Chapter 6: Energy Conservation, Efficiency and CO_2e Emission Reduction

General Comments

Chapter 6 requires that buildings and building sites be designed, constructed, commissioned and operated for the effective use of energy. Included in the chapter are provisions for all of the following:

- Energy metering, monitoring and reporting (see Section 603).
- Specific appliances and equipment (see Section 609).
- Building renewable energy systems (see Section 610).
- Energy systems commissioning and completion (see Section 611).

Where indicated by the jurisdiction in Table 302.1, buildings must also comply with the automated demand response infrastructure requirements of Section 604.

The code contains three compliance paths: performance, prescriptive, and outcome based. These paths are generally available for buildings of all sizes and occupancies that follow the minimum compliance requirements in the code. Where the jurisdiction requires enhanced energy performance in Table 302.1, only the performance path shall be used to demonstrate compliance. Note that Section 302.1.1 exempts buildings that are 25,000 square feet (2323 m^2) or less in total area from enhanced energy performance requirements if they use the prescriptive compliance path.

Purpose

Chapter 6 is intended to provide flexibility and to permit the use of innovative approaches to achieve the effective use of energy.

SECTION 601 GENERAL

601.1 Scope. The provisions of this chapter regulate the design, construction, commissioning, and operation of buildings and their associated building sites for the effective use of energy.

❖ Chapter 6 is broad in its application and establishes when the regulations contained in the code related to the effective use of energy must be followed. In general, the requirements address aspects of system design, modeling, metering, construction, and startup that affect the energy performance of the building, including design; model performance; energy metering, monitoring and reporting; automated demand response (Auto-DR) infrastructure; building envelope systems; building mechanical systems; building service water heating systems; building electrical power and lighting systems; specific appliances and equipment; building renewable energy systems; and energy systems commissioning and completion.

601.2 Intent. This chapter is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy.

❖ Because Chapter 6 regulates such a wide variety of building types there must be flexibility in its application. The goal is to achieve energy-efficient buildings whether they are designed on performance-based compliance or prescriptive-based compliance. Buildings consume 40 percent of the energy used in this country. Each building has challenges and opportunities that are unique for saving energy. The provisions of this chapter will provide flexibility to achieve the effective use of energy for human comfort or to protect the contents using a wide variety of innovative approaches and techniques. In the prescriptive path, a large number of specified choices that comply with the code are listed, providing the designer with the necessary flexibility to meet the owner's needs, while at the same time simplifying the implementation of the code. In the performance path, innovative approaches that lead to energy efficiency are encouraged, even if the approach is not specifically listed in the code. This principle is applied to methods for determining compliance with the code and the building construction techniques used to meet the code. The integrated design must be evaluated to ensure that it meets the code requirements through either path.

601.3 Application. Buildings and their associated building sites shall comply with Section 601.3.1, 601.3.2 or 601.3.3.

❖ Chapter 6 provides three alternative paths for compliance with the energy requirements of this code: performance based, prescriptive based, and outcome based. These compliance paths are described in Sections 601.3.1, 601.3.2, and 601.3.3, respectively.

601.3.1 Performance-based compliance. Buildings designed on a performance basis shall comply with Sections C402.5, C403.2, C404, C405.2, C405.3, C405.5 and C405.6 of the *International Energy Conservation Code* and with Sec-

tions 601.4, 602, 608.6, 608.7, 608.8, 608.9, 609 and 610 of this code.

❖ The performance-based compliance path is designed to establish a threshold for energy use and CO_2e emissions relative to a baseline building that is configured in accordance with ASHRAE Standard 90.1 Appendix G, while also accounting for plug loads (Section 608.6), fuel lighting systems (Section 608.7), electrical system issues (Section 608.8), and exterior lighting (Section 608.9). The performance path also requires compliance with minimum energy-efficiency requirements for fixed and portable appliances (Section 609), renewable energy systems (Section 610), and, by reference to the minimum requirements in Section 601.4, the code also requires commissioning in accordance with Section 611 and consideration of auto-demand response infrastructure where required by Section 604.1). The references to the *International Energy Conservation Code*® (IECC®) are references to traditional mandatory requirements that have always been required in the IECC when the performance path for compliance was chosen in the IECC. To be consistent with the IECC, these minimum prescriptive requirements are applicable:

- Section C402.5: Air leakage.
- Section C403.2: Provisions applicable to all mechanical systems.
- Section C404: Service water heating.
- Section C405.2: Lighting controls.
- Section C405.3: Exit signs.
- Section C405.5: Exterior lighting.
- Section C405.6: Electrical energy metering.

601.3.2 Prescriptive-based compliance. Buildings designed on a prescriptive basis shall comply with Sections C402, C403, C404 and C405 of the *International Energy Conservation Code*, and with the requirements of Sections 601.4, 605, 606, 607, 608, 609 and 610 of this code.

❖ Buildings that follow the prescriptive path need to comply with the requirements of Sections C402, C403, C404 and C405 of the IECC and Sections 605, 606, 607, 608, 609, 610 and 611 of this code. This includes building envelope provisions (see Section 605 and IECC Section C402) and minimum requirements for mechanical systems (see Section 606 and IECC Section C403), service water heating systems (see Section 607 and IECC Section C404), electrical and power systems (see Section 608 and IECC Section C405), fixed and portable appliances (see Section 609), renewable energy systems (see Section 610) and by reference to the minimum requirements in Section 601.4. The code also requires commissioning in accordance with Section 611 and consideration of auto-demand response infrastructure where required by Section 604.1. The prescriptive path is limited to those designs that fully comply with each of these sections.

601.3.3 Outcome-based compliance. Buildings designed on an outcome basis shall comply with Sections 601.4, 610 and 612, and with the *International Energy Conservation Code*.

❖ Outcome-based compliance is a method of determining compliance by measuring the actual energy usage of the building once the building and systems are in full operation. The basic requirements for the outcome-based method are provided in Section 612. In addition, the building is required to comply with the provisions of the IECC, the provisions of Section 610 for renewable energy systems, and by reference to the minimum requirements in Section 601.4. The code also requires commissioning in accordance with Section 611 and consideration of auto-demand response infrastructure where required by Section 604.1.

601.4 Minimum requirements. Buildings shall be provided with metering complying with Section 603, and commissioning complying with Section 611. Where required in accordance with Section 604.1, building shall be provided with automated-demand response complying with Section 604.

❖ All buildings, no matter which compliance path is chosen for the building, must be provided with energy metering, monitoring and reporting in accordance with Section 603. The building(s) commissioning shall comply with Section 611 of the code. Metering energy usage allows the user to know what energy has been consumed. With this information, one can work toward reducing the buildings' energy usage. Commissioning the building helps ensure that the building equipment and systems perform as designed, rather than as installed. If required by the jurisdiction, automated demand response shall be provided in accordance with the provisions of Section 604 (see commentary, Section 604).

601.5 Multiple buildings on a site and mixed use buildings. Where there is more than one building on a site and where a building has more than one use in the building, each building or each portion of a building associated with a particular use shall comply with Section 601.5.1 or 601.5.2, or a combination of both.

❖ Multiple buildings on a site and buildings with more than one use (e.g., assembly, business, storage, etc.) are required to comply with either Section 601.5.1 or Section 601.5.2, or both, depending on the particular use. This clarifies for the designer the methodology to be used in allocating energy use for more complex building configurations and uses.

601.5.1 Multiple buildings on a site. For building sites with multiple buildings, the energy use associated with the building site shall be assigned on a proportional basis to each building based on total net floor area of each building in relation to the total net floor area of all buildings on the building site.

Where energy is derived from either renewable or waste energy, or both sources located on the building site, on or in

individual buildings and delivered to multiple buildings, the energy so derived shall be assigned on a proportional basis to the buildings served based on building net floor area.

Exception: Where it can be shown that energy to be used at the building site is associated with a specific building, that energy use shall be assigned to that specific building.

❖ The approach for allocating energy use for multiple buildings is proportional energy use based on the size of each building in gross square feet (square meters) of floor area. This simplifies the allocation procedure compared to other approaches such as number of occupants or level of process activity that cannot be determined as easily during the design and construction phases.

If the multiple building facility is set up such that the energy consumed in each building can be determined separately, then this is a more accurate way to assign energy use. In some cases, this is desirable when the building uses are very different.

601.5.2 Mixed use buildings. Where buildings have more than one use, the energy use requirements shall be based on each individual occupancy.

❖ This section provides specific guidance for buildings that have multiple uses to ensure that the most equitable compliance requirements apply to the intended use of each building occupancy category. For buildings with more than one use, the energy use requirements for specific areas of the building are based on the individual occupancy category in that area of the building.

SECTION 602
PERFORMANCE-BASED COMPLIANCE

❖ The requirements of Section 602 are the core of the code's performance-based energy requirements. Section 602.1 requires that modeling evaluate annual source energy consumption normalized by building floor area in accordance with Section 602.2. Performance-based designs must have a zero energy performance index (zEPI) of not more than 50 as determined in accordance with Equation 6-1. Section 602.3 establishes maximum allowable CO_2e emissions requirements associated with the performance-based design in accordance with Equation 6-2.

As indicated previously, the options in Chapter 3 may have a significant impact on energy requirements. Where the jurisdiction indicates a "zEPI of Jurisdictional Choice" in Table 302.1, buildings must achieve a zEPI scalar no greater than the Chapter 6 zEPI "point of entry" of 50, or a more stringent (lower) value if the jurisdiction indicates an enhanced performance requirement as its "zEPI of Jurisdictional Choice." This allows individual jurisdictions to select their own performance targets as long as they are at least as stringent as the code point of entry.

602.1 Performance-based compliance. Compliance for buildings and their sites to be designed on a performance basis shall be determined by predictive modeling of both energy performance and CO_2e emissions. Predictive energy modeling shall use source energy kBtu unit measure based on compliance with Section 602.2. Predictive CO_2e emissions modeling shall be in accordance with Section 602.3.

❖ The performance-based compliance path enables users to design their building to meet a specified energy performance target while allowing a great deal of flexibility in the specific design choices. The performance target is based on annual source energy consumption per square foot of floor area and associated total annual CO_2e emissions compared to a defined reference building, including all uses. Two key aspects of a performance path are the ability to trade off building design options to meet a specific target and the opportunity to use technology options that are not specifically addressed in the code as long as the approved modeled performance is at least as stringent as the source energy and CO_2e emissions performance targets.

602.2 Energy performance modeling. Performance-based designs shall demonstrate a zEPI of not more than 50 as determined in accordance with Equation 6-1.

$$zEPI = 52 \times (\text{Proposed building performance}/\text{Baseline building performance}) \quad \textbf{(Equation 6-1)}$$

where:

Proposed Building Performance = The proposed building performance in source kBtu for the proposed design of the building and its site calculated in accordance with Section 602.2.1.

Baseline Building Performance = The baseline building performance in source kBtu for a baseline building and its site calculated in accordance with Section 602.2.1.

52 = a fixed value representing the performance of a baseline building designed to comply with ASHRAE Standard 90.1-2013.

❖ The definition of zEPI in Section 202 indicates that a zEPI of 100 is intended to represent the median energy used by commercial buildings of similar occupancy in the benchmark year of 2000. A zEPI of 0 is intended to represent a net zero energy building, or a building that consumes no more energy than it produces.

Because studies have indicated that buildings constructed in accordance with the 2006 IECC consume approximately 27 percent less energy than buildings of similar occupancy in operation circa 2000, Section 602.2.1 of Public Version 2.0 of the code deemed buildings constructed in accordance with the 2006 IECC to have a zEPI of 73 (27 percent less than 100). As the 2012 edition of the code is intended to require energy performance that is at least 30 percent better than buildings constructed in accordance with the 2006 IECC, Section 602.1.1 of the 2012 code deemed a zEPI of 51 (30 percent less than 73) as the "point of entry" to the performance-based provisions of the code. For the 2015 code, a zEPI of 50 is set as the point of entry, representing a slight increase in energy efficiency from the 2012 code.

The goal of carbon neutrality is adopted in the positions and policies of the American Institute of Architects (AIA), the U.S. Conference of Mayors, the National Governor's Association and many other organizations. The zEPI concept is consistent with Architecture 2030, the EPA Energy Star program, ASHRAE Building EQ, and energy rating systems used in California and other states.

Equation 6-1 is the cornerstone of the performance-based compliance path. The proposed building performance and baseline building performance for a building and its site are calculated in accordance with Section 602.2.1, using Appendix G to ASHRAE 90.1, as modified by Sections 602.2.1.1 and 602.2.1.2. Both the proposed building performance use and the baseline building performance calculated in accordance with Appendix G of ASHRAE 90.1 must be converted to source energy in accordance with Sections 602.2.1.1 and 602.2.1.2. The annual energy use before conversion to source energy is the building's net annual energy requirement by energy form after on-site renewable energy and waste heat recovery are deducted (i.e., energy delivered at the meter). An example of deducted renewable energy is electricity produced by photovoltaic panels producing electricity that is used by the building, or under certain circumstances, sold back to the grid. The end result of the renewable energy production or waste heat recovery is to reduce energy delivered at the utility meter.

Based on energy performance modeling of buildings that comply with Appendix G to ASHRAE 90.1 compared to commercial buildings of similar occupancy constructed in accordance with ASHRAE 90.1-2013, the baseline performance value for comparisons between the baseline performance and the proposed performance in Equation 6-1 is set at 52.

602.2.1 Modeling methodology. The proposed building performance and the baseline building performance of the building and building site shall be calculated in accordance with Appendix G to ASHRAE 90.1, as modified by Sections 602.2.1.1 and 602.2.1.2. The energy use modeling shall include all energy used for building and site functions and anticipated occupancy.

❖ Appendix G to ASHRAE 90.1 includes detailed modeling rules for rating the energy efficiency of high-performance building designs that exceed minimum energy codes such as the IECC. Appendix G uses a performance rating method that permits annual energy consumption calculations and cost comparisons between a baseline building and a proposed building. Using the Appendix G methodology, both baseline performance and proposed performance are sensitive to key parameters needed for modeling the building performance, including building occupancy type, size, configuration, schedules, envelope, lighting systems, mechanical systems, process and plug loads, location and climate.

602.2.1.1 Energy units. The building performance calculations in Section G3 of ASHRAE 90.1 shall be based on energy use instead of energy cost. Energy use shall be converted to consistent units by multiplying the nonrenewable energy fossil fuel use at the utility meter or measured point of delivery to Btus and multiplying by the conversion factor in Table 602.2.1.1 based on the geographical location of the building.

❖ The code uses a source energy methodology for its energy performance compliance requirements. The performance calculations in Appendix G to ASHRAE 90.1 use an energy cost methodology for baseline and proposed building comparisons. To align the Appendix G methodology with the code methodology, it is necessary to shift the basis of comparison from energy cost to source energy using the relevant conversion factors based on site energy consumption by energy form determined using the Appendix G calculation methodology.

TABLE 602.2.1.1
ELECTRICITY GENERATION ENERGY CONVERSION FACTORS BY EPA eGRID SUB-REGION

eGRID 2010 SUB-REGION ACRONYM	eGRID 2010 SUB-REGION NAME	ENERGY CONVERSION FACTOR
AKGD	ASCC Alaska Grid	3.15
AKMS	ASCC Miscellaneous	1.90
ERCT	ERCOT All	3.08
FRCC	FRCC All	3.26
HIMS	HICC Miscellaneous	3.67
HIOA	HICC Oahu	3.14
MORE	MRO East	3.50
MROW	MRO West	3.64
NYLI	NPCC Long Island	3.47
NEWE	NPCC New England	3.03
NYCW	NPCC NYC/Westchester	3.21
NYUP	NPCC Upstate NY	2.66
RFCE	RFC East	3.28
RFCM	RFC Michigan	3.35
RFCW	RFC West	3.29
SRMW	SERC Midwest	3.40
SRMV	SERC Mississippi Valley	3.20
SRSO	SERC South	3.20
SRTV	SERC Tennessee Valley	3.30
SRVC	SERC Virginia/Carolina	3.24
SPNO	SPP North	3.57
SPSO	SPP South	3.26
CAMX	WECC California	2.89
NWPP	WECC Northwest	2.32
RMPA	WECC Rockies	3.82
AZNM	WECC Southwest	3.10
None	Not included	3.15

❖ Table 602.2.1.1 uses the EPA's eGRID 2010 average power plant and distribution system efficiency data for

each eGRID subregion to determine the electric power source energy conversion factors. Use of regional values has the potential to reflect more accurately the actual source energy impact of the building's electricity use. eGRID subregion level data provide a good regional boundary for electricity source energy and emission calculations. Power is frequently wheeled within each subregion, and much less frequently wheeled across subregions. The EPA also uses eGRID subregions in its greenhouse gas inventory and tracking emissions calculation methodology in Portfolio Manager.

602.2.1.2 Site to source electric power conversion. In calculating the proposed building performance and the baseline building performance, electric energy used shall be calculated in source energy by multiplying the electric power use at the utility meter or measured point of delivery in Btus by the conversion factor in Tables 602.2.1.1 and 602.2.1.2 based on the geographical location of the building.

❖ This section of the code is intended to ensure that the electric energy used to calculate the annual energy index will be in consistent units by converting the electric power use at the utility meter or measured point of delivery to Btus and multiplying by the conversion factor in Tables 602.2.1.1 and 602.2.1.2, based on the geographical location of the building.

TABLE 602.2.1.2
U.S. AVERAGE BUILDING FUELS ENERGY CONVERSION FACTORS BY FUEL TYPE

FUEL TYPE	ENERGY CONVERSION FACTOR
Natural Gas	1.09
Fuel Oil	1.19
LPG	1.15
Purchased District Heating—Hot Water	1.35
Purchased District Heating—Steam	1.45
District Cooling	0.33 × value in Table 602.2.1.1
Other	1.1

❖ Table 602.2.1.2 uses national average extraction, processing, transportation and distribution system efficiency data to determine the source energy conversion factors for natural gas, propane and fuel oil, since these are the dominant fuel sources directly used in buildings. Dispersed extraction, gathering, and processing plants, national transportation networks (pipelines and trucking), variations in local distribution system networks, and relatively low loss factors in each segment make it difficult to develop useful regional conversion values for these fuels.

602.3 CO_2e emissions modeling. The CO_2e emissions for the proposed and baseline building and building site shall be based on the proposed and baseline building performance calculated in accordance with Section 602.2.1 and as modified by Sections 602.3.1 and 602.3.2. The emissions associated with the proposed design shall be less than the CO_2e emissions associated with the standard reference design in accordance with Equation 6-2.

$$CO_2e \text{ pdp} \le (\text{zEPI} \times CO_2e \text{ bbp})/52 \qquad \textbf{(Equation 6-2)}$$

where:

zEPI = score determined in accordance with Section 602.2.

CO_2e pdp = emissions associated with the proposed building performance.

CO_2e bbp = emissions associated with the baseline building performance in accordance with Section 602.2.

52 = A fixed value representing CO_2e emissions of a baseline building designed to comply with the 2012 edition of the *International Energy Conservation Code*.

❖ The code establishes requirements that reduce the negative impact of the built environment on the natural environment. As addressed in Section 602.2, a key element of the code is CO_2e emission reductions.

The building's CO_2e emissions requirement is linked to the building's zEPI in Equation 6-2. This ensures that the flexible energy efficiency measures chosen by the user to comply with the energy requirements in the performance path under Section 602.1 do not inadvertently result in higher CO_2e emissions relative to the baseline building measures in the reference building.

Equation 6-2 establishes the maximum allowable CO_2e emissions for the building. It compares the CO_2e emissions of the proposed design with the CO_2e emissions of the baseline design from Appendix G of ASHRAE 90.1, and it reduces the allowable emissions based on the zEPI of the proposed building. For instance, if the proposed building zEPI were 50, then the CO_2e emissions of the proposed building would need to be less than or equal to 96 percent (50/52) of the CO_2e emissions of the baseline building. This ensures that innovative system design options in the proposed building do not inadvertently increase CO_2e emissions relative to the baseline systems.

602.3.1 CO_2e emissions from electricity. Emissions associated with use of electric power shall be calculated by converting the electric power used by the building at the electric utility meter or measured point of delivery, to kWh, and multiplying by the CO_2e conversion factor in Table 602.3.1 based on the EPA eGRID Sub-region in which the building is located.

❖ Table 602.3.1 uses the EPA's eGRID 2010 average power plant emissions data for each eGRID subregion to determine the electric power CO_2e emissions factors for net annual electric power (converted to kWh) at the meter or measured point of delivery. Use of regional values has the potential to reflect more accurately the actual environmental impact of the building's electricity use. eGRID subregion level data provide a good regional boundary for electricity source energy and emission calculations. Power is frequently wheeled within each subregion, and much less frequently wheeled across subregions. The EPA

also uses eGRID subregions in its greenhouse gas inventory and tracking emissions calculation methodology in Portfolio Manager.

TABLE 602.3.1
ELECTRICITY EMISSION RATE BY EPA eGRID SUB-REGION

eGRID 2010 SUB-REGION ACRONYM	eGRID 2010 SUB-REGION NAME	CO_2e RATE (kg/kWh)
AKGD	ASCC Alaska Grid	0.685
AKMS	ASCC Miscellaneous	0.265
ERCT	ERCOT All	0.698
FRCC	FRCC All	0.617
HIMS	HICC Miscellaneous	0.722
HIOA	HICC Oahu	0.825
MORE	MRO East	0.909
MROW	MRO West	0.964
NYLI	NPCC Long Island	0.698
NEWE	NPCC New England	0.428
NYCW	NPCC NYC/Westchester	0.391
NYUP	NPCC Upstate NY	0.369
RFCE	RFC East	0.543
RFCM	RFC Michigan	0.874
RFCW	RFC West	0.820
SRMW	SERC Midwest	0.960
SRMV	SERC Mississippi Valley	0.572
SRSO	SERC South	0.780
SRTV	SERC Tennessee Valley	0.818
SRVC	SERC Virginia/Carolina	0.581
SPNO	SPP North	0.972
SPSO	SPP South	0.873
CAMX	WECC California	0.370
NWPP	WECC Northwest	0.453
RMPA	WECC Rockies	1.149
AZNM	WECC Southwest	0.671
None	Not included	0.692

602.3.2 Onsite nonrenewable energy. Emissions associated with the use of nonrenewable energy sources other than electrical power shall be calculated by multiplying the fossil fuel energy used by the building and its site at the utility meter or measured point of delivery by the national emission factors in Table 602.3.2. Emissions associated with purchased district cooling shall be calculated by multiplying by the factors from Table 602.3.1 based on the EPA eGRID Sub-region in which the building is located.

❖ Table 602.3.2 uses national average data that incorporate the impact of both direct use and upstream emissions associated with extraction, processing, transportation and distribution to determine the CO_2e emission factors for natural gas, propane and fuel oil, since these are the dominant fuel sources directly used in buildings. Dispersed extraction, gathering, and processing plants, national transportation networks (pipelines and trucking), variations in local distribution system networks, and relatively low loss factors in each segment make it difficult to develop useful regional conversion values for these fuels.

To ensure that no energy source is excluded from the conversion calculations, Section 602.3.2 also includes a single conversion factor for all other fuels not listed in Table 602.2.1.2 as well as factors for district heating options and district cooling. Use of regional values for district cooling acknowledges that the vast majority of district cooling systems ultimately are powered by electricity.

TABLE 602.3.2
FOSSIL FUEL EMISSION FACTORS

STATIONARY FUEL TYPE		EMISSION FACTOR
Natural Gas		141
Fuel Oil		198
Propane		172
Other Fossil Fuels		217
Purchased District Energy	Hot Water	191
	Steam	205
	Cooling	147

SECTION 603
ENERGY METERING, MONITORING AND REPORTING

❖ Section 603 requires that all buildings that consume energy, regardless of compliance path, have capabilities for energy measuring, monitoring and reporting, or they shall incorporate features that readily facilitate those measurement capabilities in the future. The intent is to provide building owners and operation and maintenance staff with information that can be used to verify that buildings perform, and continue to perform, as designed and intended.

Section 603 specifically requires:

- Individual metering for each tenant.
- Energy distribution design and load-type isolation.
- Energy metering for traditional, renewable and waste energy sources.
- Energy sub-metering for buildings 25,000 square feet (2323 m^2) in gross floor area or greater.
- Buildings less than 25,000 square feet (2323 m^2) in gross floor area to provide for the future installation of energy sub-meters.

All required meters and sub-meters must be capable of being connected to a data acquisition system. An energy display that is capable of showing the current energy demand for the whole building, updated for each fuel type at specified intervals, and the total energy use for the previous 18 months is also required as part of this standard.