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PNNL-35193

Commercial Zero Code Plug-In: Zero Energy and Operational Emissions Overlay for Model Energy Codes

Technical Brief

October 2023

E Franconi
M Rosenberg
M Tillou

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99354

Preamble

The Department of Energy (DOE) and Pacific Northwest National Laboratory (PNNL) are developing a series of technical briefs supporting national, state, and local initiatives to update and advance building energy codes. These technical briefs present specific technologies, measures, or practices that can be incorporated as module-based “plug-ins” via the national model energy codes (MEC), recognized as the International Energy Conservation Code for residential buildings or ASHRAE Standard 90.1 for commercial buildings, and adopted directly by state and local governments pursuing advanced energy savings and greenhouse gas emissions reductions. This collection of briefs is part of a larger effort to provide technical assistance supporting states and local governments and to help them realize their policy goals.

This commercial zero code plug-in technical brief presents modified code language that can be amended to adopted commercial building MEC to achieve net zero operational energy emissions (NZOEE) and net zero energy (NZE) in newly constructed buildings, either immediately or over several code cycles. The approach follows a performance-based compliance path and requires meeting two compliance metrics. For NZOEE compliance, the metrics address: 1) minimum site energy efficiency and 2) operational energy emissions that include avoided emissions from onsite and offsite renewable energy generation. For NZE compliance, the metrics include: 1) minimum site energy efficiency and 2) site energy use that accounts for offsets from onsite and offsite renewable energy generation. The metric target values were compared to the energy-use offset potential estimated for new U.S. commercial building on-site rooftop solar electricity production and the impact of advanced efficiency measures currently being installed in buildings but not yet included in MEC. The supporting analysis illustrates the magnitude of advancement needed relative to these thresholds to achieve net zero relative to current commercial MEC (ASHRAE Standard 90.1-2022) requirements. The assessment informs goal setting and helps direct future model code development.

Additional assistance may be available from DOE and PNNL to support states and local governments who are interested in adding net zero requirements and other “stretch” provisions to their adopted energy code. Assistance includes technical guidance, customized analysis of expected impacts (e.g., based on state-specific building stock, climate considerations, or utility prices), and tailoring stretch code language to overlay state adopted code or other standards. DOE provides this assistance in response to the Energy Conservation and Production Act, which directs the Secretary of Energy to provide technical assistance “to support implementation of state residential and commercial building energy efficiency codes” (42 USC 6833). PNNL supports this mission by evaluating concepts for future code updates, conducting technical reviews and analysis of potential code changes, and assisting states and local jurisdictions who strive to adopt, comply with, and enforce energy codes. This helps assure successful implementation of building energy codes, as well as a range of advanced technologies and construction practices, and encourages building standards that are proven to be practical, affordable, and efficient.

DOE Building Energy Codes Program

DOE supports the advancement of building energy codes. Modern building codes and standards offer cost-effective solutions, contributing to lower utility bills for homes and businesses and helping mitigate the impacts of climate change. Learn more at energycodes.gov.

Acknowledgments

The authors would like to acknowledge the Buildings Technologies Office (BTO) of the Department of Energy's Office of Energy Efficiency and Renewable Energy for supporting this research and development effort. Specifically, the authors thank Jeremy Williams, Christopher Perry, and Ian Blanding of BTO for their guidance on the project and commitment to meeting the goals of the Building Energy Codes Program.

Acronyms and Abbreviations

DOE	Department of Energy
eGRID	Emissions and Generation Resource Integrated Database
IECC	International Energy Conservation Code
LRMER	long run marginal emissions rate
MEC	Model Energy Codes
PEI_{site}	site performance energy index
$PEI_{site,t}$	site performance energy index target
$PEI_{site,zero,}$	site zero performance energy index
$PEI_{site,zero,t}$	site zero performance energy index target
PEI_{CO2e}	greenhouse gas performance emissions index
$PEI_{CO2e,t}$	greenhouse gas performance emissions index target
PNNL	Pacific Northwest National Laboratory
NZE	net zero energy

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1.0 Existing Initiatives to Achieve Zero Energy or Emissions Model Energy Codes

This commercial zero code tech brief provides model energy code (MEC)[1] language as an overlay to current energy code to achieve net zero energy (NZE) or net zero operational energy emissions (NZOEE) new commercial buildings. It is intended to be adopted directly by states and local governments. Future tech briefs will address net zero all-electric requirements and refrigerant emissions for commercial buildings along with a similar suite of net zero tech briefs for residential buildings This work builds on existing efforts to drive commercial energy codes towards zero energy and emissions initiated by the International Energy Conservation Code (IECC) and ASHRAE Standard 90.1.

The first instance of zero energy in MEC is found in the 2021 IECC. Zero energy commercial building requirements are specified as part of an optional appendix (Appendix CC) (ICC 2021). The appendix provides both prescriptive and performance paths to achieve net zero energy compliance. Efficiency requirements are aligned with the 2021 IECC requirements. Net zero energy use is achieved with renewable energy offsets. Also in 2021, the International Code Council (ICC) established a goal "to provide optional requirements that lead to achievement of zero energy buildings, presently, and through glidepaths that achieve zero energy buildings by 2030."[2]

The next example is the pursuit of a zero operational energy emissions option in ASHRAE Standard 90.1. The ASHRAE 90.1 standard committee established a goal of achieving NZOEE in the Standard by 2031. Recognizing the need to look across multiple code cycles in development planning, the Standard 90.1-2025 Work Plan includes preliminary recommendations for the 2028 and 2031 work plans. In addition, a goal of publishing a jurisdiction optional appendix that includes net zero operational emissions code language was established for the Fall of 2023.

[1] The term "model energy code" refers to the current published versions of the IECC for residential buildings and ASHRAE Standard 90.1 for commercial buildings. These documents are referenced by the Energy Conservation and Production Act as modified by the Energy Policy Act of 1992 as the minimum requirements for states adopting energy codes. They are published every three years and most states have adopted some version of the MEC.

[2] https://www.iccsafe.org/wp-content/uploads/ICC_Leading_Way_to_Energy_Efficiency.pdf

2.0 Achieving NZE and NZOEE Buildings

The generally accepted process for achieving NZE and NZOEE buildings incorporates efficiency first, uses low-carbon energy sources, includes demand response capabilities, and offsets emissions with on-site renewable energy sources before procuring off-site renewable energy. The NZE and NZOEE code language can help support such a process.[3] The performance path involves meeting two compliance metrics: 1) an efficiency backstop, and 2) a measure of NZE or NZOEE attainment. The efficiency backstop ensures a building is constructed to be highly efficient before renewable energy resources are procured. The plug-in code language requires higher levels of efficiency than the currently published model energy code (MEC). The NZOEE metric is typically more stringent than the NZE metric, and benefits all-electric buildings, especially in areas with clean grids. To calculate the NZOEE metric, annual emission factors are provided for the continental U.S. The electricity values, provided by eGRID region, are 2022 Cambium long-run marginal emission rates for the mid-case scenario, based on a 20-year levelized analysis period, zero discount rate, and a 20-year greenhouse gas global warming period (Gagnon, et al. 2023).[4] Jurisdictions can substitute equivalent local values, as well as hourly data, for the carbon emission factors to meet the requirements of the provided code language.

A key component of the NZE and NZOEE code language development is the establishment of the target value for the efficiency backstop. It aims to represent building performance levels that can be achieved with market-ready measures, including those currently being installed in new buildings but not yet included in MEC. It is intended to be updated each code cycle. The second metric target value, which measures net zero attainment, can also be stepped over several code cycles, or set to achieve net zero energy or emissions in one code cycle.

The market-ready efficiency requirements specified in the plug-in code were informed by building simulation analysis and code development trends. ASHRAE Standard 90.1 technical committee members also provided valuable input. The required NZE and NZOEE gross site energy performance is shown in Figure 1, which is a weighted aggregated value based on U.S. new commercial building construction data. The green dashed line shows the performance level associated with the code overlay requirements, achieved with beyond current code efficiency levels. The orange dashed line show additional reductions needed to achieve NZE, which may be achieved with renewable energy offsets and additional efficiency improvements.

The market-ready performance indicated by the efficiency backstop was informed by building simulation analysis of advanced measure performance. This performance level, indicated in Figure 1, is based on a subset of measures identified in ASHRAE Research Project 1651 – *Development of Maximum Technical Achievable Energy Targets for Commercial Buildings (RP-1651)* (Glazer 2016). The figure also indicates the potential energy offset attributed to rooftop solar for new commercial buildings. The rooftop solar performance assessment considers typical building geometries consistent with the DOE code prototype building models

[3] While NZOEE performance compliance does not explicitly include requirements for demand response capabilities, such requirements can be added by adopting plug-in code language from other tech briefs that do. In addition, jurisdictions have the option to adopt hourly carbon emission factors, which can benefit buildings practicing demand response.

[4] While this model energy code plug-in provides a set of criteria that can be used to achieve net zero operational energy emissions in new commercial construction, it does not purport to be the only way to achieve zero emissions, nor does it necessarily align with other industry definitions or standards that set criteria for achieving zero emissions buildings.

used in the federal determination analysis. This viable roof area for photovoltaic installation accounts for roof obstructions and shading to estimate the implementable system area. The assessment provides a technical basis for understanding the performance gap needing to be filled to achieve NZE with MEC (Franconi, et al. 2022).

The code-cycle 1 efficiency backstop is equivalent to reducing regulated energy use by one half that achieved with the advanced measures relative to Standard 90.1-2022. The improvements result in an estimated 11.5% overall national weighted reduction in total energy use compared to ASHRAE Standard 90.1-2022 values.

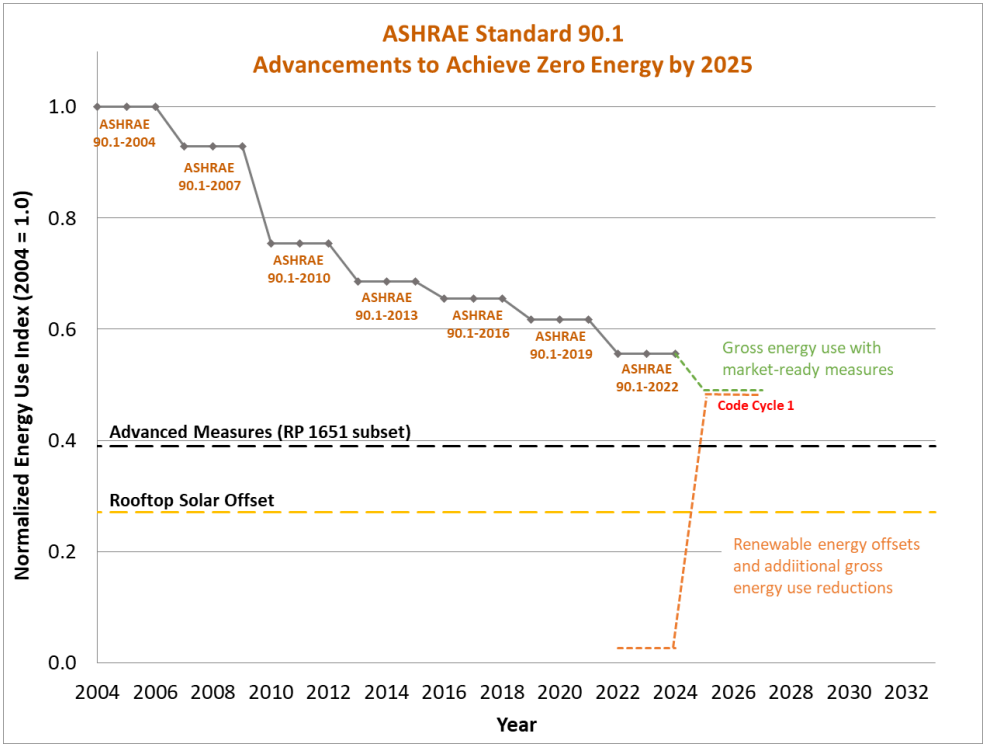

Figure 1. Proposed Commercial Model Energy Code National Site Energy Use Reduction

3.0 Zero Net Energy and Emissions Compliance Path Plug-Ins for Commercial Energy Code

This section provides modified code language that can be amended to ASHRAE Standard 90.1-2022. Each section is intended to support jurisdictions that choose either an immediate or a stepwise approach for NZE (Section 3.1) or NZOEE (Section 3.2) attainment. Section 3.3 provides example calculations of the compliance metrics, utilizing the equations and data included as part of the overlay language.

3.1 Net Zero Energy

The proposed code modifications for Net Zero Energy, described in this Section, modify the existing language in ASHRAE 90.1-2022 Sections 3, Section 4, and Appendix G. It is intended to be adopted by jurisdictions or rating authorities wanting to achieve net zero energy (NZE) buildings with the energy code over one to three code cycles. The method requires the use of the performance compliance path and includes two performance metric targets. The Site Performance Energy Index Site (PEI_{site}) provides an efficiency backstop. The Site Zero Performance Energy Index ($PEI_{site,zero}$) measures zero net energy achievement. The modifications establish the NZE performance requirements for the code cycle. This includes updated BPF values reflected in Table 4.2.1.1 that require additional reductions in regulated energy use resulting in an estimated 11.5% overall national weighted reduction in total energy use compared to ASHRAE Standard 90.1-2022 values.

3.1.1. CHANGES TO ASHRAE 90.1-2022 SECTION 3

Modify existing definitions in Section 3.2 as follows:

Replace references to “annual energy cost” with “annual site energy use” in definitions of ***baseline building performance*** and ***proposed building performance*****.**

Add new definitions in Section 3.2 as follows:

> ***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.
>
> ***directly-owned renewable energy facility***: an off-site renewable energy system under the ownership of the building project owner
>
> ***financial renewable energy purchase agreement:*** a financial arrangement between a renewable energy provider and a purchaser wherein the purchaser pays or guarantees a price to the provider for the project’s renewable energy.
>
> ***physical renewable energy purchase agreement:*** a contract for the purchase of renewable energy from a specific renewable energy provider to a purchaser of renewable energy.
>
> ***renewable energy certificate:*** a market-based instrument that represents and conveys the environmental, social, and other non-power attributes of 1 MWh of renewable electricity generation or 3,412 kBtu of renewable thermal energy or bioenergy production and could be sold separately from the underlying physical energy associated with renewable energy resources; also known as “energy attribute” and “energy attribute certificate” (EAC).

3.1.2. CHANGES TO ASHRAE 90.1-2022 SECTION 4

The following changes, items a through e, describe the required modifications to ASHRAE 90.1-2022 Section 4.

a. Replace Section 4.2.1.1, in its entirety, with the following language:

4.2.1.1 New Buildings

New *buildings* shall comply with Sections 4.2.2 through 4.2.5 and Normative Appendix G. Where using Normative Appendix G, the following performance requirements of new *buildings*, *additions* to *existing buildings*, and *alterations* to *existing buildings* shall be met:

a. The Site Performance Energy Index (PEI_{site}) shall be less than or equal to the Site Performance Energy Index Target ($PEI_{site,t}$) calculated in accordance with Section 4.2.1.1.1. Site energy shall be determined using the site energy conversion factors provided in Table 4.2.1.1-2. Conversion factors for energy sources not included in Table 4.2.1.1-2 shall be approved the rating authority.

b. The *Site Zero Performance Energy Index ($PEI_{site,zero}$)* shall be less than or equal to the *Site Zero Performance Energy Index Target ($PEI_{site,zero,t}$)* calculated in accordance with Section 4.2.1.1.2

Informative Note: As Section 4.2.1.2 and Section 4.2.1.3 are not amended, it is intended for existing buildings and alterations to have the option to comply either prescriptively in accordance with Sections 5 through 11, using Section 12 "*Energy Cost Budget*", or via Appendix G "*Performance Rating Method*" to achieve net zero performance.

b. Add a new section, Section 4.2.1.1.1, using the following language:

4.2.1.1.1 Site Performance Energy Index. The Site Performance Energy Index Target ($PEI_{site,t}$) is calculated as follows:

$$PEI_{site,t} = \frac{BBUEU_{site} + BPF_{site} * BBREU_{site}}{BBEU_{site}}$$

Where:

$PEI_{site,t}$ = Site Performance Energy Index Target.

$BBUEU_{site}$ = *baseline building design* unregulated site energy use, the portion of the annual site energy use of a *baseline building design* that is due to *unregulated energy use.*

BPF_{site} = *building performance factor* site from Table 4.2.1.1-1. For *building* area types not listed in Table 4.2.1.1-1, use "All others." Where a *building* has multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types based on their *gross floor area*.

$BBREU_{site}$ = *baseline building design* regulated site energy use, the portion of the annual site energy use of a *baseline building* design that is due to *regulated energy use*.

BBEUsite = *baseline* building *design* site energy use of a *baseline building design* that is due to both *regulated energy use* and *unregulated energy use*.

c. Replace Table 4.2.1.1 with the following Table:

Table 4.2.1.1-1 Building Performance Factor (BPF_{site})

Building Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.55	0.54	0.58	0.56	0.59	0.59	0.61	0.59	0.56	0.49	0.56	0.53	0.46	0.51	0.53	0.44	0.47	0.45	0.47
Healthcare/ hospital	0.47	0.46	0.47	0.46	0.45	0.43	0.43	0.45	0.44	0.42	0.43	0.42	0.43	0.43	0.46	0.42	0.45	0.44	0.45
Hotel/motel	0.57	0.56	0.58	0.56	0.57	0.55	0.57	0.57	0.59	0.54	0.56	0.57	0.53	0.55	0.57	0.51	0.53	0.50	0.49
Office	0.40	0.40	0.40	0.39	0.38	0.38	0.37	0.39	0.34	0.34	0.37	0.35	0.35	0.37	0.35	0.34	0.35	0.31	0.33
Restaurant	0.57	0.52	0.52	0.51	0.54	0.48	0.55	0.52	0.55	0.55	0.55	0.56	0.57	0.58	0.57	0.59	0.61	0.60	0.61
Retail	0.38	0.36	0.35	0.35	0.32	0.30	0.31	0.31	0.31	0.31	0.31	0.33	0.34	0.31	0.34	0.34	0.33	0.33	0.34
School	0.40	0.42	0.44	0.42	0.40	0.37	0.40	0.37	0.40	0.31	0.35	0.39	0.32	0.36	0.38	0.32	0.31	0.30	0.32
Warehouse	0.20	0.21	0.17	0.19	0.16	0.16	0.18	0.15	0.13	0.25	0.18	0.20	0.31	0.25	0.20	0.36	0.30	0.32	0.35
All others	0.50	0.49	0.49	0.48	0.43	0.39	0.42	0.41	0.45	0.41	0.40	0.44	0.41	0.42	0.44	0.42	0.42	0.41	0.42

d. Add new table, Table 4.2.1.1-2 using the following Table:

Table 4.2.1.1-2 Site Energy Conversion Factors

***Building* Project *Energy* Source**	**Units**	**Site *energy* Btu/unit**
Electricity	kWh	3,412
Natural Gas	Therm	100,000
Propane	Therm	100,000
Distillate fuel oil	Gallon	137,600
District Chilled Water	Ton	12,000
District Steam*	Pound	1,150
District Hot Water	Therm	100,000

*Saturated steam at 1 atmosphere (14.696 psia)

e. Add a new section, Section 4.2.1.1.2, using the following language:

4.2.1.1.2 Site Zero Performance Energy Index. The Site Zero Performance Energy Index ($PEI_{site,zero,t}$) is specified as follows.

$$PEI_{site,zero,t} = 0$$

Informative Note on item e*:* The target can be set to align with a *rating authority* timeline for achieving zero site energy with energy codes. For example, a target value of zero, achieves zero site energy in the current code cycle. If the *rating authority* plans to achieve zero site energy over two code cycles, the target equals 0.5 in the current code cycle and 0 in the second code cycle. If the goal is to achieve zero site energy over three code cycles, the target equals 0.67 in the current code cycle, 0.5 in the second code cycle and 0 in the third code cycle. *Rating authorities* may choose to adopt a different timeframe for achieving zero site energy for *alterations.*

3.1.3 CHANGES TO ASHRAE 90.1-2022 NORMATIVE APPENDIX G

The following changes, items a through g, describe the required modifications to ASHRAE 90.1-2022 Appendix G.

a. Replace Section G1.2.2, in its entirety, with the following language:

G1.2.2 Performance Rating Calculation. The performance of the *proposed design* is calculated in accordance with provisions of this appendix using the formulas provided in Section G1.2.2.1 and Section G1.2.2.2.

Both the *proposed building performance* and the *baseline building performance* shall include all end-use load components within and associated with the building when calculating the Performance Site Energy Index and the Performance Site Zero Performance Energy Index.

Exception to G1.2.2: Energy used to recharge or refuel vehicles that are used for off-*site* transportation purposes shall not be modeled in the *baseline building performance* or the *proposed building performance*.

b. Add a new section, Section G1.2.2.1 using the following language:

G1.2.2.1 Site Performance Energy Index Calculation

$$PEI_{site} = \frac{PBGEU_{site}}{BBEU_{site}}$$

Where:

PEI_{site} = Site Performance Energy Index.

$PBGEU_{site}$ = Proposed building gross site energy use, the regulated and unregulated site energy use of the *proposed design*, calculated in accordance with Appendix G, excluding the contribution of *on-site renewable energy* production and off-site renewable energy procurement.

$BBEU_{site}$ = baseline building design site energy use is the regulated and unregulated energy use of the baseline building design calculated in accordance with Section G1.2

c. Add a new section, Section G1.2.2.2, using the following language:

G1.2.2.2 Site Zero Performance Energy Index Calculation

If $PBGEU_{site} > 0$

$$PEI_{site,zero} = \frac{PBNEU_{site}}{PBGEU_{site}}$$

If $PBGEU_{site} = 0$ or $PBNEU_{site} = 0$

$$PEI_{site,zero} = 0$$

Where:

$PEI_{site,zero}$ = Site Zero Performance Energy Index

$PBNEU_{site}$ = the proposed design net site energy use including the energy reductions

associated with on-site renewable energy production and off-site renewable energy procurement.

$PBGEU_{site}$ = the proposed design gross site energy use, excluding the energy reductions associated with on-site renewable energy production and off-site renewable energy procurement.

And

$$PBNEU_{site} = PBGEU_{site} - AE$$

$$AE = \sum_{i=1}^{n} RE_i * REPF_i$$

Where:

AE = the energy offset from onsite renewable energy production and off-site renewable energy procured in accordance with Section G1.2.2.3.

RE_i = annual energy generation for the i^{th} renewable energy procurement method or class.

n = the total number of renewable energy production and procurement methods or classes.

$REPF_i$ = renewable energy procurement factor for the i^{th} renewable energy procurement method or class from Table G1.2.2.2.

d. Add a new table, Table G1.2.2.2, using the following Table:

Table G1.2.2.2 Renewable Energy Procurement Factors

Class	Procurement Factor	Classification
1	1.0	On-site production
2	1.0	Off-site procurement – In buildings that: 1. Include *equipment* for *on-site renewable energy* with a rated capacity of not less than 7.5 W/ft2 of roof, or 2. Meets exception 1, 2, or 3 to 10.5.1.1
3	0.75	Off-site procurement – Other qualifying with Section G1.2.2.3.1

e. Add a new section, G1.2.2.3, including subsections, using the following language:

G1.2.2.3 Off-site Renewable Energy

G1.2.2.3.1 Off-site procurement paths. The *building* owner shall procure and be credited for the total amount of off-site renewable energy using one or more of the following:

1. A *physical renewable energy purchase agreement.*
2. A *financial renewable energy purchase agreement.*
3. A *community renewable energy facility*.
4. Off-site *directly-owned renewable energy facility.*

The renewable energy source shall be located where the energy can be delivered to the building *site* by any of the following:

1. Direct connection to the off-site renewable energy facility

2. The local utility or distribution entity
3. An interconnected electrical or pipeline network where energy delivery capacity between the generator and the building site is available

G1.2.2.3.2 Off site contract terms. The total off-site renewable energy shall be delivered or credited to the *building site* under an energy contract with a duration of not less than 15 years. The contract shall be structured to survive a partial or full transfer of ownership of the building property.

G1.2.2.3.3 Renewable energy certificate documentation. The property owner or owner's authorized agent shall demonstrate that for an on-site or off-site renewable energy system required to comply this appendix, no RECs or EACS are associated with the renewable energy system or the following provisions for RECS and EACS shall be met:

1. The RECS and EACS are retained and retired by or on behalf of the property owner or tenant for a period of not less than 15 years;
2. The RECS and EACS are created within a 12-month period of the use of the REC; and
3. The RECS and EACS are from an asset placed in service no more than 5 years before the issuance of the certificate of occupancy.

f. Replace Section G1.3.2 item n, in its entirety, with the following:

"Site energy conversion factors used to calculate the proposed design site energy use."

g. Append Section G1.3.2 item q to include the following phrase after the term on-site renewable energy:

"production and off-site renewable energy procurement"

3.2 Net Zero Operational Energy Emissions

The proposed code modifications for net zero operational energy emissions (NZOEE), described in this Section, modify the existing language in ASHRAE 90.1-2022 Sections 3, Section 4, Section 13, and Appendix G. It is intended to be adopted by jurisdictions or rating authorities wanting to achieve NZOEE buildings with the energy code over one to three code cycles. The method requires the use of the performance compliance path and includes two performance metric targets. The Site Performance Energy Index Site (PEI_{site}) provides an efficiency backstop. The Greenhouse Gas Performance Emissions Index ($PEI_{CO2e)}$ measures zero net operational emissions achievement. The modifications establish the NZOEE performance requirements for the code cycle. This includes updated BPF values reflected in Table 4.2.1.1 that require additional reductions in regulated energy use resulting in an estimated 11.5% overall national weighted reduction in total energy use compared to ASHRAE Standard 90.1-2022 values based on code prototype building analysis.

In addressing the operational energy greenhouse gas emissions of buildings, the requirements focus on the emissions associated with building energy consumption and do not address emissions associated with other building operations, such as refrigerants or embodied emissions associated with building materials. The calculation of operational energy greenhouse gas emissions accounts for both combustion and precombustion greenhouse gas emissions. Combustion greenhouse gas emissions are the result of burning a solid or liquid or gaseous fuel, either within the building or to generate electricity, steam, hot water or chilled water that is generated outside the building and used within the building. Precombustion greenhouse gas

emissions are associated with fuel extraction, processing, and transport prior to combustion within the building or to generate electricity, steam, hot water or chilled water used within the building.

3.2.1. CHANGES TO ASHRAE 90.1-2022 SECTION 3

Modify existing definitions in ASHRAE 90.1-2022 Section 3.2 as follows:

Replace references to “annual energy cost” with “annual site energy use” in definitions of ***baseline building performance*** and ***proposed building performance*****.**

Add new definitions into Section 3.2 as follows:

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.

directly-owned renewable energy facility: an off-site renewable energy system under the ownership of the building project owner.

financial renewable energy purchase agreement: a financial arrangement between a renewable energy provider and a purchaser wherein the purchaser pays or guarantees a price to the provider for the project’s renewable energy.

physical renewable energy purchase agreement: a contract for the purchase of renewable energy from a specific renewable energy provider to a purchaser of renewable energy.

renewable energy certificate: a market-based instrument that represents and conveys the environmental, social, and other non-power attributes of 1 MWh of renewable electricity generation or 3,412 kBtu of renewable thermal energy or bioenergy production and could be sold separately from the underlying physical energy associated with renewable energy resources; also known as “energy attribute” and “energy attribute certificate” (EAC).

lower-carbon fuel: a gaseous or liquid fuel that has lower lifecycle greenhouse gas emissions on a per unit energy basis than the equivalent fossil fuel.

3.2.2. CHANGES TO ASHRAE 90.1-2022 SECTION 4

The following changes, items a through e, describe the required modifications to ASHRAE 90.1-2022 Section 4.

a. Replace Section 4.2.1.1, in its entirety, with the following language.

4.2.1.1 New Buildings. New *buildings* shall comply with Sections 4.2.2 through 4.2.5 and Normative Appendix G. Where using Normative Appendix G, the following performance requirements of new *buildings*, *additions* to *existing buildings*, and *alterations* to *existing buildings* shall be met:

a. The Site Performance Energy Index (PEI_{site}) shall be less than or equal to the Site Performance Energy Index Target ($PEI_{site,t}$) calculated in accordance with Section 4.2.1.1.1. Site energy shall be determined using the site energy conversion factors provided in Table 4.2.1.1-2. Conversion factors for energy sources not included in Table 4.2.1.1-2 shall be approved by the rating authority.

b. The Greenhouse Gas Performance Emissions Index (PEI_{CO2e}) shall be less than or equal to the Greenhouse Gas Performance Emissions Index Target ($PEI_{CO2e,t}$) calculated in accordance with Section 4.2.1.1.2. The greenhouse gas emissions associated with the building operation energy use shall be calculated using the emission factors provided in Table 4.2.1.1-3 and Table 4.2.1.1-4.

i. The electricity emission factor from Table 4.2.1.1-4 shall correspond to the property’s eGRID

subregion and to two years after the project permit application year or 2030, whichever is earlier.

ii. Emissions factors other than those in Table 4.2.2(1) shall be permitted for lower-carbon fuels where approved by the *rating authority* and where all the following conditions are met:

1. emissions factors are calculated in accordance with the California Air Resources Board Low Carbon Fuel Standard or the U.S. Environmental Protection Agency Renewable Fuel Standard; and
2. lower-carbon fuels are delivered to the building site under an energy contract with a duration of not less than 15 years and structured to survive a partial or full transfer of ownership of the building property.

iii. Fossil fuel or electricity emissions factors other than those in Tables 4.2.1.1-3 and Table 4.2.1.1-4, including hourly values, shall be permitted where adopted by the *rating authority* and including all of the following:

1. Combustion greenhouse gas emissions associated with the burning of a fuel, either within the building or site or to generate electricity, steam, hot water, or chilled water used within the building or site;
2. Precombustion greenhouse gas emissions associated with fuel extraction, processing, and transport, including fugitive emissions, prior to combustion within the building or site or to generate electricity or thermal energy used within the building or site;
3. Carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4);
4. Where converted to carbon dioxide equivalent (CO_{2e}), a 20-year global warming potential basis;
5. Where applicable, transmission and distribution losses.

iv. Distributed thermal energy emission factors other than those in Table 4.2.1.1-3 shall be permitted where approved the *rating authority* and accounting for all of the following:

1. Input fuel and electricity emission factors in accordance with Table 4.2.1.1-3; Table 4.2.1.1-4 and Section 4.2.1.1(b)(i); Section 4.2.1.1(b)(ii); or Section 4.2.1.1(b)(iii);
2. Conversion efficiency of the heating or cooling plant;
3. Auxiliary equipment and distribution losses associated with delivery of thermal energy to the building.

Informative Note:

As Section 4.2.1.2 and Section 4.2.1.3 are not amended, it is intended for existing buildings and alterations to have the option to comply either prescriptively in accordance with Sections 5 through 11, using Section 12 "*Energy Cost Budget*", or via Appendix G "*Performance Rating Method*" as modified for net-zero operational energy emissions performance.

b. Add a new section, Section 4.2.1.1.1, using the following language:

4.2.1.1.1 Site Performance Energy Index. The Site Performance Energy Index Target ($PEI_{site,t}$) is calculated as follows:

$$PEI_{site,t} = \frac{BBUEU_{site} + BPF_{site} * BBREU_{site}}{BBEU_{site}}$$

Where:

$PEI_{site,t}$ = Site Performance Energy Index Target.

$BBUEU_{site}$ = *baseline building design* unregulated site energy use, the portion of the annual site energy use of a *baseline building design* that is due to *unregulated energy use.*

BPF_{site} = *building performance factor* site from Table 4.2.1.1-1. For *building* area types not listed in Table 4.2.1.1-1, use "All others." Where a *building* has multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types based on their *gross floor area*.

$BBREU_{site}$ = *baseline building design* regulated site energy use, the portion of the annual site energy use of a *baseline building* design that is due to *regulated energy use*.

BBEUsite = *baseline* building *design* site energy use of a *baseline building design* that is due to both *regulated energy use* and *unregulated energy use*.

c. Replace Table 4.2.1.1 with the following Table:

Table 4.2.1.1-1 Building Performance Factor (BPF_{site})

Building Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.55	0.54	0.58	0.56	0.59	0.59	0.61	0.59	0.56	0.49	0.56	0.53	0.46	0.51	0.53	0.44	0.47	0.45	0.47
Healthcare/ hospital	0.47	0.46	0.47	0.46	0.45	0.43	0.43	0.45	0.44	0.42	0.43	0.42	0.43	0.43	0.46	0.42	0.45	0.44	0.45
Hotel/motel	0.57	0.56	0.58	0.56	0.57	0.55	0.57	0.57	0.59	0.54	0.56	0.57	0.53	0.55	0.57	0.51	0.53	0.50	0.49
Office	0.40	0.40	0.40	0.39	0.38	0.38	0.37	0.39	0.34	0.34	0.37	0.35	0.35	0.37	0.35	0.34	0.35	0.31	0.33
Restaurant	0.57	0.52	0.52	0.51	0.54	0.48	0.55	0.52	0.55	0.55	0.55	0.56	0.57	0.58	0.57	0.59	0.61	0.60	0.61
Retail	0.38	0.36	0.35	0.35	0.32	0.30	0.31	0.31	0.31	0.31	0.31	0.33	0.34	0.31	0.34	0.34	0.33	0.33	0.34
School	0.40	0.42	0.44	0.42	0.40	0.37	0.40	0.37	0.40	0.31	0.35	0.39	0.32	0.36	0.38	0.32	0.31	0.30	0.32
Warehouse	0.20	0.21	0.17	0.19	0.16	0.16	0.18	0.15	0.13	0.25	0.18	0.20	0.31	0.25	0.20	0.36	0.30	0.32	0.35
All others	0.50	0.49	0.49	0.48	0.43	0.39	0.42	0.41	0.45	0.41	0.40	0.44	0.41	0.42	0.44	0.42	0.42	0.41	0.42

d. Add new tables, Tables 4.2.1.1-2, 4.2.1.1-3 and 4.2.1.1-4, using the following Tables; electricity greenhouse gas emission factors should only be included in Table 4.2.1.1-4 for the eGRID subregion associated with the adopting jurisdiction or rating authority.

Table 4.2.1.1-2 Site Energy Conversion Factors

***Building* Project *Energy* Source**	**Units**	**Site *energy* Btu/unit**
Electricity	kWh	3,412
Natural Gas	Therm	100,000
Propane	Therm	100,000
Distillate fuel oil	Gallon	137,600
District Chilled Water	Ton	12,000
District Steam*	Pound	1,150
District Hot Water	Therm	100,000

*Saturated steam at 1 atmosphere (14.696 psia)

Table 4.2.1.1-3 Greenhouse Gas Emission Factors

Greenhouse gas emissions associated with site energy usage	**CO_{2e} GWP-20 Emissions**	
	(lb/MWh)	**(kg/MWh)**
Fuels Delivered to Buildings		
Natural gas	611	277
LPG or propane	650	295
Fuel oil (residual)	737	334
Fuel oil (distillate)	714	324
Coal	842	382
Gasoline	742	337
Lower-carbon fuels	Calculated in accordance with Section 4.2.1.1(b)(ii)	
Other fuels not specified in this table	842	382
Thermal Energy		
Chilled water	0.24*electricity emission factor for the appropriate eGrid subregion	
Steam	1028	466
Hot Water	971	440

Table 4.2.1.1-4 Electricity Greenhouse Gas Emission Factors*

eGRID Subregion	CO_{2e} GWP-20 Emissions (lb/MWh)						
	20-Year Analysis Start Year**						
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
AZNMc	458	439	438	438	446	454	465
CAMXc	132	106	91	75	67	59	53
ERCTc	258	230	216	199	197	195	197
FRCCc	684	691	706	723	747	772	793
MROEc	639	628	628	628	633	638	645
MROWc	420	407	409	412	423	433	442
NEWEc	648	625	608	590	577	565	556
NWPPc	317	283	263	243	235	227	227
NYSTc	210	169	134	99	76	53	40
RFCEc	909	902	901	900	906	912	918
RFCMc	1141	1140	1140	1138	1137	1136	1135
RFCWc	990	977	967	955	947	939	933
RMPAc	485	454	435	417	412	407	410
SPNOc	432	411	408	406	418	431	442
SPSOc	498	472	461	450	452	454	464
SRMVc	964	935	910	881	859	837	816
SRMWc	629	599	581	556	541	527	518
SRSOc	999	1003	1018	1027	1043	1058	1064
SRTVc	1151	1162	1173	1179	1183	1188	1184
SRVCc	548	518	500	479	465	452	438

***** The total (combined combustion and pre-combustion) greenhouse gas emissions factors (referred to as CO_{2e} and associated with CO_2, CH_4, and N_20) are listed in Table 4.2.2(2) for fossil fuels and thermal energy and Table 4.2.2(3) for the production of electricity. The delivered fossil fuel factors are U.S. averages based on 2019 EIA and EPA data and a 20-year greenhouse gas global warming potential. The electricity conversion factors are 2022 Cambium long-run marginal emission rates. The electricity data are site end-use values for the Cambium mid-case scenario, based on a 20-year levelized analysis period, zero discount rate, and a 20-year greenhouse gas global warming period. The Cambium eGRID subregions are based on balancing area and do not completely align with EPA eGRID subregion, which are based on utility service territory. Look up tables that indicate $eGRID_c$ subregions by zip code or county are included in the published Cambium 2022 LRMER workbooks available at .https://data.nrel.gov/submissions/206. More details on the Cambium input assumptions and methodology are described in the documentation report, available at https://www.nrel.gov/docs/fy23osti/84916.pdf.

** The analysis start year corresponds to the year that is two years after the project permit application.

Informative Notes:

Table 4.2.2(1) and Table 4.2.2(2) list aggregate annual emissions of GHGs using standard CO_2 equivalent (CO_{2e}) emission metrics for CO_2, CH_4, and N_20 for a 20-year GWP emissions rate period. When comparing or combining CO_{2e} emission values, care should be taken to ensure that the values have been computed for a consistent GWP time horizon.

e. Add a new section, Section 4.2.1.1.2, using the following language:

4.2.1.1.2 Greenhouse Gas Performance Emissions Index. The Greenhouse Gas Performance Emissions Index Target ($PEI_{CO2e,t}$) is specified as follows.

$$PEI_{CO2e,t} = 0$$

Informative Note for item e: The Greenhouse Gas Performance Emissions Index target can be set to align with a *rating authority* timeline for achieving zero site emissions with energy codes. For example, a target value of zero, achieves zero emissions in the current code cycle. If the *rating authority* plans to achieve zero emissions over two code cycles, set the target equal to 0.5 in the current code cycle and update the target to be 0 in the second code cycle. If the goal is to achieve zero emissions over three code cycles, the target equals 0.67 in the current code cycle, 0.5 in the second code cycle and 0 in the third code cycle. *Rating authorities* may choose to adopt a different timeframe for achieving zero emissions for *alterations.*

3.2.3. CHANGES TO 90.1-2022 NORMATIVE APPENDIX G

The following changes, items a through g, describe the required modifications to ASHRAE 90.1-2022 Appendix G.

a. Replace Section G1.2.2, in its entirety, with the following language:

G1.2.2.2 Performance Rating Calculation. The performance of the *proposed design* is calculated in accordance with provisions of this appendix using the formulas provided in Section G1.2.2.1 and Section G1.2.2.2.

Both the *proposed building performance* and the *baseline building performance* shall include all end-use load components within and associated with the building when calculating the Site Performance Energy Index and the Greenhouse Gas Performance Emissions Index.

Exception to G1.2.2: Energy used to recharge or refuel vehicles that are used for off-*site* transportation purposes shall not be modeled in the *baseline building performance* or the *proposed building performance*.

b. Add a new section, Section G1.2.2.1, using the following language:

G1.2.2.1 Site Performance Energy Index Calculation

$$PEI_{site} = \frac{PBGEU_{site}}{BBEU_{site}}$$

Where:

PEI_{site} = Site Performance Energy Index.

$PBGEU_{site}$ = Proposed building gross site energy use, the regulated and unregulated site energy use of the *proposed design,* calculated in accordance with Appendix G, excluding the contribution of *on-site renewable energy* production and off-site renewable energy procurement.

$BBEU_{site}$ = *baseline building design* site energy use is the regulated and *unregulated energy use* of the *baseline building design* calculated in accordance with Section G1.2.

c. Add a new section, Section G1.2.2.2, using the following language:

G1.2.2.2 Greenhouse Gas Performance Emissions Index

If $PBGEU_{CO2e} > 0$

$$PEI_{CO2e} = \frac{PBNEU_{CO2e}}{PBGEU_{CO2e}}$$

If $PBGEU_{CO2e} = 0$ or $PBNEU_{CO2e} = 0$

$$PEI_{CO2e} = 0$$

Where:

PEI_{CO2e} = Greenhouse Gas Performance Emissions Index

$PBNEU_{CO2e}$ = the *proposed design* emissions associated with the proposed building net site energy including the emission reductions associated with on-site renewable energy production and off-site renewable energy procurement, based on the greenhouse gas emission factors in accordance with Section 4.2.1.1(b).

$PBGEU_{,CO2e}$ = the *proposed design* gross greenhouse gas emissions associated with the proposed building site energy use, excluding the emission reductions associated with on-site renewable energy production and off-site renewable energy procurement, based on greenhouse gas emission factors provided in accordance with Section 4.2.1.1(b).

And

$$PBNEU_{CO2e} = PBGEU_{CO2e} - AE$$

$$AE = \sum_{i=1}^{n} RE_i * REPF_i * GHG_i$$

Where:

AE = the avoided emissions from onsite renewable energy production and off-site renewable energy procured in accordance with Section G1.2.2.3.

RE_i = annual energy generation for the i^{th} renewable energy procurement method or class.

n = the total number of renewable energy production and procurement methods or classes.

$REPF_i$ = renewable energy procurement factor for the i^{th} renewable energy procurement method or class from Table G1.2.2.2-1.

GHG_i = greenhouse gas emission conversion factor from Tables 4.2.1.1-3 and 4.2.1.1-4. For renewable electricity resources for projects within the continental U.S., select the value corresponding to the property's eGRID subregion or use locally derived values approved by the rating authority.

d. Add a new table, Table G1.2.2.2, using the following Table:

Table G1.2.2.2 Renewable Energy Procurement Factors

Class	Procurement Factor	Classification
1	1.0	On-site production
2	1.0	Off-site procurement – In buildings that: 1. Include *equipment* for *on-site renewable energy* with a rated capacity of not less than 7.5 W/ft2 of roof area, or 2. Meets exception 1, 2, or 3 to 10.5.1.1
3	0.75	Off-site procurement – Other qualifying with Section G1.2.2.3.1

e. Add a new section G1.2.2.3, including all subsections, using the following language:

G1.2.2.3 Off-site Renewable Energy

G1.2.2.3.1 Off-site procurement paths. The *building* owner shall procure and be credited for the total amount of off-site renewable energy using one or more of the following:

1. A *physical renewable energy purchase agreement.*
2. A *financial renewable energy purchase agreement.*
3. A *community renewable energy facility*.
4. Off-site *directly-owned renewable energy facility*.

The renewable energy source shall be located where the energy can be delivered to the building *site* by any of the following:

1. Direct connection to the off-site renewable energy facility
2. The local utility or distribution entity
3. An interconnected electrical or pipeline network where energy delivery capacity between the generator and the building site is available

G1.2.2.3.2 Off site contract terms. The total off-site renewable energy shall be delivered or credited to the *building site* under an energy contract with a duration of not less than 15 years. The contract shall be structured to survive a partial or full transfer of ownership of the building property.

G1.2.2.3.3 Renewable energy certificate documentation. The property owner or owner's authorized agent shall demonstrate that for an on-site or off-site renewable energy system required to comply this appendix, no RECs or EACS are associated with the renewable energy system or the following provisions for RECS and EACS shall be met:

1. The RECS and EACS are retained and retired by or on behalf of the property owner or tenant for a period of not less than 15 years;
2. The RECS and EACS are created within a 12-month period of the use of the REC; and
3. The RECS and EACS are from an asset placed in service no more than 5 years before the issuance of the certificate of occupancy.

f. Replace Section G1.3.2 item n, in its entirety, with:

"Greenhouse gas emission conversion factors used to calculate the *proposed design* greenhouse gas emissions."

g. Append Section G1.3.2 item q to include the following phrase after the term on-site *renewable energy:*

"production and off-site renewable energy procurement"

3.2.4 CHANGES TO ASHRAE 90.1-2022 SECTION 13

Add the following references into ASHRAE 90.1-2022 Section 13.

Reference		Section
California Air Resources Board		
LCFS 22-02	Low Carbon Fuel Standard	4.2.1.1
U.S. Environmental Protection Agency		
40 CFR Part 80 - 2023	Renewable Fuel Standard	4.2.1.1

3.3 Example Calculation of NZOEE Compliance Metrics

This section demonstrates the application of the plug-in NZOEE commercial code language (Section 3.2) to calculate target and proposed design compliance metrics. The example highlights the impact of different eGRID subregion emission factors on the amount of solar PV electricity generation needed to achieve NZOEE. In Case 1, the example considers an eGRID subregion with emissions factors less than the national average. In Case 2, the example considers an eGRID subregion with emission factors greater than the national average. For each case, the calculations are completed for a mixed-fuel building (Cases 1a and 2a) and an all-electric building (Cases 1b and 2b). In the example, the gross energy use of the project mixed-fuel and all-electric buildings are equal and meet but do not exceed the site energy efficiency backstop (the Site Performance Energy Index Target). Therefore, in the example, the impact of electrification affects the proportion of energy supplied by electricity but not the building site energy use.

Step 1. Demonstrate the project meets the Site Performance Energy Index Target

1. Look up the BPF value associated with the project building type and climate zone provided in Table 4.2.1.1-1.
2. Determine the baseline and proposed design total annual energy use (for example in kBtu/ft^2 year) by applying the site energy conversion factors in Table 4.2.1.1-2 to the Appendix G building simulation results.
3. Calculate Site Performance Energy Index Target ($PEI_{site,t}$) using the equation in Section the 4.2.1.1.1.
4. Calculate the Site Performance Energy Index for the proposed building following Section G1.2.2.1.
5. Verify that the PEI_{site} is less than or equal to the $PEI_{site,t}$.

As indicated in Table 1, the site energy use values are based on the medium office building located in climate zone 4A, and do not vary across cases. The example building performance meets the site energy use target.

Table 1. Example Calculation of the Site Performance Energy Index

NZOEE PEIsite Compliance	Case 1a Med Office 4A Mixed Fuel	Case 1b Med Office 4A All-Electric	Case 2a Med Office 4A Mixed Fuel	Case 2b Med Office 4A All-Electric o
Building Performance Factor (BPF)	0.34			
Baseline Building Energy Use Site (kBtu/ ft^2 yr)	49.7			
Baseline Building Regulated Energy Use (kBtu/ ft^2 yr)	39.4			
Baseline Building Unregulated Energy Use (kBtu/ ft^2 yr)	10.3			
Code Cycle 1 $PEI_{site,target}$ (kBtu/ ft^2 yr)	0.48			
Proposed Building Gross Energy Use (kBtu/ ft^2 yr)	23.7			
Proposed Building PEI_{site}	0.48			
PEI_{site} =< $PEI_{site,t}$	Yes			

Step 2. Calculate the greenhouse gas emissions associated with the gross energy use of the proposed building

1. Determine the break down in annual site energy use by source energy type (e.g., natural gas, electricity, etc.) for the proposed design building based on the Appendix G building simulation results.
2. Look up the site energy conversion factors in Table 4.2.2.1-2 and the corresponding greenhouse house gas emission factors provided in Table 4.2.1.1-3 and 4.2.1.1-4.
3. Apply the factors and determine the proposed design gross annual greenhouse gas emissions.

As indicated in Table 2, the electricity emission factors differ between Case 1 and Case 2. The percent electricity also differs between subcases *a* and *b*. But the total annual site energy use is stipulated to be the same for each case and subcase. The annual greenhouse gas operational energy use emissions do vary. For Case 1, a grid with lower than average emissions, the total annual emissions are lower for the all-electric case. For Case 2, a grid with higher than average emissions, the total annual emissions are not lower for the all-electric case. This results from the electricity CO_{2e} emissions factor being higher than that for natural gas, which is the fuel type displaced by electrification.

Table 2. Example calculation of the greenhouse gas emissions associated with the proposed design gross annual energy use

NZOEE Greenhouse Gas Emissions Calculation	Case 1a Med Office Mixed Fuel	Case 1b Med Office All- Electric	Case 2a Med Office Mixed Fuel	Case 2b Med Office All-Electric
Natural Gas CO_{2e} Emissions Factor (lb/MWH)	611			
Electricity CO_{2e} Emissions Factor (lb/MWH)	210		990	
Proposed Building Electricity	80%	100%	80%	100%
Proposed Building Natural Gas Proportion	20%	0%	20%	0%
Proposed Building Gross Annual Energy Use (kBtu/ft^2 year)	23.7	23.7	23.7	23.7
Proposed Building Gross Annual Greenhouse Gas Emissions (lbs/ft^2 year)	2.0	1.5	6.4	6.9

Step 3. Determine the annual energy production needed from renewable energy resources to comply with the greenhouse gas performance emissions index target ($PEI_{CO2e,t}$)

1. Identify the target compliance value for the greenhouse gas performance emissions index established by the jurisdiction. The value is specified in Section 4.2.1.1.2.
2. Determine the net annual emissions to be avoided by renewable energy sources based on the target value and the proposed building gross annual emissions.
3. Determine the annual energy generation produced by the renewable energy resource that provides the needed avoided emissions.

For the example, the avoided emissions will be provided by an on-site PV electric system. For renewable electricity energy production, the associated avoided emissions are based on the property's eGRID subregion emissions factor. The procurement factor for on-site production is one, as indicated in Table G1.2.2.2, and no production derating is necessary. Table 3 shows the needed amount of annual energy produced by the on-site system required to achieve compliance. To determine the value, the avoided emissions are divided by the eGRID emissions factor and multiplied by the appropriate energy conversion factor (e.g., 3412 kBtu/MWh or 1000 kWh/MWh). Due to the one-for-one tradeoff for electricity use and production, the two all-electric building cases need the same level of PV electric production regardless of their eGRID subregion. For electric grids with emissions lower than natural gas, the required PV electric production needed for NZOEE compliance is lower for the all-electric building than the mixed-fuel building.

Table 3. Example calculation of the greenhouse gas emissions associated with the proposed design gross annual energy use

NZOEE PEI_{CO2e} Compliance	**Case 1a**	**Case 1b**	**Case 2a**	**Case 2b**
	Med Office Mixed Fuel	**Med Office All-Electric**	**Med Office Mixed Fuel**	**Med Office All-Electric**
$PEI_{CO2e,\ target}$ (Net/Gross)	0			
Proposed building gross annual emissions rate (lbs/ft^2 year)	2.0	1.5	6.4	6.9
Avoided emissions needing to be produced from renewables (lbs/ft^2 year)	2.0	1.5	6.4	6.9
eGRID CO_{2e} emissions factor (lb/MWH)	210		990	
PV electric production needed for compliance (kBtu/ft^2 year)	32.7	23.7	21.9	23.7
PV electric production needed for compliance (kWh/ft^2 year)	9.6	7.0	6.4	7.0

References

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