NS	Nova Scotia	2.84
PE	Prince Edward Island	2.71

6.2.2 Hourly Source Energy Conversion Factors for Electricity. Where the adopting authority determines that hourly power generation mixes can be applied to imported and exported electricity, a qualified person shall calculate the total annual source energy from a source using the source energy conversion factors in Table 4 for the hourly imported and exported electricity based on the electric generation mix during that hour. The hourly source energy shall be totaled to determine the annual source energy and shall be reported on Appendix A Form 3.

TABLE 4 Hourly Electric Generation Mix and Source Energy Conversion Factors

Generation Type	Hourly Generation Mix (fraction of whole)	Source Energy Conversion Factor
Coal	Footnote 1	3.51
Oil	Footnote 1	3.82
Natural Gas	Footnote 1	2.91
Nuclear	Footnote 1	3.38
Hydro	Footnote 1	1.05
Biomass	Footnote 1	1.89
Wind	Footnote 1	1.05
Solar	Footnote 1	1.05
Geothermal	Footnote 1	1.05
Other	Footnote 1	5.15
Total	1.00	

Footnote 1: The qualified person shall provide hourly generation mix and total source energy conversion factor.

6.3 Annual Site Calculation. Net source energy shall be calculated using source energy calculated from imported energy minus the total of exported energy and any qualified off-site renewable energy procurement in accordance with and discounted as determined in Section 8. The total shall be the net for annual source energy in accordance with Equation 1.

$$\Sigma (E_{imp} \cdot SF_{imp}) - [\Sigma (E_{exp} \cdot SF_{exp}) + \Sigma (E_{rec} \cdot SF_{rec} \cdot DF_{rec})] = E_{net} \quad (1)$$

Where

E_{imp} = imported energy by energy form crossing the site boundary

SF_{imp} = source energy factor by energy form for imported energy crossing the site boundary

E_{exp} = exported energy by energy form crossing the site boundary

SF_{exp} = source energy factor by energy form for exported energy crossing the site boundary

E_{rec} = qualified off-site renewable energy

SF_{rec} = source energy factor for qualified off-site renewable energy

DF_{rec} = discount factor for off-site renewable energy in accordance with Section 8

E_{net} = net source energy of the site

Informative note: See Section 8.2 for the maximum limit allowed on the off-site source energy term.

7. GREENHOUSE GAS EMISSIONS PERFORMANCE

7.1 Calculation. The annual GHG of a site shall be reported using Appendix A Form 4 in accordance with Sections 7.2, 7.3, 7.4, and Section 8 based on annual carbon related flows calculated in accordance with Sections 5, 7.3, and 8.

7.2 Greenhouse Gas Emission Factors. GHG shall be calculated by a qualified person in accordance with Section 7.3 and either Section 7.2.1 or Section 7.2.2.

7.2.1 Annual Greenhouse Gas Emission Factors. GHG associated with energy crossing the site boundary shall be calculated by multiplying the site energy by energy form reported using Appendix A Form 2 by the GHG factors in Table 5. Where a building imports energy from a specific off-site energy provider, the adopting authority shall be permitted to use a GHG factor in Table 8 that is applicable to that energy form.

TABLE 5 Annual Greenhouse Gas Emission Factors for the United States and Canada

Form 2 Row	Energy Form (Footnote 3)	Greenhouse Gas Emission Factor (kg/kWh) (Footnote 1)
1.a	Imported Grid Electricity	Table 6 or Table 7
1.b	Imported Specific Electricity	Footnotes 2 and 3
2.a	Imported Grid Natural Gas	0.228
2.b	Imported Renewable Natural Gas	Footnote 2
3.	Imported Steam	0.383 or footnote 2
4.	Imported Hot Water	0.362 or footnote 2
5.	Imported Chilled Water	0.128 or footnote 2
6.a	Imported Fuel Oil	0.303
6.b	Imported Renewable Fuel Oil	Footnote 2
7.	Imported Propane	0.261
8.	Imported Coal or Other	0.342 or footnote 2
9.	Imported Biomass	Footnote 2
10.	On-Site Non-Renewable Energy	Footnote 2
11.a	Imported Transportation Vehicle Energy	Footnote 2
11.b	Imported Landscaping Energy	Footnote 2
12.	Exported Non-Renewable Electricity	Footnote 2
13.	Exported Renewable Electricity	Table 6 or Table 7
14.	Exported Steam	0.383 or footnote 2
15.	Exported Hot Water	0.362 or footnote 2
16.	Exported Chilled Water	0.128 or footnote 2
17.	Exported other	0.342 or footnote 2
18.	Exported Transportation Vehicle Energy	Footnote 2

Footnote 1: For locations outside the United States or Canada, the adopting authority shall fill in Table 5 with greenhouse gas emission factors.

Footnote 2: A qualified person shall provide the greenhouse gas emission factor.

Footnote 3: Grid energy forms are from the electric grid or fuel utility or distribution system. Specific renewable energy forms are from a specific provider meeting the requirements of the adopting authority.

TABLE 6 Regional Electricity Greenhouse Gas Emission Factors for United States

eGRID 2018 Sub-region Acronym	eGRID 2018 Sub-region Name	Greenhouse Gas Emission Factor (kg/kWh)
AKGD	ASCC Alaska Grid	0.576
AKMS	ASCC Miscellaneous	0.297
ERCT	ERCOT All	0.507
FRCC	FRCC All	0.499
HIMS	HICC Miscellaneous	0.670
HIOA	HICC Oahu	0.916
MROE	MRO East	0.872
MROW	MRO West	0.644
NYLI	NPCC Long Island	0.674
NEWE	NPCC New England	0.312
NYCW	NPCC NYC/Westchester	0.356
NYUP	NPCC Upstate NY	0.157
RFCE	RFC East	0.400
RFCM	RFC Michigan	0.682
RFCW	RFC West	0.611
SRMW	SERC Midwest	0.826
SRMV	SERC Mississippi Valley	0.483
SRSO	SERC South	0.555
SRTV	SERC Tennessee Valley	0.543
SRVC	SERC Virginia/Carolina	0.407
SPNO	SPP North	0.601
SPSO	SPP South	0.618
CAMX	WECC California	0.276
NWPP	WECC Northwest	0.333
RMPA	WECC Rockies	0.657
AZNM	WECC Southwest	0.549

TABLE 7 Regional Electricity Greenhouse Gas Emission Factors for Canada

Abbreviation	Province or Territory	Greenhouse Gas Emission Factor (kg/kWh)
YT	Yukon	0.049
NT	Northwest Territories	0.250
NU	Nunavut	0.715
BC	British Columbia	0.003
AB	Alberta	0.547
SK	Saskatchewan	0.638
MB	Manitoba	0.003
ON	Ontario	0.013
QC	Quebec	0.001
NB	New Brunswick	0.295
NL	Newfoundland and Labrador	0.035
NS	Nova Scotia	0.677
PE	Prince Edward Island	0.295

Informative Note: If using I-P calculations, multiply the kg/kWh emissions factors by 0.64611 to convert to lb/kBtu

7.2.2 Hourly Greenhouse Gas Emission Factors for Electricity. Where the adopting authority determines that hourly power generation mixes can be applied to imported and exported electricity, a qualified person shall calculate the total annual GHG using the GHG factors in Table 8 for the hourly imported and exported electricity based on the electric generation mix during that hour. The hourly GHG shall be totaled to determine the annual GHG and shall be reported on Appendix A Form 4.

TABLE 8 Hourly Generation Mix and Greenhouse Gas Emission Factors

Generation Type	Generation Mix (%)	Greenhouse Gas Emission Factor (kg/kWh)
Coal	Footnote 1	1.114
Oil	Footnote 1	0.999
Natural Gas	Footnote 1	0.525
Nuclear	Footnote 1	0.042
Hydro	Footnote 1	0
Biomass	Footnote 1	0.024
Wind	Footnote 1	0
Solar	Footnote 1	0
Geothermal	Footnote 1	0
Other	Footnote 1	0.964
Total	100	Footnote 1

Footnote 1: The qualified person shall provide hourly generation mix and total greenhouse gas emission factor.

Informative Note: If using I-P calculations, multiply the kg/kWh emissions factors by 0.64611 to convert to lb/kBtu

7.3 Refrigerant Leakage. Projects shall account for refrigerant leakage and associated GHG. The unit leakage shall be calculated by taking the manufacturer’s specified charge and multiplying it by the Typical Annual Leakage Rate for that unit type as shown in Table 9 and by the Greenhouse Gas Emission Factor as shown in Table 10. Annual refrigerant leakage shall be calculated on Form 4A of Appendix A and reported on Form 4.

Exception: Existing sites may calculate mass leakage based on actual leakage derived from service records and reporting.

TABLE 9 Typical Annual Refrigerant Leakage Rates by Equipment Type

Equipment Type		Typical Annual Leakage Rate of Refrigerant Mass Charge Per Year
1.	Supermarket refrigeration	30%
3.	Commercial condensing units	15%
4.	Water chillers	5%
5.	Hermetic units with no field installed refrigerant piping	1%
6.	Rooftop unit air conditioner	6%
7.	Residential heat pump and air conditioner	2%
8.	Variable refrigerant flow air conditioner	10%
9.	Other refrigeration	2%
10.	Other air conditioning	2%

TABLE 10 Refrigerant Greenhouse Gas Emission Factors

Refrigerant Type	Greenhouse Gas Emission Factor (kgCO ₂ e/kg)
HCFC-22	1760
HFC-134a	1300
R-404A	4970
R-407C	1620
R-408A	3260
R-410A	1920
R-438A	2060
R-504	4300
R-717 (Ammonia)	0
R-744 (CO ₂)	1
Other	Footnote 1

Footnote 1: To be approved by the authority having jurisdiction.

Informative note: Information on the 100-year values for other refrigerants is available from the “2017 ASHRAE Handbook – Fundamentals” Chapter 29 Table 3B and Table 4 (AR5).

7.4 Annual Site Calculation. Net GHG shall be calculated using greenhouse gas emissions calculated from imported energy plus refrigerant leakage minus exported energy and any qualified off-site renewable energy procurement, in accordance with and discounted as determined in Section 8. The total shall be the net for annual net GHG in accordance with Equation 2.

$$[\Sigma (E_{imp} \cdot GEF_{imp}) + \Sigma (REF_{leak} \cdot GEF_{ref})] - [\Sigma (E_{exp} \cdot GEF_{exp}) + (E_{rec} \cdot GEF_{rec} \cdot DF_{rec})] = GHG_{net} \quad (2)$$

Where

GHG_{net} = net greenhouse gas emissions of the site

E_{imp} = imported energy by energy form crossing the site boundary

GEF_{imp} = greenhouse gas emission factor by energy form for imported energy crossing the site boundary

REF_{leak} = refrigerant mass leakage across the site boundary for each type of refrigerant

GEF_{exp} = greenhouse gas emission factor for each type of refrigerant

E_{exp} = exported energy by energy form crossing the site boundary

GEF_{exp} = greenhouse gas emission factor by energy form for exported energy crossing the site boundary

E_{rec} = qualified off-site renewable energy.

GEF_{rec} = greenhouse gas emission factor by energy form for qualified off-site renewable energy

DF_{rec} – discount factor for off-site renewable energy in accordance with Section 8

8 QUALIFICATIONS FOR OFF-SITE RENEWABLE ENERGY PROCUREMENT

8.1 Calculation. The qualified off-site renewable energy procurement shall be calculated and reported using Appendix A Form 5 in accordance with Sections 8.2 through 8.4.

8.1.1 The discounted qualified renewable energy procured shall be valued at a source factor similar to that used to determine the equivalent exported renewable energy form shown in Table 1 or as used to calculate the annual sum of the hourly calculation using Section 6.2.2.

8.1.2 The discounted qualified renewable energy procured shall be valued at a greenhouse gas emission factor similar to that used to determine the equivalent to the equivalent exported renewable energy form shown in Table 5 or as determined in the annual sum of the hourly calculation using Section 7.2.2.

8.2 Offsite Renewable Energy Procurement Limit. Annual off-site renewable source energy procurement, including the discount factor given in Table 15, shall be less than or equal to:

1. for nonresidential buildings and spaces: the product of the gross floor area of the non-residential building and the applicable source energy limit in Table 11 (IP) or 13 (SI).
2. for residential buildings and spaces: the product of the gross floor area of the residential building and the applicable source energy limit in Table 12 (IP) or 14 (SI).

Table 11 (IP) Procured Offsite Source Energy Intensity Limit (kWh/ft²-yr) – Nonresidential

	Climate Zone	1A	2A	2B	3A	3B-C	3B-O	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
1	Administrative/professional office	31	32	29	33	24	29	24	28	24	30	24	24	24	27	25	29	41
2	Bank/other financial	44	46	41	47	34	41	34	40	34	43	35	34	34	38	36	41	58
3	Government office	39	40	36	41	30	36	30	36	30	38	30	30	30	34	31	36	51
4	Medical office (non-diagnostic)	27	27	25	28	21	24	20	24	20	26	21	20	20	23	21	25	35
5	Mixed-use office	36	37	34	38	28	33	28	33	27	35	28	28	28	31	29	34	47
6	Other office	30	31	28	32	23	28	23	27	23	29	24	23	23	26	24	28	40
7	Laboratory	143	141	127	140	109	122	115	121	104	134	106	107	111	117	112	126	167
8	Distribution/shipping center	10	13	12	16	8	13	10	17	14	16	18	17	15	25	21	30	57
9	Non-refrigerated warehouse	5	6	6	8	4	6	5	8	7	8	9	8	7	12	10	15	28
10	Convenience store	108	117	100	121	94	103	102	103	90	118	90	92	102	98	95	105	133
11	Convenience store with gas station	87	94	81	98	76	83	82	83	73	95	73	74	83	79	77	85	107
12	Grocery store/food market	90	98	84	101	78	86	85	86	75	98	75	77	85	81	79	88	111
13	Other food sales	27	30	25	31	24	26	26	26	23	30	23	23	26	25	24	27	33
14	Fire station/police station	53	52	47	51	40	45	42	45	38	49	39	39	41	43	41	46	62
15	Other public order and safety	48	47	42	47	37	41	38	41	35	45	36	36	37	39	38	42	56
16	Medical office (diagnostic)	27	26	24	26	22	24	19	20	18	21	15	17	17	16	16	15	18
17	Clinic/other outpatient health	40	39	36	38	33	36	29	30	27	32	23	25	26	24	24	23	26
18	Refrigerated warehouse	55	55	49	54	42	47	44	47	40	52	41	41	43	45	43	49	65
19	Religious worship	19	19	17	18	14	16	15	16	14	18	14	14	15	15	15	17	22
20	Entertainment/culture	19	18	16	18	14	16	15	16	14	17	14	14	15	15	15	16	22
21	Library	49	49	44	48	37	42	39	42	36	46	36	37	38	40	39	43	57
22	Recreation	21	21	19	21	16	18	17	18	15	20	16	16	17	17	17	19	25
23	Social/meeting	22	22	20	22	17	19	18	19	16	21	16	17	17	18	17	19	26
24	Other public assembly	23	22	20	22	17	19	18	19	17	21	17	17	18	19	18	20	26
25	College/university	50	49	45	50	33	43	37	46	37	49	41	38	41	48	43	52	78
26	Elementary/middle school	30	30	27	30	23	26	23	25	22	27	21	21	21	23	22	25	36
27	High school	36	36	33	36	24	32	27	33	26	35	29	27	29	33	30	36	54
28	Preschool/daycare	39	38	34	38	29	33	30	33	28	35	28	27	28	30	28	32	47

29	Other classroom education	20	20	18	20	14	18	15	18	15	20	16	15	17	19	17	20	30
30	Fast food	210	215	195	221	176	197	182	191	168	212	168	172	181	183	177	198	251
31	Restaurant/cafeteria	113	117	104	120	93	106	99	103	91	117	91	93	102	99	96	107	135
32	Other food service	62	64	57	66	51	58	54	57	50	64	50	51	56	54	52	59	74
33	Hospital/inpatient health	114	115	104	113	99	103	94	90	77	101	70	72	83	72	69	72	84
34	Nursing home/assisted living	68	67	60	66	51	58	54	57	49	63	50	50	52	55	53	59	79
35	Dormitory/fraternity/sorority	32	34	31	38	23	32	29	36	29	40	33	31	32	38	35	43	60
36	Hotel	40	41	36	41	35	36	35	34	31	39	29	31	32	31	31	33	38
37	Motel or inn	45	42	39	41	35	37	34	32	30	36	27	29	30	28	28	29	35
38	Other lodging	43	40	37	39	34	36	32	31	29	34	26	27	29	27	27	28	33
39	Vehicle dealership/showroom	39	40	36	42	28	35	30	37	31	39	34	33	36	39	37	44	63
40	Retail store	23	23	21	24	16	20	17	21	18	22	20	19	20	23	21	25	36
41	Other retail	39	40	36	42	28	35	30	37	31	39	34	33	35	39	37	44	63
42	Post office/postal center	34	34	30	33	26	29	27	29	25	32	25	26	26	28	27	30	40
43	Repair shop	23	23	20	22	17	20	18	19	17	21	17	17	18	19	18	20	27
44	Vehicle service/repair shop	26	26	23	26	20	23	21	22	19	25	20	20	20	22	21	23	31
45	Vehicle storage/maintenance	11	11	10	11	9	10	9	10	8	11	8	9	9	9	9	10	13
46	Other service	48	48	43	47	37	41	39	41	35	45	36	36	37	40	38	43	56
47	Strip shopping mall	47	47	43	50	34	42	37	45	37	47	41	40	44	48	45	53	76
48	Enclosed mall	45	45	41	47	32	40	35	43	35	45	39	38	42	45	42	51	73

Informative Note: Climate zone locations referenced by county are available at ANSI/ASHRAE 90.1.

Table 12 (IP) Procured Offsite Source Energy Intensity Limit (kWh/ft²-yr) – Residential

	Climate Zone	1A	2A	2B	3A	3B-C	3B-O	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
49	Mobile/manufactured home	30	32	29	36	22	30	27	34	27	38	31	30	30	36	33	40	56
50	Single-family detached	23	24	22	26	16	22	20	25	20	28	23	22	22	26	25	30	42
51	Single-family attached	26	27	25	30	19	26	23	29	23	32	27	25	26	30	28	35	48
52	Apartment (in 2-4 unit building)	38	40	37	45	28	38	34	43	34	48	39	37	37	45	42	51	71
53	Apartment (in 5+ unit building)	26	27	25	30	19	26	23	29	23	32	27	25	26	30	28	35	48

Informative Note: Climate zone locations referenced by county are available in ANSI/ASHRAE 90.1.

Table 13 (S-I) Procured Offsite Source Energy Intensity Limit (kWh/m²-yr) – Nonresidential

	Climate Zone	1A	2A	2B	3A	3B-C	3B-O	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
1	Administrative/professional office	337	347	313	357	262	310	259	306	256	325	263	257	257	291	270	314	440
2	Bank/other financial	478	493	445	507	371	440	367	435	363	462	373	364	370	413	383	446	625
3	Government office	420	433	391	446	326	386	323	382	319	406	328	320	323	363	337	392	550
4	Medical office (non-diagnostic)	287	296	267	304	223	264	220	261	218	277	224	218	218	248	230	268	375
5	Mixed-use office	390	402	363	413	303	358	299	354	296	376	304	297	297	337	312	363	509
6	Other office	325	335	303	345	253	299	250	296	247	314	254	248	251	281	261	303	425
7	Laboratory	1540	1522	1363	1504	1173	1317	1234	1301	1122	1440	1139	1148	1194	1259	1208	1353	1798
8	Distribution/shipping center	106	135	131	171	85	142	112	181	146	176	194	184	158	267	230	326	612
9	Non-refrigerated warehouse	51	65	64	83	41	69	54	88	71	85	94	89	79	129	112	158	296
10	Convenience store	1163	1261	1082	1307	1013	1108	1098	1114	969	1265	973	993	1102	1051	1023	1132	1429
11	Convenience store with gas station	937	1016	871	1053	816	893	885	897	781	1019	784	800	891	847	824	912	1151
12	Grocery store/food market	969	1051	901	1089	844	924	915	928	808	1054	810	827	917	876	852	943	1190
13	Other food sales	293	318	273	330	256	280	277	281	245	319	245	250	277	265	258	286	360
14	Fire station/police station	567	561	502	554	432	485	455	479	413	530	419	423	442	464	445	498	662
15	Other public order and safety	517	511	457	505	394	442	414	437	376	483	382	385	403	423	405	454	603
16	Medical office (diagnostic)	289	279	259	275	240	257	208	213	197	227	166	182	185	169	172	166	190
17	Clinic/other outpatient health	433	418	389	413	360	385	312	319	296	340	249	274	277	254	259	250	285
18	Refrigerated warehouse	597	590	528	583	454	510	478	504	435	558	441	445	462	488	468	524	696
19	Religious worship	202	200	179	198	154	173	162	171	147	189	150	151	158	165	159	178	236
20	Entertainment/culture	201	198	178	196	153	172	161	170	146	188	148	150	158	164	157	176	234
21	Library	530	523	469	517	403	453	424	448	386	495	392	395	409	433	415	465	618
22	Recreation	228	226	202	223	174	195	183	193	166	213	169	170	178	187	179	201	267
23	Social/meeting	238	235	211	233	181	204	191	201	173	223	176	178	185	195	187	209	278
24	Other public assembly	244	241	216	238	186	209	196	206	178	228	180	182	191	199	191	214	285
25	College/university	533	530	457	535	340	442	365	402	312	499	278	304	350	320	310	350	519
26	Elementary/middle school	326	321	287	321	243	278	248	274	231	291	230	226	231	251	234	266	391
27	High school	389	387	350	392	261	339	286	353	284	380	311	292	310	359	324	393	582
28	Preschool/daycare	421	414	370	414	313	358	320	353	298	375	296	291	304	324	302	343	504

29	Other classroom education	218	216	196	219	146	190	160	197	159	213	174	163	178	201	181	220	326
30	Fast food	2260	2316	2097	2382	1893	2122	1961	2053	1813	2286	1807	1849	1947	1975	1906	2135	2700
31	Restaurant/cafeteria	1221	1256	1124	1293	1005	1139	1064	1114	980	1255	978	998	1095	1062	1033	1157	1456
32	Other food service	668	686	614	707	549	623	582	609	536	686	534	546	601	580	565	632	796
33	Hospital/inpatient health	1224	1235	1118	1212	1067	1104	1012	964	834	1088	757	776	891	773	746	780	900
34	Nursing home/assisted living	727	718	643	710	553	621	582	614	529	679	537	542	561	594	570	639	848
35	Dormitory/fraternity/sorority	348	368	338	407	251	347	312	388	313	435	357	339	343	408	379	463	647
36	Hotel	428	438	386	443	373	389	374	367	336	421	313	336	350	332	336	352	407
37	Motel or inn	479	455	418	438	381	403	361	347	322	385	288	309	323	303	299	311	373
38	Other lodging	458	435	400	418	364	385	345	332	308	368	275	296	310	290	286	297	356
39	Vehicle dealership/showroom	424	433	390	452	300	381	328	401	335	418	368	358	383	424	395	471	676
40	Retail store	242	248	223	259	172	218	188	229	192	239	211	205	218	242	226	270	387
41	Other retail	422	432	389	450	299	380	326	399	334	417	367	357	376	422	394	469	673
42	Post office/postal center	369	365	326	360	281	315	296	312	269	345	273	275	284	302	289	324	431
43	Repair shop	246	243	217	240	187	210	197	208	179	230	182	183	191	201	193	216	287
44	Vehicle service/repair shop	285	282	252	278	217	244	228	241	208	266	211	213	218	233	224	250	333
45	Vehicle storage/maintenance	124	122	109	121	94	106	99	105	90	116	91	92	99	101	97	109	144
46	Other service	521	515	461	509	397	445	418	440	379	487	385	388	403	426	409	458	608
47	Strip shopping mall	509	508	460	534	365	455	396	481	400	511	446	431	469	513	479	574	821
48	Enclosed mall	485	484	438	508	348	433	377	458	381	487	425	410	449	488	456	547	782

Informative Note: Climate zone locations referenced by county are available at ANSI/ASHRAE 90.1.

Table 14 (S-I) Procured Offsite Source Energy Intensity Limit (kWh/m²-yr) – Residential

	Climate Zone	1A	2A	2B	3A	3B-C	3B-O	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
49	Mobile/manufactured home	327	346	318	383	236	326	293	365	294	409	335	318	323	383	356	435	608
50	Single-family detached	243	257	236	284	175	242	218	271	218	304	249	236	238	285	265	323	451
51	Single-family attached	279	295	271	327	202	279	250	312	251	350	287	272	277	328	305	372	520
52	Apartment (in 2-4 unit building)	410	434	398	480	297	409	368	458	369	513	421	400	403	481	447	546	763
53	Apartment (in 5+ unit building)	279	295	271	327	202	278	250	312	251	349	286	272	277	327	304	372	519

Informative Note: Climate zone locations referenced by county are available in ANSI/ASHRAE 90.1.

8.3 Qualified Off-Site Renewable Energy Procurement. Projects shall be credited for off-site renewable energy resources provided the renewable energy credits are retired. Procured renewable energy, but not renewable energy credits (RECs), in excess of the site’s annual consumption shall be distributed by the owner in a manner that does not increase greenhouse gas emissions. RECs shall be conveyed to and retired on behalf of the entity who has financial or operational control over the site’s energy consumption. Documentation shall be provided to the AHJ that indicates an exclusive chain of custody and ownership of the RECs.

8.4 Off-Site Renewable Energy Restrictions. Off-site renewable energy procurement shall be from facilities located on property owned by the site’s owner, be from a community renewable energy facility, or be directly contracted from a third party for a minimum of 15 years. The generation source shall be located where the energy is capable of being delivered to the site by any of the following:

- a) By direct connection to the off-site renewable energy facility.
- b) By the local utility or distribution entity.
- c) By an interconnected electrical network where energy delivery capacity between the generator and the building site is available.

Informative note: Examples of interconnected electrical networks include regional power pools and regions served by Independent System Operators or Regional Transmission Organizations.

8.5 Renewable Energy Discounting. Off-site renewable energy resources that begin operation prior to January 1, 2022, shall be discounted by the factors in Table 15. For off-site renewable energy generation that begin operation on or after January 1, 2022, a factor of 0.95 shall be used.

TABLE 15 Renewable Energy Discount Factor

Location of Of-Site Renewable Energy Source	Discount Factor
Community Renewable Energy Facility	0.85
Directly Owned Off-Site Renewable Energy System	0.80
Physical Renewable Energy PPA	0.75
Financial (Virtual) Renewable Energy PPA	0.75
Renewable Natural Gas	AHJ*
Other	AHJ*

*“Other” sources of off-site renewable energy resources shall be discounted subject to the approval of the Authority Having Jurisdiction.

9 NORMATIVE REFERENCES

1. ASHRAE. 2019. ANSI/ASHRAE/IES Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, Atlanta: ASHRAE
2. ASHRAE. 2018. ANSI/ASHRAE/IES Standard 90.2-2018, *Energy-Efficient Design of Low-Rise Residential Buildings*, Atlanta: ASHRAE
3. ASHRAE. 2014. ANSI/ASHRAE Standard 105-2014, *Standard Methods for Determining, Expressing, and Comparing Building Energy Performance and Greenhouse Gas Emissions*, Atlanta: ASHRAE

(This appendix is part of this standard. It contains requirements necessary for conformance to the standard.)

NORMATIVE APPENDIX A –COMPLIANCE FORMS

FORM 1— GENERAL BUILDING AND SITE DESCRIPTION

ID _____ Measurement
Start Date _____
Address _____ End Date _____
City, State, Country, _____
ZIP (mail) Code _____

Primary year of construction² _____ Secondary _____

Gross Floor Area for non-residential building
(GFANR): _____

Gross Floor Area for residential building (GFAR): _____

Site Area _____

Non-green roof building footprint area _____

Other site area not requiring landscape care _____

Landscape Area:

LA = Site less non-green roof less area not requiring care, see section 5.3.1.3 _____

On-Site Renewable Energy System Type _____
On-Site Renewable Energy System Design Max Output (kW) _____

On-site renewable energy annual output (kWh) _____

Compliance Type:

Portion of Building? _____

Building? _____

Part of a Portfolio? If “Yes,” Portfolio Name? _____

Part of a Community? If “Yes,” Community Name? _____

FORM 2—ANNUAL SITE ENERGY CONVERSION CALCULATION

Energy Form ^{2, 4}	Energy Use Numerical Value	Units	Conversion Factor ¹ to kWh	Annual Site Energy kWh/yr
1a. Imported Grid Electricity				
1b. Imported Specific Electricity				
2a. Imported Grid Natural Gas				
2b. Imported Renewable Natural Gas				
3. Imported Steam				
4. Imported Hot Water				
5. Imported Chilled Water				
6a. Imported Grid Fuel Oil				
6b. Imported Renewable Fuel Oil				
7. Imported Grid Propane				
8. Imported Coal or Other ³				
9. Imported Biomass ⁴				
10. On-Site Non-Renewable Energy				
11. Imported Transportation Vehicle Energy				
12. Imported Landscape Energy ⁵				
13. Exported Non-Renewable Electricity				
14. Exported Renewable Electricity				
15. Exported Steam				
16. Exported Hot Water				
17. Exported Chilled Water				
18. Exported Other ⁵				
19. Exported Transportation Vehicle Energy				

1 See Section 5.2.

2 Grid energy forms are from the electric grid or fuel utility or distribution system. Specific renewable energy forms are from a specific provider meeting the requirements of the adopting authority.

3 If there is more than one “other” energy form, the entry shall be split or additional notations made to so indicate.

4 See Section 8 and Form 5 for Off-Site Certified Renewable Energy.

5 Either actual Landscape Energy or Landscape Area (LA) from Form 1 times 0.0018 kWh/ft² (6 Btu/ft²).

FORM 3—ANNUAL NET SOURCE ENERGY CALCULATION

Energy Form ⁵	Annual Site Energy (Form 2 Column 5) kWh/yr	Source Energy Conversion Factor ¹	Annual Source Energy kWh/yr
1a. Imported Grid Electricity			
1b. Imported Specific Electricity			
2a. Imported Grid Natural Gas			
2b. Imported Renewable Natural Gas			
3. Imported Steam			
4. Imported Hot Water			
5. Imported Chilled Water			
6a. Imported Grid Fuel Oil			
6b. Imported Renewable Fuel Oil			
7. Imported Grid Propane			
8. Imported Coal or Other ³			
9. Imported Biomass			
10. On-Site Non-Renewable Energy			
11. Imported Transportation Vehicle Energy			
12. Imported Landscaping Energy			
13. Exported Non-Renewable Electricity			
14. Exported Renewable Electricity			
15. Exported Steam			
16. Exported Hot Water			
17. Exported Chilled Water			
18. Exported Other ⁵			
19. Exported Transportation Vehicle Energy			
20. Qualified Off-Site Renewable Energy ⁶			
Annual Net Source Energy² Sum of rows 1a through 12 minus sum of rows 13 through 20		Annual Net Source Energy, kWh:	
Previous Measurement Period⁷		Previous Annual Net Source Energy	
Sum, Two Year Net Source Energy			

1 See Section 6.

2 When the imported energy meter records the imported energy minus the exported energy under a net metering agreement, exported energy shall not be double counted.

3 If there is more than one “other” energy form, the entry shall be split or additional notations made to so indicate.

5 Grid energy forms are from the electric grid or fuel utility or distribution system. Specific energy forms are from a specific provider meeting the requirements of the adopting authority.

6 See Section 8 and Form 5

7 The previous 12 month measured period for existing sites, zero for existing sites less than two years old and for proposed and new sites.

FORM 4—ANNUAL NET GREENHOUSE GAS EMISSIONS CALCULATION

Energy Form ⁵	Annual Site Energy (Form 2 Column 5) kWh/yr	Greenhouse Gas Emission Factor ¹ kg/kWh	Annual Greenhouse Gas Emissions kgCO _{2e} /yr
1a. Imported Grid Electricity			
1b Imported Specific Electricity			
2a. Imported Grid Natural Gas			
2b. Imported Renewable Natural Gas			
3. Imported Steam			
4. Imported Hot Water			
5. Imported Chilled Water			
6a. Imported Grid Fuel Oil			
6b. Imported Renewable Fuel Oil			
7. Imported Grid Propane			
8. Imported Coal or Other ³			
9. Imported Biomass			
10. On-Site Non-Renewable Energy			
11. Imported Transportation Vehicle Energy			
12. Imported Landscaping Energy			
13. Exported Non-Renewable Electricity			
14. Exported Renewable Electricity			
15. Exported Steam			
16. Exported Hot Water			
17. Exported Chilled Water			
18. Exported Other ⁵			
19. Exported Transportation Vehicle Energy			
20. Qualified Off-Site Renewable Energy ⁶			
21. Refrigeration Loss, Sum from Form 4A			
Annual Greenhouse Gas Net Emissions² Sum of rows 1a through 12 plus row 21 minus sum of rows 13 through 20		Annual Greenhouse Gas Net Emissions:	
Previous Measurement Period⁷		Previous Net Annual Greenhouse Gas Emissions	
Sum, Two Year Greenhouse Gas Net Emissions			

1 See Section 7.

2 When the imported energy meter records the imported energy minus the exported energy under a net metering agreement, exported energy shall not be double counted.

3 If there is more than one “other” energy form, the entry shall be split or additional notations made to so indicate.

4 Refrigerant leakage shall be either actual or calculated by taking the charge times the percent leakage per year.

5 Grid energy forms are from the electric grid or fuel utility or distribution system. Specific renewable energy forms are from a specific provider meeting the requirements of the adopting authority.

6 See Section 8.2 and Form 5.

7 The previous 12 month measured period for existing sites, zero for existing sites less than two years old and for proposed and new sites.

FORM 4A —REFRIGERANT LOSS CALCULATION

Equipment Identification	Equipment Type, See Table 9	Refrigerant Leakage Rate, See Table 9	Refrigerant Charge kg	Annual Refrigerant Loss ¹ kg	Refrigerant Type	Greenhouse Gas Emission Factor, See Table 10 kgCO ₂ e/kg	Annual Greenhouse Gas Emissions per Year Loss x Factor kgCO ₂ e/yr
						Sum, to Form 4:	

¹ For Existing Buildings, Annual Refrigerant Loss shall be either actual annualized loss based on service records for the equipment or the Table 9 Leakage Rate times Refrigerant Charge.

FORM 5 — QUALIFIED OFF-SITE RENEWABLE ENERGY PROCUREMENT CALCULATION

Off-Site Renewable Energy Calculation	A. Annual Off-Site Renewable Energy ¹ kWh/yr	B. Discount Factor ²	C. Source Energy Conversion Factor ³	D. Greenhouse Gas Emission Factor ⁴ kg/kWh	E. Annual Renewable Source Energy Procurement AxBxC kWh/yr	F. Annual Greenhouse Gas Emissions Procurement AxBxD kg/yr
1. Electricity						
2. Natural Gas						
3. Fuel Oil						
4. Biomass						
5. Sum of Column F Rows 1 to 4						
6. Max Annual Off-Site Permitted (from Form 5A) The Smaller of Line 5 or 6 (to Form 3 Row 20)						
Sum of Column F Rows 1 to 4 (to Form 4, Row 20)						

Footnotes:

1. See Section 8 for required qualifications.
2. See Table 15.
3. See Table 1.
4. See Table 5.

FORM 5A – MAXIMUM ANNUAL OFF-SITE RENEWABLE ENERGY PROCUREMENT CALCULATION, See Section 8.2

Climate Zone	
--------------	--

	G. Space Type	H. Gross Floor Area ft ²	I. Intensity Limit kWh/ft ² -yr	J. Total H x I kWh
Non-Res				
1. NR				
2. NR				
3. NR				
Residential				
4. Res				
5. Res				

Maximum Allowed Procurement, sum of lines 1 to 5	
--	--

FORM 5A – OTHER INFORMATION

Ownership of Off-Site Renewable Energy Resource

Own off-Site Generation?
 Contract for Generation?
 Address of Off-Site Renewable Generation

Yes	No
Must be > = 15 years	

Connection of Off-Site RE Resources to Site (check one)

	Y/N	Name of Company
Direct		
Local Utility Distribution Entity, name		
Interconnected Local Elec Utility Network, name		

FORM 6 —ZERO ENERGY PORTFOLIO OF COMMUNITY CALCULATION

Site Name or Identifier	Site Address	Sum of Two Year Individual Site Source Net Energy (Form 3, bottom)	Notes
	Sum of Portfolio or Community Net Energy		Must sum to zero or negative

FORM 7 —ZERO CARBON PORTFOLIO AND COMMUNITY CALCULATION

Site Name or Identifier	Site Address	Sum of Two Year Individual Site Source Greenhouse Gas Equivalent Performance (Form 4, bottom)	Notes
	Sum of Portfolio or Community Carbon		Must sum to zero or negative

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INFORMATIVE APPENDIX B – RECOMMENDED CHARACTERISTICS OF OFF-SITE RENEWABLE ENERGY PROCUREMENT

Section 8 of this standard includes a few of the most common current mechanisms for procuring off-site renewable energy, but procurement of off-site renewable energy is an area of active innovation. New instruments, markets, and certifications are in ongoing development. Furthermore, Section 8 allows for some authority having jurisdiction (AHJ) interpretation of off-site renewable energy procurement options. With these considerations, this informative appendix is created as a resource for AHJs or others who would like to evaluate sources of off-site renewable energy in relation to application of this standard. This appendix details suggested characteristics of off-site renewable energy procurement mechanisms. As stringency may vary based on jurisdiction or other context, each element is identified according to one of the following levels of stringency:

- Absolute minimum requirements
- Moderate stringency
- Most stringent practice

The characteristics are also divided into categories, primarily for convenience.

General

- Unless the site owner has direct ownership of the renewable energy asset, a legal agreement or contract (dictating property rights) must be obtained for the renewable energy. The legal agreement may take the form of a broadly recognized instrument like a certificate or a transaction in an established regional renewable energy market, or it may be an independent agreement. It just needs to cover the other key functions below and be legally enforceable.
- These agreements need to be long-term in nature, at least ten years but ideally 15 or more.
- The energy and environmental attributes need to be purchased together via the same legal mechanism. In other words, they need to be bundled. Unbundled attributes (for example, Renewable Energy Credits in the United States) are not an effective market mechanism within the purpose of this standard. (There is less case to be made for additionality, and there is not strong enough demand for them to have an impact on the same order as bundled instruments). None of the attributes, environmental or otherwise, of the energy may be sold, transferred, or claimed by any other site.
- Agreements with broad acceptance in the renewable energy industry are ideal. The model Leases and PPAs supplied by the Solar Energy Industry Association are a good example. Agreements that have already had significant usage in regional greenhouse gas markets are another example.
- The payment for renewable energy can be integrated into the financing for the construction or renovation of the net zero site and paid via the same financing mechanisms used for the overall site project.

Generation type

- Sources of energy must be from renewable energy resources.
- The ultimate source of the renewable energy being generated is known for each unit of energy procured. (Some green tariff programs, for example, document a mix of renewable energy sources without each unit of energy being tied to a specific source; this is not ideal).

- The renewable energy resource is used to immediately produce electricity. The electricity is the commodity that is procured for off-site usage (electricity is more fungible and easily tracked than most end-use fuels).

Timing

- The production of the renewable energy must occur within 9 months of crossing the site boundary.
- The lifetime of the facility used to generate the renewable energy should be 20 years or more.
- The facility used to generate the renewable energy must have begun operations no more than 15 years prior to the start of the Standard 228 measurement period.

Additionality factors

- Both the renewable energy and all associated attributes can be applied to only this site and not be shared with other sites. Making any renewable electricity consumption claim is one example of an application. If attributes can be reasonably attributed to any other party, the related energy is not renewable.
- The renewable energy must not be also counted toward a specific government policy, legislation, or other requirement for renewable energy production. Requirements that cause energy to be ineligible include:
 - Legal settlement or other law requiring construction of the renewable energy facility.
 - Renewable Portfolio Standard.
 - Electricity rates or tariffs that require renewable electricity be used as part of a government program to increase all consumers' use of renewable electricity.
 - Renewable or Low-Carbon Fuel Standards.
- The price paid for renewable energy and all associated attributes should be greater than 25% of the average price of electricity for the local utility and sector corresponding to the site. Average cost data is provided at: https://www.eia.gov/electricity/sales_revenue_price/

Location and delivery

For renewable electricity, the renewable energy generation and the building should be connected by:

- An interconnected electrical network where energy delivery capacity between the generator and the site is available. Examples of interconnected electrical networks include regional power pools and regions served by Independent System Operators or Regional Transmission Organizations.
- Transmission and/or distribution networks for the same electric utility or distribution provider.
- A direct connection within local distribution, without transmission.

For renewable fuels, the renewable energy should be connected by:

- Either a common carrier pipeline that connects the injection point and the site for use, or a truck or other means of transport (if the latter, the source factor and carbon factors should include this other means of transport).
- A common carrier pipeline that connects the injection point and site for use directly.

Verification process

- Environmental and other generation attributes for all renewable energy must be electronically tracked with the building, using a tracking system or direct contract. The building should retain the documentation that justifies environmental attributes and tracking. A method for retiring or cancelling the attributes must be included.

- The tracking and documentation of the environmental attributes is subject to independent audits, are conducted by an independent entity (not participating in the market), and are conducted transparently.
- An electronic tracking system should be used in which certificates are electronically issued to generators, tracked between different owners, and permanently retired or cancelled electronically by the site. The system should issue certificates for all generation, and for each unit of energy include unique serial numbers, location, resource type, facility startup date, date of generation, and date of issuance.
- The tracking system must meet the requirements of Section V.B of the Green-e Framework for Renewable Energy Certification.

Grid flexibility

- The generation source includes some type of energy storage or other mechanism to provide a measure of flexibility and reliability in its generation of renewable energy to the grid or pipeline.

References and further guidance

This appendix was developed by including guidance from the following references. These references can also be used by AHJs for further, more detailed guidance.

ASHRAE Standard 189.1-2020. ASHRAE’s general green building design standard (which informs the International Green Construction Code) also includes guidance for what type of renewable energy procurement can be incorporated. From ASHRAE. June 2020.

EPA Green Power Partnership Requirements. Requirements for procuring green power as part of this EPA program. This standard is somewhat less stringent than others, allowing for more tariff-based mechanisms. From the US Environmental Protection Agency. May 2019.

Green-e Framework for Renewable Energy Certification. The defining standard for a popular certification program for renewable procurement. Detailed language to evaluate types of procurement. From the Center for Resource Solutions. July 2017.

Green-e Renewable Fuels Standard for Canada and the United States. The defining standard for the use of non-electric fuels in this popular certification program for renewable procurement. Detailed language to evaluate types of fuel and procurement instruments. From the Center for Resource Solutions. Expected 2020.

Making credible renewable electricity usage claims. A white paper providing best practices to companies and other entities for procuring renewable energy toward. From the RE100 Technical Advisory Group. Aril 2016.

Policies for Enabling Corporate Sourcing of Renewable Energy Internationally. A report guiding governments and other policy-making entities to provide the right policies and initiatives to promote procurement of renewable energy. From the National Renewable Energy Laboratory. May 2017.

ZERO Code Off-Site Procurement of Renewable Energy; Technical Support Document. This technical support document describes in detail how off-site renewable energy is treated within the ZERO Code, which is a standard for net-zero carbon building design. From Architecture 2030. April 2018.

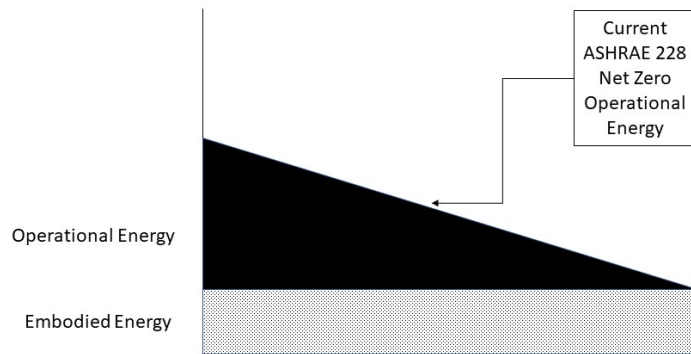
Solar Energy Industries Association Model Leases and PPAs. A library of model contracts that was originally developed under the Solar Access to Public Capital working group but is now managed (and endorsed) by SEIA for ongoing use. From SEIA. Last accessed December 2020.

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INFORMATIVE APPENDIX C– EMBODIED ENERGY AND CARBON CALCULATIONS

Aluminum has been described as “Congealed Electricity.” Beyond the operational energy used in a building or on a site, there is energy used and carbon generated in the creation of materials used in the building and the construction of the building itself.

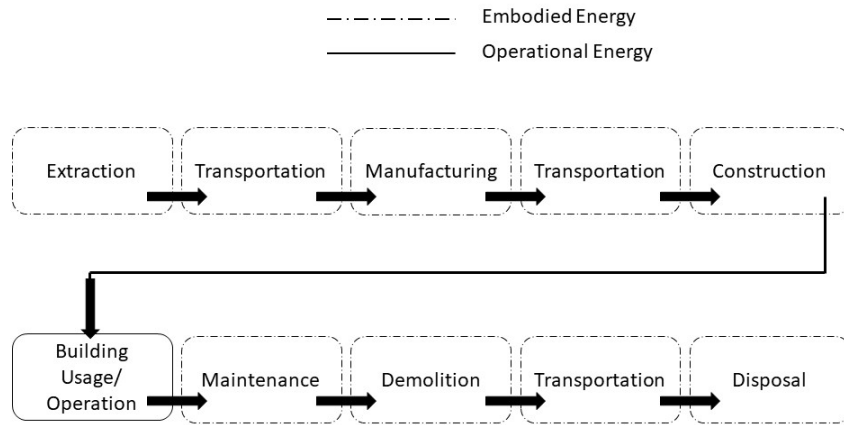
ASHRAE 228 Zero Net Energy and Zero Net Carbon Guidelines for Buildings are applied to reduce operational energy use. The World Council on Sustainable Business Practices found that embodied energy of manufacturing, transport, and construction accounted for 12% and Maintenance and renovation, 4% of the energy footprint of a Building (The World Council on Sustainable Business Practices, 2007). As operational energy reaches net-zero usage, the non-operational embodied energy becomes a higher percentage of the non-renewable energy footprint of the facility up to 100%. Addressing embodied energy is the next step in energy conservation of facilities. This analysis is similar but not identical to a net-zero carbon analysis.



Embodied Energy becomes larger portion of Building Energy as Operational Energy is Reduced

Embodied energy is defined as *the total amount of non-renewable primary energy required for all direct and indirect processes related to the creation of the building, its maintenance, and end-of-life. In this sense, the forms of embodied energy consumption include the energy consumption for the initial stages, the recurrent processes, and the end of life processes of the building.* (Institute for Building Environment and Energy Conservation, 2016).

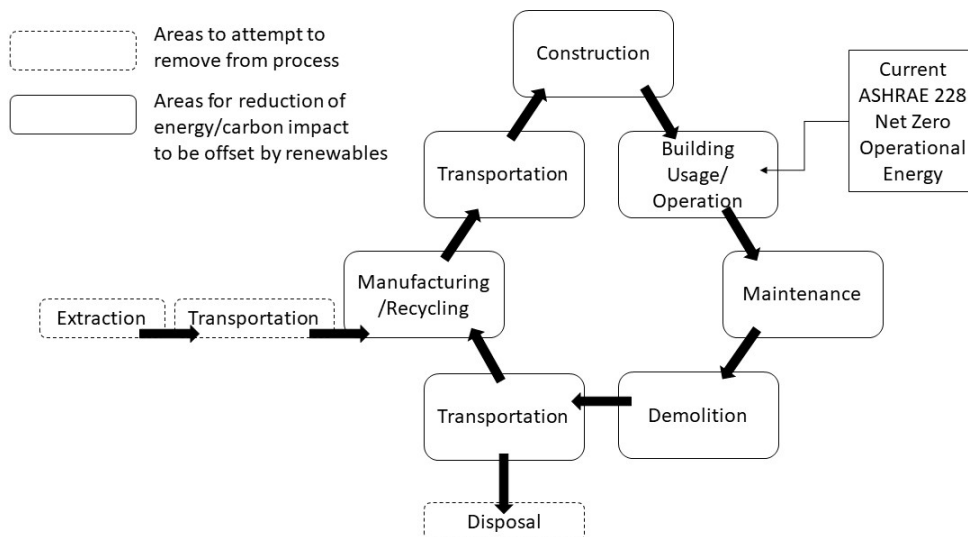
It is usually expressed in *megajoules (MJ) per reference unit per year of the RSP.* (Institute for Building Environment and Energy Conservation, 2016) (*RSP – Reference Study Period*).



Traditional Building Life Cycle

There are multiple definitions and boundaries of embodied energy. Some definitions only account for cradle (raw material extraction) to gate (produced material) while others take a cradle to grave (end of life disposal) approach. Each stage within the building process uses energy and creates carbon emissions. Standard EN15978:2011 illustrates the lifecycle stages that can be incorporated into the calculations of a building's total impact. Each aspect of the process incorporates energy. Therefore, when possible, a cradle to grave analysis should be pursued as shown in the above definitions to account for life cycle energy usage.

The analysis usually initiates between an owner, architect, and structural engineer at the commencement of the design initiative. The layout and structural members make up the bulk of the embodied energy framework of a facility. Once a layout is decided upon, a reference "baseline" is modeled to determine how much non-renewable energy a general code compliant structure would require. This "baseline" must be of the same dimensions and usage type as the reduced energy final design. Iterative material analyses are then completed until a maximum reduction that benefits the facility, maintains the operational net zero, and is within the client's budget is found. The same steps may be used throughout the entire process until the completion of building construction. These iterations lead to a **reduction** of embodied energy.



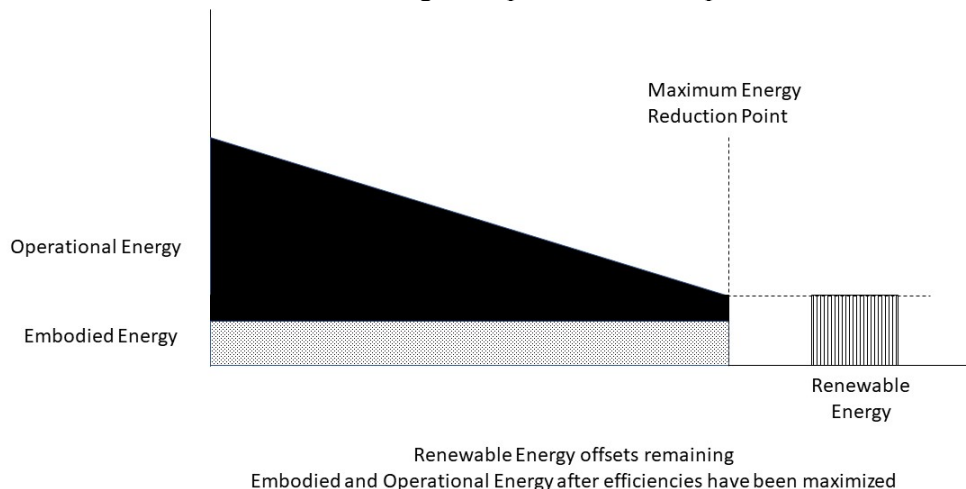
Reduced Impact Building Life Cycle

The analyzing process includes employing third party verified datasets of environmental product declarations (EPD's) for each material or assembly used and applying their usage factors to each corresponding component usually within BIM software or applying it by a calculated area of each material. EPD's currently exist for many regions and are provided by manufacturers. ISO 14025 has been instituted

to assist in regulating these declarations as ambiguity has persisted within reporting metrics such as how to incorporate travel distance to different construction sites from one manufacturing facility which may be beyond the manufacturer’s control.

Due to its complexities, different software packages and add-ons have been developed, such as Athena Impact Estimator, GaBi, and SimaPro, for the process of life cycle analysis to determine the embodied energy of a structure. A life cycle analysis shall be performed in accordance with ASTM E2921 and ISO Standard 14044.

Additional information may be found through *International Energy Agency Energy in Building and Communities Programme Annex 57* released in 2016, the *AIA Guide to Building Life Cycle Assessment in Practice* released in 2010, *Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method, EN 15978:2011* and *LEED v.4*. These documents explain useable data sets, specific software, benefits, short-comings, and processes to complete an embodied energy assessment.



Achieving Zero Net Energy – Operational and Embodied

Achieving net-zero embodied energy as well as operational energy requires that the facility utilize renewable energy to such an extent that it offsets both embodied and operational energy. Embodied energy can also be reduced or zeroed out by selecting suppliers that have reduced or zeroed out their own energy and emissions impacts. Operational energy may be reviewed as required within ASHARE 228 on yearly terms. Achieving net-zero embodied energy may be recovered over a referenced study period of 20-50 years (75 years in ASHRAE 189.1) (adjustable to local code requirement thresholds). In short, non-renewable energy related to all operational energy plus all embodied energy shall be compensated for with renewable energy generation. This moves the facility from a *zero net operational and reduced embodied energy* identification to a *zero net operational and embodied energy* classification. A life cycle analysis shall be performed in accordance with ASTM E2921 and ISO Standard 14044.

If an embodied energy analysis is completed as part of the scope of a project, it is recommended to include a record of the results as a procedural practice. This record may be required to justify achievement of a net-zero facility in the future or to fulfill specific conservation requirements.

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INFORMATIVE APPENDIX D – TABLE DERIVATION SOURCES

TABLE 1 Annual Source Energy Conversion Factors for the United States

BSR/ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K, Table K2-A, “Primary Annual Energy Conversion Factors for National Comparisons.” The committee decided to value non-combustible renewable energy generation at a source factor of 1.05 for these calculations, taking a captured energy approach while considering transportation and distribution losses.

TABLE 2 Regional Electricity Source Energy Conversion Factors for the United States

BSR/ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K, Table K3-A, “Primary Energy Conversion Factor” using the Captured Energy Efficiency Approach.

The Standard 105 table is calculated from information reported in the eGRID2018 database (<https://www.epa.gov/energy/egrid>) at the individual generator level using the Gas Technology Institute’s Source Energy and Emissions Analysis Tool (<http://seeatcalc.gastechnology.org>). The technique is described in Standard 105-2014R, Second Public Review, Appendix K. The committee decided to value renewable energy generation at a source factor of 1.05 for these calculations.

TABLE 3 Regional Electricity Source Energy Conversion Factors for Canada

The information in this table was derived using the technique described in Standard 105-2014R, Second Public Review, Appendix K using Canadian Information. The data source used for the calculation was Canada’s “National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada,” specifically the Electricity Generation amounts in Table A13.

TABLE 4 Hourly Electric Generation Mix and Source Energy Conversion Factors

The values in Table 4 are derived from the eGRID 2018 database for each type of power generation, with factors for extraction, processing, transportation, transmission, and distribution energy use applied based on the methodology described in ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K.

TABLE 5 Annual Greenhouse Gas Emission Factors for the United States

BSR/ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K, Table K2-B, “Greenhouse Gas Emissions Conversion Factors for National Comparisons Using Either a 100 or 20 Year Time Horizon.” The column used was the 100 year Global Warming Potential.

TABLE 6 Regional Electricity Greenhouse Gas Emissions Factors for the United States

BSR/ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K, Table K3-B, “Electric Greenhouse Gas Emissions Factors for Regional Comparisons.” The column used was the 100 year Global Warming Potential.

The Standard 105 table is calculated from information reported in the eGRID2018 database (<https://www.epa.gov/energy/egrid>) at the individual generator level using the Gas Technology Institute’s Source Energy and Emissions Analysis Tool (<http://seeatcalc.gastechnology.org>). The technique is described in Standard 105-2014R, Second Public Review, Appendix K.

TABLE 7 Regional Electricity Greenhouse Gas Emission Factors for Canada

The information in this table was derived using the technique described in Standard 105-2014R, Second Public Review, Appendix K using Canadian Information. The data source used for the calculation was Canada’s “National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada,” specifically the Greenhouse Gas intensity values in Table A13, in conjunction with the emissions factors for each generating type listed in Table 7.3.

TABLE 8 Hourly Generation Mix and Greenhouse Gas Emissions Factors

The values in Table 8 are derived from the eGRID 2018 database for each type of power generation, with factors for extraction, processing, transportation, transmission, and distribution energy use applied based on the methodology described in ASHRAE Standard 105-2014R, Second Public Review, Informative Appendix K.

TABLE 9 Typical Annual Refrigerant Leakage Rates by Building Type

The information in this table is based on Table 6, fugitive emission rates by field and sub-sector from “Refrigerant Containment Study.” *Agence de l’Environnement et de la Maîtrise de l’Energie*, September, 2015.

TABLE 10 Refrigerant Greenhouse Gas Emission Factors

Data from the 2017 ASHRAE Handbook – Fundamentals, Page 29.5, Table 3B “Refrigerant Environmental Properties” and Table 4. These values are based on IPCC (2013) and GWP₁₀₀.

TABLES 11, 12, 13, and 14 Procured Off-site Source Energy Intensity Limit (non-residential, residential, IP and SI)

These tables are based on Table 7.2b in ASHRAE Standard 100-2018, with units modified. In addition to units, the source energy conversion factors were modified to be consistent with the eGRID2018 database used elsewhere in this standard (see Tables 2 & 6 explanation above). The source energy conversion factors used for this table are 2.74 for electricity and 1.09 for natural gas, which are national averages of eGRID2018 data using the captured energy value of 1 for noncombustible renewable energy. The offsite procurement limits in Tables 11 through 14 are equivalent, with the two technical modifications noted above, to the standardized targets in Standard 100 for existing building performance in the United States. Building types in these tables correspond to classifications used in Standard 100 and were taken from the U.S. Energy Information Administration’s Residential Energy Consumption Survey and the Commercial Building Energy Consumption Survey (<https://www.eia.gov/consumption/commercial/building-type-definitions.php>).

TABLE 15 Renewable Energy Discount Factor

The Renewable Energy Discount Factors are based on the judgment of the Committee regarding losses between the off-site generation and the site as well as other factors.

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INFORMATIVE APPENDIX E – REFERENCES AND BIBLIOGRAPHY

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