CITY OF BOULDER
CITY COUNCIL AGENDA ITEM

MEETING DATE: MAY 16, 2024

AGENDA TITLE

Second reading and consideration of a motion to amend and pass Ordinance 8629, repealing the "2020 City of Boulder Energy Conservation Code," adopting by reference the "2024 City of Boulder Energy Conservation Code," and amending Title 10, "Structures," B.R.C. 1981, and other sections of the Boulder Revised Code in relation thereto, and setting forth related details.

PRESENTERS

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EXECUTIVE SUMMARY

The purpose of this item is for City Council to consider proposed Ordinance 8629 (**Attachment A**) updating the City of Boulder's energy code. The ordinance would amend Title 10, "Structures" by repealing the current 2020 City of Boulder Energy Conservation Code and adopting the new 2024 City of Boulder Energy Conservation Code (**Attachment B**). The ordinance also includes changes to various sections of the

Boulder Revised Code, that are being updated in association with the adoption of the 2024 City of Boulder Energy Conservation Code. Council approved the ordinance at First Reading on March 21, 2024.

The City of Boulder Energy Conservation Code (CoBECC) sets the minimum energy efficiency and conservation standards for new buildings and additions and alterations to existing buildings. The requirements of the CoBECC are intended to promote public health, safety and welfare by requiring the design and construction of buildings in the City of Boulder to be consistent with the city's energy, climate and sustainability goals; national safety standards; and best practices for engineering and construction technology.

The City of Boulder's energy code was last updated July 1, 2020. The proposed code focuses on carbon reduction through electrification and improved energy efficiency in continued pursuit of the City of Boulder's aggressive climate action goals of a 70% reduction in greenhouse gas (GHG) emissions by 2030, targeting carbon neutrality by 2035 and being carbon/climate positive by 2040. The proposed code is also intended to ensure that buildings are high performing and resilient to the effects of climate change and insulate future occupants from the volatility of utility costs.

At the study session with council on June 22, 2023, feedback was provided to consider looking into embodied carbon, updated EV requirements, affordable housing impacts and more community outreach. In response, the ordinance has been updated to include embodied carbon credits, updated EV requirements, and additional outreach was performed as detailed herein. Responding to affordable housing impacts, staff have emphasized the authority of the Chief Building Office to amend requirements on a case-by-case basis based on technical infeasibility, which would include a situation where requirements impeded the construction of an affordable housing project.

Staff are recommending the adoption of the 2024 CoBECC, which is a localized version of the International Energy Conservation Code (IECC). The 2024 CoBECC is updated from the 2020 CoBECC and designed to meet, and in some places to exceed, the 2021 IECC, the minimum code edition required by state law. The 2024 CoBECC will provide a reduction in carbon by electrifying new building construction. Through the update process, staff also worked to provide flexibility for existing buildings, pursuing additions and/or alterations without sacrificing efficiency.

The proposed updates to the CoBECC include:

- Residential
    - Incorporation of all-electric appliance requirements for new building construction targeting an overall carbon emissions reduction.
    - Incorporation of all-electric space and water heating requirements for substantial renovations that include mechanical system replacement and substantial envelope alteration targeting overall carbon emissions reduction.

- Incorporation of a pre-solar performance requirement for residential new building construction.
- Simplification and alleviation of requirements for small residential construction (<1000 square feet)
- Elimination of the need for off-site solar if solar requirements cannot be fully met on-site.
- Creation of an additional energy conservation objective that is set up as a conservation credit/point system. The credit/point system allows an applicant to choose from a variety of conservation measures to reach the required number of credits, each measure is assigned a number of credits based on the energy use of the measure with the goal of efficiency gains in the design of the building. The measures also include credits for low embodied carbon materials.
- Modifications to align requirements with the 2021 International Energy Conservation Code (IECC) and the State minimum requirements for adoption of this code.
- Simplification of requirements throughout.

- Commercial (including multi-family)
  - Incorporation of all-electric appliance requirements for new building construction with exceptions for commercial cooking, hospitals, laboratory facilities, emergency generators and certain large industrial spaces targeting overall carbon emissions reductions.
  - Incorporation of requirements for 100% offset of natural gas usage through on-site solar for new building construction with exceptions for commercial cooking and process heat targeting overall carbon emissions reductions.
  - Modification and increase in electric vehicle (EV) charging infrastructure requirements.
  - Addition of new construction performance targets for large office, retail, and restaurant occupancy types which provides more compliance path flexibility for mixed-use buildings.
  - Creation of an additional energy conservation objective that is set up as a credit/point system. The credit/point system allows an applicant to choose from a variety of measures to reach the required number of credits. The measures also include credits for installation of low embodied carbon material.
  - General modifications to align requirements with the 2021 International Energy Conservation Code (IECC), ASHRAE 90.1 and the State minimum requirements for adoption of this code.
  - Simplification of requirements throughout.

City Council passed Ordinance 8629 at first reading on March 21, 2024.

Following first reading, staff worked with the International Code Council (ICC) to make minor adjustments to correct an error and to clarify two provisions in the 2024 CoBECC after these were noted by public participants in the process. These changes have been included in the 2024 CoBECC that was published with the ICC and have been available for review in the City Clerk's office since April 1, 2024. These minor modifications include refining the requirements for demand responsive water heating (C404.7), eliminating the additional conservation requirements from the commercial performance pathway (an error correction), and streamlining the energy modeling calculations in Appendix CA. These updates are shown in **Attachment** D, 2024 CoBECC Modifications. Regarding each of these minor changes, the scope of demand-responsive water heating has been expanded to encompass all capable units, additional conservation measures have been corrected to be only prescriptively required to bridge the gap between prescriptive and performance projects, and the modeling equations in Appendix CA were revised by excluding solar components to prevent confusion from the current modeling process.

Since first reading, Ordinance 8629 has also been minimally revised to remove two energy conservation options for commercial buildings to ensure compliance with federal law (an error correction). The two credit options related specifically to HVAC heating and HVAC cooling performance. The remaining credit options continue to provide a variety of choices for commercial buildings to meet the required energy conservation objective.

The 2024 CoBECC is provided in **Attachment B** to the memo. The revised Ordinance 8629 is provided in **Attachment A** to the memo. The second reading changes can be found on page 2, lines 10 through 25 and page 3, lines 1 through 4 of the revised ordinance. The ordinance as read on first reading can be found as Attachment A to the March 21 staff memo.

Due to the amendments at second reading, a third reading is required, at which the ordinance may be adopted. The third reading and final adoption is proposed to be scheduled on the consent agenda of Council's June 6, 2024, meeting. Ordinances may not take effect until 30 days after their final passage. In light of this later adoption date, the effective date for the ordinance and new code has been changed in the revised ordinance to be Monday, July 8, 2024 (previously July 1).

A summary of public feedback to the energy code draft through the website is provided in **Attachment C** to the memo.

STAFF RECOMMENDATION

Staff requests City Council consideration of this matter and action in the form of the following motion:

Motion to amend and pass on second reading Ordinance 8629, repealing the "2020 City of Boulder Energy Conservation Code," adopting by reference the "2024 City of Boulder Energy Conservation Code," and amending Title 10, "Structures," B.R.C. 1981, and other sections of the Boulder Revised Code in relation thereto, and setting forth related details.

COMMUNITY SUSTAINABILITY ASSESSMENTS AND IMPACTS

- **Economic** – Some of the updates to the city's energy code may result in higher upfront construction costs. While solar represents the largest cost contributor, some cost impacts may result from requirements for more efficient, lower carbon, and superior products to meet the enhanced performance standards. While upfront construction cost may be higher, up to $4 per square foot depending on solar and electric vehicle infrastructure requirements, investments in energy efficiency and reduction of dependency on natural gas is expected to lead to reduced operational and lifecycle costs for buildings, with paybacks less than 10 years for most if not all projects.
- **Environmental** – This project represents a crucial advancement towards achieving the city's goal to reduce greenhouse gas (GHG) emissions by 70% by 2030, carbon neutrality by 2035 and carbon/climate positive by 2040. In addition to a focus on carbon emission reduction through electrification and efficiency measures, efforts are also focused on reducing embodied carbon associated with construction materials, deconstruction and construction waste. Additionally, there will be a continued emphasis on on-site renewable energy sources as the community aims to transition away from fossil fuels. These measures will not only enhance the performance and resiliency of buildings but also create a healthier indoor environment for occupants. This code update is expected to more aggressively address the environmental and health impacts associated with natural gas use.
- **Social** – One of the objectives of this project is to examine the equity aspect as the city progresses towards achieving carbon neutrality and becoming climate/carbon positive. These updates will prioritize the equitable impact on the community, by recognizing the need for energy efficiency across all new construction and acknowledging a need for flexibility with the existing building stock without sacrificing energy efficiency. The focus of this code is on improving efficiency, resilience, and sustainability in buildings as well as providing a level of energy independence, thus improving the well-being of the community as a whole (lower utility bills, lower maintenance, cleaner air, etc.).

OTHER IMPACTS

- **City Resources** – This project is included in the 2023 work plan for Planning and Development Services and is also supported by staff in the Climate Initiatives department. The city contracted with NORESCO, an engineering consulting firm, to support the analysis and code development project. Resources will also be allocated in 2024 to provide training to city plan review, inspection and code compliance personnel, and to develop and publish templates and other resources for the city website pertaining to implementation of the new energy code requirements.

PUBLIC/STAKEHOLDER FEEDBACK

The scope of this project has been informed by feedback from City Council, Planning Board, the Environmental Advisory Board, design professionals, builders, developers, consultants, and the broad community. The project is also informed by peer exchange with other municipalities and aligns with Boulder County's Code Cohort adopted roadmap.

A list of key consultations and feedback received is summarized below and detailed summaries of the public feedback of the energy code are in **Attachment C**.

- Environmental Advisory Board offered their unanimous support for the proposed code updates in a meeting on Oct. 4, 2023.
- Staff held an open house on October 20, 2023, with over 20 people in attendance to elicit feedback on support and concerns related to the new 2024 CoBECC.
- Staff met with Boulder Area Housing and Rental Association (BARHA) on December 28, 2023. BARHA's main concern was the impact on existing buildings and system electrification, which is not impacted by the proposed changes.
- Staff met with Boulder Housing Partners (BHP) on January 9, 2024. BHP confirmed the new energy code would not represent an incremental cost of construction for them as all-electric construction is already part of their standard of construction.
- Planning Board offered unanimous support for the 2024 CoBECC as drafted in a meeting on Feb. 27, 2024.

Below is a summary of the feedback from the open house and other stakeholder engagement.

Stakeholder: Energy Code Open House Group	
Comment / Feedback	**Staff Response**
Concerns for infeasibility for affordable housing projects that rely on natural gas, primarily for water heating.	We hear your concern and would urge these projects to reach out as we do have the ability for allowance of alternatives means and methods.
Concerns over increased efficiency requirements and being compared against a building with a relatively cheap fuel source (i.e. natural gas) Denver has moved away from the Performance Cost Index (PCI) baseline to a site Energy Use Intensity (EUI) baseline.	This is valuable feedback and we have moved to a site based EUI target instead of the performance cost index target (PCIt) that is based on energy cost which is the current metric.
Look at incentivizing more level 3 charging (i.e. DC fast charging)	Thank you for this feedback. The new code allows commercial occupancies up to 10 space requirements to be satisfied with 1 level 3 charger; for multifamily up to 5 space requirements could be satisfied with 1 level 3 charger. In the commercial spaces level 3 chargers make a lot of sense.
Stakeholder: Boulder Area Rental and Housing Association	
Comment / Feedback	**Response**
Concerns over replacing an existing gas appliance	The code is structured to allow this to happen; only if it is a gut-rehab (50% building area, a mechanical system is replaced and 50% of thermal envelope is altered) would you be required to install all-electric equipment for primary space conditioning or water heating; the existing appliance can remain if desired as a backup system. No point in leaving stranded appliances.
Stakeholder: Boulder Housing Partners	
Comment / Feedback	**Response**
Concerns over funding, in particular, that with the increase in efficiency requirements in the new code market rate construction could slow and, in turn slow affordable housing funding	We encourage affordable projects, for that matter any projects, to reach out if feasibility comes into question. It is not the intent to impede construction in the City of Boulder.

A draft of the 2024 CoBECC was published on the energy code project website on November 30, 2023. Any member of the public could submit feedback to the project team through the website from November 30th, 2023, through the end of January 2024; 12 comments have been received through this channel. Feedback received has been

incorporated into the 2nd draft which the project team has released on the energy code website at the beginning of March. Key themes emerging from the feedback received online includes the following requests:

- Exceptions for commercial cooking offset requirements.
- Consideration to make slab-edge insulation mandatory.
- Increased solar-ready zone size requirements for alignment with actual panel sizing.
- Consideration for additional options for energy sources outside of all-electric (i.e. carbon free power).

The project team also heard some feedback that was not incorporated into the updated code. This feedback and the reasons the project team does not recommend incorporating them are summarized in **Attachment C** of the memo.

BACKGROUND

On November 9, 2023, city staff presented an in-depth overview of the energy code changes being proposed in the 2024 CoBECC project and sought City Council's feedback on the areas of focus using Key Questions. These areas have been summarized below.

- *Did City Council support the draft 2024 CoBECC code elements as presented?* City Council was in support of staff's proposal but also wanted consideration for embodied carbon, a look at greater integration/collaboration across city departments and services and higher electric vehicle (EV) charging infrastructure requirements for multi-family and larger commercial projects. Based on this feedback, staff have initiated a 2024 work plan item to begin developing an overall embodied carbon strategy. Staff also anticipate integrated embodied carbon requirements as part of the 2024 planned adoption of the 2024 International Building codes. Staff also updated the EV charging requirements for the proposed 2024 CoBECC.

- *Did City Council support allowance of natural gas water heating for affordable multi-family projects on a case-by-case basis?* City Council supported this allowance to ensure feasibility for affordable projects when pursuing electrification. Staff have provided additional clarity in the 2024 CoBECC in the alternative means and measures section, as well as added provisions for technical infeasibility within the commercial all-electric provisions.

- *Were there revisions or additional analysis/consideration City Council wanted staff to address prior to bringing forward the ordinance?* City Council encouraged more community outreach and allowing more time if needed to fine tune the new code. It was also recommended to work with builders, developers (including those in the affordable housing space), design professionals, homeowners, and tenants. Staff conducted additional outreach as discussed in this memo.

With this feedback, the feedback received from the Environmental Advisory Board and the feedback solicited from City Council at their June 22, 2023, and November 9, 2023, study sessions, staff proceeded with preparing the 2024 City of Boulder Energy Conservation Code. Staff are now recommending that City Council adopt Ordinance 8629 that would adopt the 2024 City of Boulder Energy Conservation Code by reference and sets forth other related details.

ANALYSIS

The significant changes proposed for the 2024 CoBECC are summarized in the November 9, 2023, City Council Study Session. The *most* significant changes proposed are as follows:

All Electric Appliance Requirements

Natural gas combustion appliances in buildings significantly contribute to GHG emissions, urban air pollution and poor indoor air quality. The reliance on natural gas appliances also leaves building occupants vulnerable to volatile fuel costs as well as unforeseen health problems.[1] Achieving carbon and air quality goals, as well as mitigating future energy cost burdens, necessitates the elimination of natural gas use, at least in any application for which there is a technically viable and economically feasible electric alternative.

Based on unanimous support from City Council, Planning Board and the Environmental Advisory Board in study sessions, staff have proceeded with a drafting code that limits the use of gas combustion appliances in most instances. The 2024 CoBECC requires:

Residential

- New Building Construction: All installed appliances, indoor and outdoor, must be electric.
- Additions: All **new** appliances installed as part of the addition must be electric.
- Substantial Alterations (Level 3+): Alterations that modify 50% or more of the floor area and include replacement of major mechanical systems and substantial thermal envelope modifications must install electric equipment as the primary source of space and water heating. Gas appliances would still be allowed for backup space and water heating or small loads, such as cooking and drying.
- Major Alterations (Level 3): Alterations that modify 50% or more of the floor area and involve replacement of mechanical equipment, will be required to make the equipment space electric ready. Installation of electric appliances is not required.
- Minor Alterations (Level 1-2): Must comply with efficiency requirements only.

[1] https://www.lung.org/policy-advocacy/healthy-air-campaign/healthy-efficient-homes/residential-combustion

Discussion

For construction of new residential buildings, cost-effective electric technology solutions exist to meet all equipment and appliance needs. Since the CoBECC was first adopted by the city in 2017, the majority of new homes in Boulder have already successfully been built to be all or predominantly electric. Similarly, projects where new equipment or appliances are installed as part of or to serve an addition are conducive to all electric requirements.

For substantial alterations, where a large enough portion of the thermal envelope is modified (50% or greater) and mechanical systems are replaced (often referred to as a gut rehabilitation), transitioning to electric space and water heating is also considered cost effective. The proposed code would limit electric requirements to space and water heating, while allowing natural gas to serve as a backup and for smaller appliance use. This recommendation is based on the likelihood that gas infrastructure is already in place and may not be modified in full as part of the project. Legal considerations and a concern about promulgating unpermitted appliance installations have guided this approach.

For major alterations affecting 50% or more of the floor area and that include the replacement of space conditioning and/or water heating equipment, but would otherwise leave mechanical systems and envelope intact, if adopted, the code would require that this equipment space be made electric ready for future installation of an electric appliance. This would align city requirements with those of the state model code for electric ready requirements, meaning dedicated electric circuits appropriate for a future electric appliance would have to be installed along with any gas combustion appliance included in the project.

For clarification, when just replacing a gas water heater or furnace, there is no requirement for the replacement equipment to be all-electric unless that replacement is part of a substantial level 3 alteration. Similarly, when a level 3 alteration does not include replacement of HVAC equipment, there is also no requirement that electric equipment be installed.

Commercial

- New Building Construction: All appliances, indoor and outdoor, must be electric.
    - Exemptions:
        - Hospitals, Laboratories, Commercial Kitchens and some Large S-1 Industrial spaces reliant on radiant heating.
        - Consideration for instances that can be approved by the Chief Building Official based on technology and equipment availability.
    - Where exceptions apply, natural gas use must be 100% offset by an on-site solar system. Exemptions apply for commercial cooking and process loads.
- Additions: All new appliances installed as part of an addition must be electric.
- Substantial Alterations (Level 3+): Alterations that modify 50% or more of the floor area and include replacement of major mechanical systems and substantial

thermal envelope modifications must install electric equipment as the primary source of space and water heating. Gas equipment and appliances would still be allowed for backup space and water heating and for small loads, such as cooking and drying.

- Major Alterations (Level 3): Alterations that modify 50% or more of the floor area and involve replacement of mechanical equipment, but largely leave the balance of mechanical systems and envelope intact, will be required to make the equipment space electric ready. Installation of electric appliances is not required.
- Alterations (Level 1-2): Must comply with efficiency requirements only.

Discussion

For construction of new commercial buildings, cost-effective technology solutions exist to meet appliance needs for most, but not all applications. Of particular concern are instances where tight environmental control is needed, such as in hospitals or laboratories; high-volume industrial bays with in-and-out vehicle traffic; and commercial kitchens. Another area of concern raised during stakeholder engagement is water heating for multi-family affordable housing projects in some instances. There remain limited electric technology options suitable for centralized domestic water systems. Dedicated systems to serve individual residential units can increase costs of both construction and operations and maintenance, again in some, but not all instances. Finally, there may be project types not already considered where technological limitations, including supply chain constraints, make moving forward under all-electric requirements infeasible. Based on this analysis, staff have proposed to allow exceptions for all-electric requirements for the pre-identified projects – hospitals, laboratories, some industrial S-1 facilities – as well as through approval by the Chief Building Official on a case-by-case basis. This approach is consistent with approaches used by other jurisdictions.

Like residential, all-electric requirements would apply to additions and to substantial renovations that include replacement of mechanical systems along with substantial modification to the thermal envelope. However, smaller alterations would only be required to meet the efficiency components of the code.

For new construction projects and additions, where gas combustion appliances are allowed, the project would be required to offset the equivalent amount of energy used by gas appliances with on-site solar with some exceptions for commercial cooking and process heat applications.

Residential Performance for Construction of New Buildings, Additions and Substantial Alterations

Under the 2017 and 2020 CoBECC, projects were required to achieve a final performance outcome using an Energy Rating Index (ERI). In addition to the final ERI, prescriptive backstop requirements also had to be maintained. The backstops were the prescriptive values used in the energy code to ensure efficiency was not sacrificed by just adding more solar to achieve the required ERI target. To retain the same intent, while

simplifying the process and allowing for greater design flexibility, the 2024 CoBECC shifts to a pre- and post-solar ERI approach. Specifically, all projects following the ERI path would need to achieve a maximum ERI score of 50 without solar. Solar or additional efficiency would then credit towards the final required ERI based on the project size. Table 1 outlines the pre- and post-solar ERI requirements proposed for the 2024 CoBECC, as well as the anticipated adjustments that would be made in future code updates.

Table 1 – Proposed Residential New Construction Performance Roadmap

≥3000 Square Feet ERI Compliance Scores		
Code Cycle	**Pre-Solar**	**Post-Solar**
2024	50	0
2027	47	0
2030	45	0
0 to 2999 Square Feet ERI Compliance Scores		
Code Cycle	**Pre-Solar**	**Post-Solar**
2024	50	30
2027	47	20
2030	45	0

For projects less than 3,000 square feet, the code update would result in additional resilience through requirements for incorporation of solar energy systems. For projects less than 1,000 square feet, only solar-ready zone requirements would apply. Also, for these smaller projects (<1,000sf) the prescriptive pathway can be followed to streamline and simplify the construction process for smaller projects.

Commercial Performance for New Building Construction, Additions and Substantial Alterations

With the 2020 CoBECC, the city introduced the Energy Use Intensity (EUI) pathway for commercial construction. The EUI pathway prescribes the maximum energy use (kBTU) allowed per square foot of building area over a year. The 2024 CoBECC adds additional EUI targets for large (≥50,000 square foot) office buildings, retail stores and restaurants. These additional Fixed EUI targets will provide more flexibility for mixed-use buildings by expanding the categories available so more projects can pursue this pathway. Because of the transition to all-electric requirements, no change was made to the EUI targets for the building types that had targets previously set under the 2020 CoBECC. The proposed targets for all building types are shown in Table 2.

Table 2 – Comparison between the 2020 and proposed 2024 EUI targets for new Commercial Construction

Building Type	2020 CoBECC	2024 CoBECC (proposed)
	90.1-2016	90.1-2022[a]
	20-25%	10-15%
Small Office (<5,000 sqft)	19	19
Medium Office (5,000-50,000 sqft)	23	23
Large Office (>50,000 sqft)	--[b]	40
Primary School	34	34
Secondary School	31	31
Mid-rise Apartment	32	32
Warehouse	11	11
Retail Store	--[b]	40
Restaurant	--[b]	200
Mixed Use	--[b]	Weighted average based on use types

[a] Staff are working with the consulting team to determine equivalency for using the 2022 standards to provide greater flexibility.
[b] This building type previously did not have a EUI target per the 2020 CoBECC.

The modeled baseline pathway remains available for buildings that elect to use it or for those that do not have a Fixed EUI target available. The modeled approach specifies a percent better than the baseline model established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 standard. The 2020 CoBECC uses the 2016 version of the standard. The 2024 CoBECC aims to update to the ASHRAE 90.1-2022 version of the standard.

A challenge of the previous ASHRAE standard approach is that it utilizes a cost-based approach for demonstrating the percent better improvement. The baseline is a mixed fuel building, and modeling an all-electric building compared to the mixed-fuel baseline is challenging for demonstrating percent better since costs are not a good identifier of efficiency. In adopting their code, Denver developed an energy-based modeling template (2022 DEC companion tool) that can be used in lieu of the cost methodology. Along similar lines, the 2024 CoBECC utilizes a new appendix to ASHARE's 90.1-2022 Standard that modifies this and moves away from the cost -based approach to allow for the use of a site based EUI.

Electric Vehicle (EV) Charging Infrastructure

The 2024 CoBECC also refines EV charging infrastructure requirements, and ensures alignment with the new state model codes, as mandated by state law. In particular, the state's EV capable light category was included in the 2024 CoBECC, which focuses on

installation of conduit and physical space for future electrical service expansion. This class of EV infrastructure can be employed to increase the number of parking spaces that can more cost effectively be retrofitted if charging demand grows beyond initially installed infrastructure without adversely driving up the initial cost of construction. Table 3 outlines staff's proposed EV infrastructure requirements for commercial projects under the 2024 CoBECC. The changes from the 2020 CoBECC include (see table footnotes for definitions of different charging infrastructure requirements):

- Adjusting the definition of small parking lots from 25 or less spaces to 10 or less spaces to align with the state minimum code requirement, which is ten or less spaces.
- Adding EV Capable Light requirements for R-2 (i.e., multi-family) occupancies to allow 100% of spaces to be served by at least conduit. [Exceeds state minimum requirements.]
- Requiring 100% of the spaces in small parking lots serving R-2 occupancies be electric ready (pre-wired with a dedicated circuit). [Exceeds state minimum requirements.]
- Increasing the percent of EV Ready spaces for parking lots with more than ten spaces that serve R-2 occupancies to align with the state minimum code.
- Adding EV Capable Light requirements to other commercial group occupancies, increasing the number of spaces served by at least conduit by 20%. [Exceeds state minimum requirements.]
- Increasing the space substitution count from the current 5 to 10 to try and encourage more fast charging installations.

Table 3 – Proposed EV Charging Infrastructure Requirements

	Number of EVSE Installed Spaces[a]	Number of EV Ready Spaces[b]	Number of EV Capable Spaces[c]	Number of EV Capable Light Spaces[d]	Change from 2020 CoBECC
Group R Occupancies (e.g., multi-family, hotels)					
1-10[f] Spaces	-	100% of spaces	-	-	Changed from just 1 EV ready space to 100% of spaces
>10[f] Spaces including parking garages[e]	5% (min. 1 dual port)	15% of spaces	40% of spaces	40% of spaces	Increased EV Ready spaces from 10% to 15% Added 40% EV Capable Light

	Number of EVSE Installed Spaces[a]	Number of EV Ready Spaces[b]	Number of EV Capable Spaces[c]	Number of EV Capable Light Spaces[d]	Change from 2020 CoBECC
Group A, B, E, I, M and S-2 Occupancies					
1-10[f] Spaces	2 spaces	2 spaces	0	Remaining spaces	Increased EV Ready and Capable from 1 space and added all remaining to be EV light
>10[f] Spaces including parking garages[e]	5% (min. 1 dual port)	10% of spaces	10% of spaces	20% of spaces[e]	Added 20% EV Capable Light

[a] Charging equipment installed
[b] Pre-wired circuit terminated at an outlet or junction box
[c] Service capacity and panel space available for future installation; conduit from panel to parking space
[d] Physical space for future service; conduit to parking space
[e] Parking garages will require 100% of remaining spaces to, at a minimum, have conduit installed
[f] Parking space categories were updated from 2020 CoBECC to align with state code. Small lots are now considered 10 or less spaces (previously 25 or less).

Additional Conservation Requirements

Under the proposed updates, in addition to meeting the minimum code requirements, projects would also need to earn points by implementing additional conservation measures to achieve an energy conservation objective. These points-based systems are detailed in Sections C406 and R408. Examples of proposed eligible measures, include:

- Whole building lifecycle analysis
- Low Embodied Carbon Materials
    - Concrete products, rebar, cross-laminated timber, insulation, steel, floor/wall coverings,
- Roof Reflectance/Cool Roof
- Reduced Air Leakage w/ Energy Recovery Ventilation (ERV) installed
- Ground Source Heat Pump
- Heat Pump Water Heater/Solar Water Heating
- Battery Storage
- Energy Efficient Appliances
- All Electric Equipment (Commercial Kitchens)

NEXT STEPS

- **May–July 2024**: Provide staff and community outreach training on code changes. Update the supporting documentation and resources on the city's website to help explain the energy code and documentation materials required to demonstrate compliance.
- **May 16, 2024**: City Council Second Reading to amend and pass the 2024 CoBECC.
- **June 6, 2024**: City Council Third Reading to adopt the 2024 CoBECC
- **July 8, 2024**: New 2024 CoBECC takes effect for all newly permitted projects (with the exception of pending site and form-based code review applications and existing approvals of such applications which may proceed through the process subject to the 2020 CoBECC, provided all progress deadlines and code requirements are met and building permit applications are filed before July 8, 2027.)

ATTACHMENTS

Attachment A: Ordinance 8629

Attachment B: 2024 City of Boulder Energy Conservation Code (CoBECC)

Attachment C: 2024 CoBECC feedback – with responses

Attachment D: 2024 CoBECC Modifications

ORDINANCE 8629

AN ORDINANCE REPEALING THE "2020 CITY OF BOULDER ENERGY CONSERVATION CODE," ADOPTING BY REFERENCE THE "2024 CITY OF BOULDER ENERGY CONSERVATION CODE," AND AMENDING TITLE 10, "STRUCTURES," B.R.C. 1981, AND OTHER SECTIONS OF THE BOULDER REVISED CODE IN RELATION THERETO; AND SETTING FORTH OTHER RELATED DETAILS.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF BOULDER, COLORADO:

Section 1. Section 4-20-47, "Zoning Adjustment and Building Appeals Filing Fees," B.R.C. 1981, is amended to read as follows:

4-20-47. Zoning Adjustment and Building Appeals Filing Fees.

(a) The fee for filing an appeal to or requesting a variance from the board of zoning adjustment under Subsection 9-9-21(s) or Section 10-3-9, "Temporary License Appeals," 10-2-2, "Adoption of International Property Maintenance Code With Modifications," 10-5-2, "Adoption of International Building Code With Modifications," 10-6-2, "Adoption of the National Electrical Code With Modifications," 10-7-2, "Energy Conservation Code," 10-8.5-2, "Adoption of the International Wildland-Urban Interface Code With Modifications," 10-9-2, "Adoption of the International Mechanical Code With Modifications," 10-9.5-2, Adoption of the International Fuel Gas Code With Modifications," 10-10-2, "Adoption of the International Plumbing Code With Modifications," or 10-12-24, "Appeals and Variances," B.R.C. 1981, is $106, except that the fee for an emergency appeal is $210.

. . .

Section 2. Section 9-9-12, "Landscaping and Screening Standards," B.R.C. 1981 is amended to read as follows:

9-9-12. Landscaping and Screening Standards.

…

(d) General Landscaping and Screening Requirements:

(1) Landscaping Plan: A landscaping plan designed in accordance with this section and Sections 9-9-13, "Streetscape Design Standards," and 9-9-14, "Parking Lot Landscaping Standards," B.R.C. 1981, shall be provided for all developments. The site plan shall include the following:

…

(L) The landscaping plan shall consider and attempt to avoid shading of new trees onto a solar-ready zone required under the ~~2017~~ City of Boulder Energy Conservation Code.

…

Section 3. Section 10-5-2, "Adoption of International Building Code With Modifications," B.R.C. 1981, is amended to read as follows:

10-5-2. Adoption of International Building Code With Modifications.

(a) The 2018 edition of the *International Building Code* of the International Code Council is hereby adopted by reference as the City of Boulder Building Code and has the same force and effect as though fully set forth in this chapter, except as specifically amended by the provisions of this chapter.

…

(cc) Section 1404.3, "Vapor retarders," is amended by adding two exceptions:

4. Commercial and multiple-residence buildings complying with the 2024~~0~~ City of Boulder Energy Conservation Code Section C402.5, Air leakage – thermal envelope (mandatory).

5. Residential buildings complying with the 202~~0~~4 City of Boulder Energy Conservation Code Section R402.4, Air leakage (mandatory).

…

(ll) A new Chapter 36 is added to read:

CHAPTER 36. COMMERCIAL CONSTRUCTION WASTE RECYCLING.

3601.1 Commercial construction recycling requirement. An applicant for a building permit to construct a new building shall demonstrate all recyclable wood, metal and cardboard materials were donated, reused or recycled.

3601.1.1 Reporting. Within sixty days following rough inspections ~~the completion~~ of the

project and prior to final inspection, the applicant shall submit documentation to the city manager which proves that all recyclable wood, metal and cardboard was donated, reused, or recycled. The documentation shall consist of a final completed waste diversion report in a form as prescribed by the city manager showing the tonnage of materials salvaged for recycling and reuse, supported by original weight receipts or other waste documentation that reasonably verifies that materials generated from the site have been accepted for recycling, reuse, salvage or otherwise diverted. For construction debris for which weighing is not practical due to size, lack of scales at the facility, or other considerations, a volumetric measurement shall be used. For conversion of volumetric measurements to weight, the applicant shall use the standardized conversion rates established by the city manager.

3601.2 Commercial deconstruction waste recycling. An applicant for a full demolition shall adhere to the requirements of Sections 3601.2.1 through 3601.2.5.

3601.2.1 Diversion requirements. The applicant shall divert from landfills at least seventy-five percent of the waste tonnage of demolition debris generated from the project by using recycling, reuse, and diversion programs. The city manager may modify this requirement if the applicant demonstrates it is unfeasible as set forth in Section 3601.2.2. The materials diverted must also include at least three of the material types set forth in the deconstruction plan form established by the city manager.

3601.2.2 Information required before issuance of demolition permit. The applicant shall submit a properly completed deconstruction plan in a form as established by the city manager. The applicant must propose to divert at least three of the material types identified by the city manager in the deconstruction plan form. No building permit or demolition permit shall be issued prior to the approval of the deconstruction plan by the city manager. In estimating the volume or weight of materials identified in the deconstruction plan, the applicant shall use the standardized conversion rates established by the city manager. The city manager may modify the required diversion percentage if the applicant demonstrates in the deconstruction plan that the percentage is not feasible because the maximum weight of materials that can be reused or recycled is less than the required diversion rate, or due to the presence of materials that are unable to be diverted due to special waste conditions such as environmental hazards.

3601.2.3 Administrative fee and deposit required. Prior to issuance of a permit for a full demolition ~~or a level 4 alteration as defined in the 2020 City of Boulder Energy Conservation Code,~~, the applicant shall post a cash deposit and pay the administrative fee described in Section 4-20-72, B.R.C. 1981. The cash deposit shall be one dollar per square foot of the demolition or work area of the alteration as identified in the permit application, or $1,500, whichever is greater.

…

Section 4. Section 10-5.5-2, "Adoption of the International Residential Code with Modifications," B.R.C. 1981, is amended to read as follows:

10-5.5-2. Adoption of the International Residential Code With Modifications.

(a) The 2018 edition of the International Residential Code of the International Code Council is hereby adopted by reference as the City of Boulder Residential Building Code and has the same force and effect as though fully set forth in this chapter, except as specifically amended by the provisions of this chapter.

…

(q) A new Section R328, Construction Waste Management, is added to read:

SECTION R328 CONSTRUCTION WASTE MANAGEMENT

R328.1 Residential construction waste recycling. An applicant for a building permit to construct a new dwelling unit shall demonstrate all recyclable wood, metal and cardboard materials were donated, reused or recycled.

R328.1.1 Reporting. Within sixty days following ~~the completion~~rough inspection of the project and prior to final inspection, the applicant shall submit documentation to the city manager which proves that all recyclable wood, metal and cardboard was donated, reused, or recycled. The documentation shall consist of a final completed waste diversion report in a form as prescribed by the city manager showing the tonnage of materials salvaged for recycling and reuse, supported by original weight receipts or other waste documentation that reasonably verifies that materials generated from the site have been accepted for recycling, reuse, salvage or otherwise diverted. For construction debris for which weighing is not practical due to size, lack of scales at the facility, or other considerations, a volumetric measurement shall be used. For conversion of volumetric measurements to weight, the applicant shall use the standardized conversion rates established by the city manager.

R328.2 Residential deconstruction waste recycling. An applicant for a full demolition ~~or level 4 alteration as defined in the *2020 City of Boulder Energy Conservation Code*~~ shall adhere to the requirements of Sections R328.2.1 through R328.2.5.

R328.2.1 Diversion requirements. The applicant shall divert from landfills at least seventy-five percent of the waste tonnage of demolition debris generated from the project by using recycling, reuse, and diversion programs. The city manager may modify this requirement if the applicant demonstrates it is unfeasible as set forth in Section R328.2.2. The materials diverted must also include at least three of the material types set forth in the deconstruction plan form established by the city manager.

R328.2.2 Information required before issuance of demolition and/or building permit. The applicant shall submit a properly completed deconstruction plan in a form as established by the city manager. The applicant must propose to divert at least three of the material types identified by the city manager in the deconstruction plan form. No building permit or demolition permit shall be issued prior to the approval of the deconstruction plan by the city manager. In estimating the volume or weight of materials identified in the deconstruction plan, the applicant shall use the standardized conversion rates established

by the city manager. The city manager may modify the required diversion percentage if the applicant demonstrates in the deconstruction plan that the percentage is not feasible because the maximum weight of materials that can be reused or recycled is less than the required diversion rate, or due to the presence of materials that are unable to be diverted due to special waste conditions such as environmental hazards.

R328.2.3 Administrative fee and deposit required. Prior to issuance of a permit for a full demolition ~~or a level 4 alteration as defined in the *2020 City of Boulder Energy Conservation Code*~~, the applicant shall post a cash deposit and pay the administrative fee described in Section 4-20-72, B.R.C. 1981. The cash deposit shall be one dollar per square foot of the demolition or work area of the alteration as identified in the permit application, or $1,500, whichever is greater.

R328.2.4 Reporting. Within sixty days following the completion of the demolition ~~or alteration~~, the applicant shall submit documentation to the city which proves compliance with the requirements of Sections R328.2.1 and R328.2.2. The documentation shall consist of a final completed waste diversion report in a form established by the city manager showing the tonnage of materials salvaged for recycling and reuse, supported by original weight receipts or other waste documentation that reasonably verifies that materials generated from the site have been accepted for recycling, reuse, salvage or otherwise diverted at the required diversion percentage. The documentation shall further demonstrate that the diverted materials include at least three material types. For demolition debris for which weighing is not practical due to size, lack of scales at facility, or other considerations, a volumetric measurement shall be used. For conversion of volumetric measurements to weight, the applicant shall use the standardized conversion rates established by the city manager.

R328.2.5 Deposit refunded or forfeited. No applicant shall fail to comply with Sections R328.2.1 through R328.2.4. The deposit shall be refunded to the applicant in proportion to the ratio of the actual diversion rate to the required diversion rate. If the required diversion percentage is not fully complied with, the remainder of the deposit shall be forfeited to the city as a civil penalty for failure to comply with the requirements of this chapter, after notice and an opportunity for hearing under the procedures prescribed by Chapter 1-3, "Quasi-Judicial Hearings," B.R.C. 1981. The city manager may adjust the amount of the refund or forfeiture where the applicant demonstrates that the required diversion percentage was not feasible based on the factors identified in Section R328.2.2 for modification of the diversion percentage. The forfeiture remedy is cumulative and is in addition to any other action the city manager is authorized to take, including suspension or revocation of a building contractor license or prosecution in the municipal court. Each 2,500 square feet of the demolition or alteration shall give rise to a separate violation, and each violation is subject to a maximum fine of $2,500.

…

(z) Chapter 11, "Energy Efficiency." Sections N1101 through N1105 are repealed. A new Section N1101 is added to read:

N1101 Scope. Regulations concerning the design and construction of buildings for the

effective use of energy and requirements for green building practices shall be administered in accordance with the ~~2020~~ *City of Boulder Energy Conservation Code* as adopted by Chapter 10-7, "Energy Conservation Code," B.R.C. 1981.

Section 5. Section 10-7-2, "Energy Conservation Code," B.R.C. 1981, is amended to read as follows:

10-7-2. Energy Conservation Code.

(a) Council adopts by reference the ~~*2020*~~ *2024 City of Boulder Energy Conservation Code* ~~of~~ published by the International Code Council which shall have the same force and effect as though fully set forth in the Boulder Revised Code, 1981, except as specifically amended by the provisions of this chapter. This code shall also be known as the City of Boulder Energy Conservation Code. This chapter and the ~~*2020*~~ *2024 City of Boulder Energy Conservation Code* shall be administered, applied, and interpreted in accordance with and as part of Chapter 10-5, "Building Code," B.R.C. 1981.

(b) Section C406.2.2, "More efficient HVAC performance," is repealed and reenacted to read as follows:

C406.2.2 More efficient HVAC performance. To achieve credits for more efficient HVAC performance, all heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in tables referenced by Section C403.3.3. Where multiple efficiency requirements are listed, equipment shall meet the seasonal or part-load efficiencies, including SEER/SEER2, EER/integrated energy efficiency ratio (IEER), integrated part load value (IPLV), or AFUE. Equipment that is larger than the maximum capacity range indicated in tables referenced by Section C403.3.3 shall meet the efficiencies listed for the largest capacity for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve a project, the HVAC performance improvement of the project shall be the weighted average improvement based on individual system capacity. Projects will achieve HVAC efficiency credits for one or several of the following measures:

1. C406.2.2.4 H04
2. C406.2.2.5 H05

(c) Section C406.2.2.2, "H02 More efficient HVAC equipment heating performance," is repealed and reenacted to read as follows:

C406.2.2.2 H02. Reserved.

(d) Section C406.2.2.3, "H03 More efficient HVAC equipment cooling and fan performance," is repealed and reenacted to read as follows:

C406.2.2.3 H03. Reserved.

(e) Lines H02 and H03 in Table C406.2, "Base Credit for Additional Conservation Measures," are repealed to read as follows:

H02	Reserved
H03	Reserved

Section 6. Section 10-7.7-8, "Large Industrial Campus," B.R.C. 1981, is amended to read as follows:

10-7.7-8. Large Industrial Campus.

...

(c) By June 1, 2025, each owner of a large industrial campus shall:

(1) Replace or upgrade any interior lighting fixtures necessary to meet the lighting power allowances for interior lighting established in the *2017~~20~~ City of Boulder Energy Conservation Code*.

(2) Replace or upgrade any exterior lighting fixtures as necessary to meet the lighting power allowances for exterior lighting established in the *2012~~20~~ International Energy Conservation Code*.

(3) Comply with the requirements for automatic time switch control devices, occupancy sensors, and exterior lighting controls as necessary to meet the ~~*2020*~~ *2017 City of Boulder Energy Conservation Code*.

(4) Provide to the city manager a summary of any actions taken pursuant to this subsection. The city manager may grant an owner of a large industrial campus a reasonable extension of time in which to comply with this upon proof of technical difficulties or financial hardship.

Section 7. The city council deems it appropriate to repeal the *2020 City of Boulder Energy Conservation* and adopt by reference the "2024 City of Boulder Energy Conservation Code." The *2024 City of Boulder Energy Conservation Code* prescribes minimum energy efficiency and conservation standards for new buildings and for additions and alterations to existing buildings. The city council orders that at least one copy of the *2024 City of Boulder Energy Conservation Code* being considered for adoption by reference in this ordinance be on file with the city clerk, Municipal Building, 1777 Broadway, City of Boulder, County of

Boulder, State of Colorado, and open for public inspection during the business hours of the city. Such copy shall be certified to be true by the mayor and the clerk.

Section 8. Unless expressly provided otherwise, any violation of the provisions of the 2024 City of Boulder Energy Conservation Code adopted herein by reference shall be punishable as provided in Section 5-2-4, "General Penalties," B.R.C. 1981, by a fine of up to $2,650 per violation, as adjusted by inflation, or by incarceration of not more than 90 days in jail, or by both such fine and incarceration. The maximum fine was adjusted for inflation on January 1, 2022, and again was and is adjusted on January 1 of each year thereafter, as set forth in Section 5-2-4, B.R.C. 1981.

Section 9. The city council orders and directs the city manager to make any additional citation, renumbering, and reference changes not included in this ordinance that are necessary to properly implement this ordinance and the code adopted herein. The city council authorizes the city manager to change the formatting and layout of the *2024 City of Boulder Energy Conservation Code*.

Section 10. The city council intends that the sections, paragraphs, clauses, phrases, items, and compliance options of this ordinance and the code adopted herein by reference be severable. If any compliance option, item, phrase, clause, sentence, paragraph or section of this ordinance or the code adopted herein by reference is declared unconstitutional or invalid by the valid judgement or decree of any court of competent jurisdiction, such unconstitutionality or invalidity does not affect any of the remaining compliance options, items, phrases, clauses, sentences, paragraphs and sections of this ordinance or the code adopted herein, unless it appears to the court that the valid provisions of the section or ordinance are so essentially and inseparably connected with, and so dependent upon, the void provision that it cannot be presumed the

council would have enacted the valid provisions without the void one; or unless the court determines that the valid provisions, standing alone, are incomplete and are incapable of being executed in accordance with the legislative intent. If the provision of an exception invalidates a prohibition, but the prohibition without the exception would be valid, then it is council's intent in such cases that the exception be severed, and the prohibition upheld.

Section 11. This ordinance shall take effect on July 8, 2024 ("effective date"). It shall be applied to building permit applications submitted on or after the effective date. Building permits applied for before the effective date shall be considered under the City of Boulder Energy Conservation Code in effect at the time of application. Notwithstanding the foregoing, if the construction of a new building or an addition, alteration, or renovation of an existing building requires a site review or form-based code review and a complete application for such site or form-based code review has been submitted to the city, or such site or form-based code review has been approved, on or before the effective date of this ordinance, then the initial building permits issued to implement the approval of such site review or form-based code review application will be permitted to be reviewed under the City of Boulder Energy Conservation Code in effect on the date of submittal of the complete site or form-based code review application provided that the building permit is application is submitted no later than three years following the effective date. Such applicants shall be required to pursue all development approvals and meet all requirements deadlines set by the city manager or her delegates and the Boulder Revised Code necessary to establish the proposed development. The applicants for such projects shall demonstrate compliance with all applicable laws. Any failure to meet the requirements of the city manager, her delegates, this section of this ordinance, or the Boulder Revised Code will result in a denial of such application. Any subsequent building permit

applications shall be reviewed under the standards in effect at the time of building permit application.

Section 12. This ordinance is necessary to protect the public health, safety, and welfare of the residents of the city, and covers matters of local concern.

Section 13. The city council deems it appropriate that this ordinance be published by title only and orders that copies of this ordinance be made available in the office of the city clerk for public inspection and acquisition.

INTRODUCED, READ ON FIRST READING, AND ORDERED PUBLISHED BY TITLE ONLY this 21st day of March 2024.

_____
Aaron Brockett,
Mayor

Attest:

_____
Elesha Johnson,
City Clerk

READ ON SECOND READING, AMENDED AND PASSED this 16th day of May 2024.

_____
Aaron Brockett,
Mayor

Attest:

_____
Elesha Johnson,
City Clerk

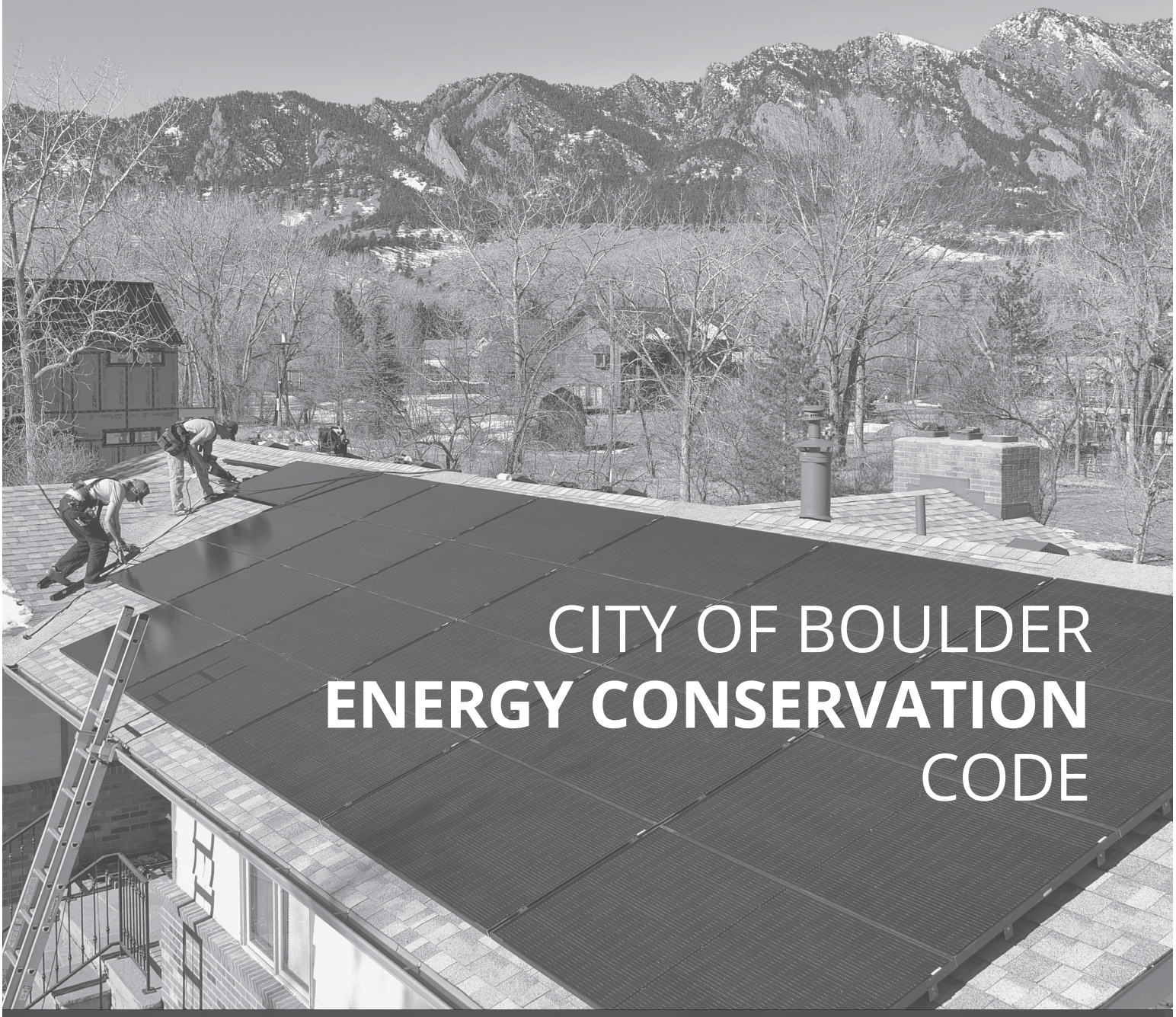
READ ON THIRD READING, PASSED AND ADOPTED this _____ day of _____ 2024.

_____
Aaron Brockett,
Mayor

Attest:

_____
Elesha Johnson,
City Clerk

2024



CITY OF BOULDER
ENERGY CONSERVATION
CODE

2024 City of Boulder Energy Conservation Code

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by
Ash Matthews

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PREFACE

Introduction

The 2024 *City of Boulder Energy Conservation Code* (COBECC) prescribes minimum energy efficiency and conservation standards for new buildings and for additions and alterations to existing buildings. The requirements of the COBECC are intended to promote public health, safety and welfare by requiring the design and construction of buildings in the City of Boulder consistent with the city's energy, climate and sustainability goals; national safety standards; and best practices for engineering and construction technology.

The COBECC introduces new energy efficiency measures and improves the energy performance requirements for residential buildings and prescriptive requirements for commercial buildings.

The COBECC is based on the 2021 edition of the *International Energy Conservation Code*® (IECC®), published by the International Code Council® (ICC®), and incorporates local amendments to the model code. The COBECC eliminates portions of the model code that do not apply to Boulder and incorporates Boulder's local energy conservation requirements in one document.

Since 1996, the city has adopted local amendments to the IECC to impose more stringent energy efficiency requirements than the model code. Like previous local amendments, the COBECC imposes more stringent energy efficiency requirements than the model code. The COBECC requirements support the climate action plan adopted by the City of Boulder in 2021:

- 70 percent reduction of the community's greenhouse gas emissions below 2018 levels by 2030.
- Net Zero carbon emissions by 2035.
- Carbon/Climate Positive by 2040

In support of these goals, Boulder has set a target of reaching net zero energy construction by 2031 for new buildings and major alterations through building and energy code requirements. Boulder has developed a strategy to achieve that target; adopting increasingly aggressive energy codes is a key part of the strategy.

Adoption

The 2024 *City of Boulder Energy Conservation Code* was adopted at _____ reading by the City Council of the City of Boulder on _____, 2024, with the passage of City of Boulder Ordinance 8629.

Information regarding the adoption of Ordinance 8629 can be reviewed at the City of Boul-der Central Records Office as part of the City Council agenda materials for _____, 2024.

Marginal Markings

| | = Indicates a City of Boulder amendment has been made to the 2018 *International Energy Conservation Code*.

> = Indicates model code language deleted by the City of Boulder.

Italicized Terms

Selected words and terms defined in Chapter 2, Definitions, are italicized where they appear in code text and the Chapter 2 definition applies. Where such words and terms are not italicized, common-use definitions apply. The words and terms selected have code-specific definitions that the user should read carefully to facilitate better understanding of the code.

EFFECTIVE USE OF THE INTERNATIONAL ENERGY CONSERVATION CODE

The 2024 *City of Boulder Energy Conservation Code* (COBECC) is a model code that regulates minimum energy conservation requirements for new buildings and for additions, alterations, and repairs of existing buildings. This code addresses energy conservation requirements for all aspects of energy uses in both commercial and residential construction, including heating and ventilating, lighting, water heating, and power usage for appliances and building systems.

This code is a design document. For example, before one constructs a building, the designer must determine the minimum insulation *R*-values and fenestration *U*-factors for the building exterior envelope. Depending on whether the building is for residential use or for commercial use, the COBECC sets forth minimum requirements for exterior envelope insulation, window and door *U*-factors and SHGC ratings, duct insulation, lighting and power efficiency, and water distribution insulation.

Arrangement and Format of the 2024 COBECC

The COBECC contains two separate sets of provisions—one for commercial buildings and one for residential buildings. Each set of provisions is applied separately to buildings within their scope. The Commercial Provisions apply to all buildings except for residential buildings three stories or less in height. The Residential Provisions apply to detached one- and two-family dwellings and multiple single-family dwellings as well as Group R-3 and R-4 buildings three stories or less in height. These scopes are based on the definitions of "Commercial building" and "Residential building," respectively, in Chapter 2 of each set of provisions. Note that the Commercial Provisions therefore contain provisions for R-2 buildings and occupancies not included as per the definition of residential building. Each set of provisions is divided into six different parts:

Chapters	Subjects
1–2	Administration and Definitions
3	General Materials Requirements
4	Energy Efficiency Requirements
5	Existing Buildings
6	Referenced Standards

The following is a chapter-by-chapter synopsis of the scope and intent of the provisions of the *City of Boulder International Energy Conservation Code* and applies to both the commercial and residential energy provisions:

Chapter 1 Scope and Administration. This chapter contains provisions for the application, enforcement and administration of subsequent requirements of the code. In addition to establishing the scope of the code, Chapter 1 identifies which buildings and structures come under its purview. Chapter 1 is largely concerned with maintaining "due process of law" in enforcing the energy conservation criteria contained in the body of this code. Only through careful observation of the administrative provisions can the *code official* reasonably expect to demonstrate that "equal protection under the law" has been provided.

Chapter 2 Definitions. Chapter 2 is the repository of the definitions of terms used in the body of the code. Codes are technical documents and every word, term and punctuation mark can impact the meaning of the code text and the intended results. The code often uses terms that have a unique meaning in the code and the code meaning can differ substantially from the ordinarily understood meaning of the term as used outside of the code.

The terms defined in Chapter 2 are deemed to be of prime importance in establishing the meaning and intent of the code text. The user of the code should be familiar with and consult this chapter because the definitions are essential to the correct interpretation of the code and the user may not be aware that a term is defined.

Where understanding of a term's definition is especially key to or necessary for understanding of a particular code provision, the term is shown in *italics*. This is true only for those terms that have a

meaning that is unique to the code. In other words, the generally understood meaning of a term or phrase might not be sufficient or consistent with the meaning prescribed by the code; therefore, it is essential that the code-defined meaning be known.

Guidance regarding tense, gender and plurality of defined terms as well as guidance regarding terms not defined in this code is provided.

Chapter 3 General Requirements. Chapter 3 provides interior design conditions that are used as a basis for assumptions in heating and cooling load calculations, and provides basic material requirements for insulation materials and fenestration materials.

Chapter 4 Energy Efficiency. Chapter 4 of each set of provisions contains the technical requirements for energy efficiency.

Commercial Energy Efficiency. Chapter 4 of the Commercial Provisions contains the energy-efficiency-related requirements for the design and construction of most types of commercial buildings, including buildings with residential uses and occupancies that do not meet the definition of a residential building. This chapter defines requirements for the portions of the building and building systems that impact energy use in new commercial construction and promote the effective use of energy. In addition to energy conservation requirements for the building envelope, this chapter contains requirements that impact energy efficiency for the HVAC systems, the electrical systems and the plumbing systems. It should be noted, however, that requirements are contained in other codes that have an impact on energy conservation. For instance, requirements for water flow rates are regulated by the *International Plumbing Code*.

Residential Energy Efficiency. Chapter 4 of the Residential Provisions contains the energy-efficiency-related requirements for the design and construction of residential buildings regulated under this code. It should be noted that the definition of a *residential building* in this code is unique for this code, a *residential building* is defined as detached one- and two-family dwellings and townhouses, and *Group* R-3 and R-4 buildings three stories or less in height above grade plane with separate means of egress. All other buildings, including those containing Group R-2 occupancies, shall be regulated by the energy conservation requirements in the Commercial Provisions. The applicable portions of a residential building must comply with the provisions within this chapter for energy efficiency. This chapter defines requirements for the portions of the building and building systems that impact energy use in new residential construction and promote the effective use of energy. The provisions within the chapter promote energy efficiency in the building envelope, the heating and cooling system and the service water heating system of the building.

Chapter 5 Existing Buildings. Chapter 5 of each set of provisions contains the technical energy efficiency requirements for existing buildings. Chapter 5 provisions address the maintenance of buildings in compliance with the code as well as how additions, alterations, repairs and changes of occupancy need to be addressed from the standpoint of energy efficiency. Specific provisions are provided for historic buildings.

Chapter 6 Referenced Standards. The code contains numerous references to standards that are used to regulate materials and methods of construction. Chapter 6 contains a comprehensive list of all standards that are referenced in the code. The standards are part of the code to the extent of the reference to the standard. Compliance with the referenced standard is necessary for compliance with this code. By providing specifically adopted standards, the construction and installation requirements necessary for compliance with the code can be readily determined. The basis for code compliance is, therefore, established and available on an equal basis to the *code official*, contractor, designer and owner.

Chapter 6 is organized in a manner that makes it easy to locate specific standards. It lists all of the referenced standards, alphabetically, by acronym of the promulgating agency of the standard. Each agency's standards are then listed in either alphabetical or numeric order based on the standard identification. The list also contains the title of the standard; the edition (date) of the standard referenced; any addenda included as part of the ICC adoption; and the section or sections of this code that reference the standard.

Appendix CA, Boulder Modified Appendix G Protocol. This appendix is part of this code for the commercial provisions as referenced in Section C407. This appendix provides guidance on modifications to the ASHRAE 90.1–2022, Appendix G for the purpose of energy modeling for compliance with C407.3.

Abbreviations and Notations

The following is a list of common abbreviations and units of measurement used in this code. Some of the abbreviations are for terms defined in Chapter 2. Others are terms used in various tables and text of the code.

AFUE	Annual fuel utilization efficiency
bhp	Brake horsepower (fans)
Btu	British thermal unit
Btu/h-ft^2	Btu per hour per square foot
C-factor	See Chapter 2—Definitions
CDD	Cooling degree days
cfm	Cubic feet per minute
cfm/ft^2	Cubic feet per minute per square foot
ci	Continuous insulation
COP	Coefficient of performance
DCV	Demand control ventilation
°C	Degrees Celsius
°F	Degrees Fahrenheit
DWHR	Drain water heat recovery
DX	Direct expansion
E_c	Combustion efficiency
E_v	Ventilation efficiency
E_t	Thermal efficiency
EER	Energy efficiency ratio
EF	Energy factor
ERI	Energy rating index
EUI	Energy use intensity
F-factor	See Chapter 2—Definitions
FDD	Fault detection and diagnostics
FEG	Fan efficiency grade
FL	Full load
ft^2	Square foot
gpm	Gallons per minute
HDD	Heating degree days
hp	Horsepower
HSPF	Heating seasonal performance factor
HVAC	Heating, ventilating and air conditioning
IEER	Integrated energy efficiency ratio
IPLV	Integrated Part Load Value
Kg/m^2	Kilograms per square meter
kW	Kilowatt
LPD	Light power density (lighting power allowance)

L/s	Liters per second
Ls	Liner system
m^2	Square meters
MERV	Minimum efficiency reporting value
NAECA	National Appliance Energy Conservation Act
NPLV	Nonstandard Part Load Value
Pa	Pascal
PF	Projection factor
pcf	Pounds per cubic foot
psf	Pounds per square foot
PTAC	Packaged terminal air conditioner
PTHP	Packaged terminal heat pump
R-value	See Chapter 2—Definitions
SCOP	Sensible coefficient of performance
SEER	Seasonal energy efficiency ratio
SEER2	Seasonal energy efficiency ratio 2
SHGC	Solar Heat Gain Coefficient
SPVAC	Single packaged vertical air conditioner
SPVHP	Single packaged vertical heat pump
SRI	Solar reflectance index
SWHF	Service water heat recovery factor
U-factor	See Chapter 2—Definitions
VAV	Variable air volume
VRF	Variable refrigerant flow
VT	Visible transmittance
W	Watts
w.c.	Water column
w.g.	Water gauge

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COMMERCIAL PROVISIONS

TABLE OF CONTENTS

CHAPTER 1 [CE]
SCOPE AND ADMINISTRATION

User note:

About this chapter: *Chapter 1 establishes the limits of applicability of the code and describes how the code is to be applied and enforced. Chapter 1 includes two parts: Part 1—Scope and Application and Part 2—Administration and Enforcement. Section 101 identifies what buildings, systems, appliances and equipment fall under its purview and references other I-Codes as applicable. Standards and codes are scoped to the extent referenced.*

The provisions of Chapter 1 establish the authority and duties of the code official appointed by the authority having jurisdiction and also establish the rights and privileges of the design professional, contractor and property owner.

PART 1—SCOPE AND APPLICATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title. This code shall be known as the 2024 *City of Boulder Energy Conservation Code* and shall be cited as such. It is referred to herein as "this code."

C101.2 Scope. This code applies to *commercial buildings* and the buildings' sites and associated systems and equipment.

C101.3 Intent. This code shall regulate the design and construction of buildings for the effective use and conservation of energy over the useful life of each building. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

C101.4 Applicability. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

C101.4.1 Mixed residential and commercial buildings. Where a building includes both *residential building* and *commercial building* portions, each portion shall be separately considered and meet the applicable Commercial Provisions of this code or Residential Provisions of this code.

C101.5 Compliance. *Residential buildings* shall meet the Residential Provisions of this code. *Commercial buildings* shall meet the Commercial Provisions of this code.

C101.5.1 Compliance materials. The *code official* is authorized to require compliance documentation, certificates, or reports prior to issuance of the building permit, the certificate of occupancy, or prior to passing inspections. The production of this documentation shall be in support of demonstrating compliance with the applicable requirements, construction installation method, or the energy compliance path being utilized.

SECTION C102
ALTERNATIVE MATERIALS, DESIGN AND METHODS OF CONSTRUCTION AND EQUIPMENT

C102.1 General. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. The *chief building official* shall have the authority to approve an alternative material, design or method of construction upon the written application of the owner or the owner's authorized agent. The *chief building official* shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, *fire resistance*, durability, energy conservation and safety. The *code official* shall respond to the applicant in writing, stating the reasons why the alternative was approved or was not *approved*.

C102.1.1 Above code programs. The *chief building official* shall be permitted to deem a national, state or local energy efficiency program exceeding the energy efficiency required by this code. Buildings *approved* in writing by such an energy efficiency program shall be considered to be in compliance with this code. The requirements identified in Table C407.2 shall still be met.

C102.1.2 Technical infeasibility. The *chief building official* has the authority to modify this code where equipment, as mandated by this code, is unavailable.

C102.1.3 Compliance with federal and state law and regulations. The *chief building official* may modify, for individual cases, the provisions of this code to allow a design, installation, or construction not in compliance with the provisions of this code, if otherwise the provisions of this code would result in a violation of federal or state legislation or regulations and the modification would be the minimum modification that provides relief.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION C103
CONSTRUCTION DOCUMENTS

C103.1 General. Construction documents and other supporting data shall be submitted in one or more sets, or in a digital format where allowed by the *building official*, with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary construction documents to be prepared by a registered design professional.

Exception: The *code official* is authorized to waive the requirements for construction documents or other supporting data if the *code official* determines they are not necessary to confirm compliance with this code.

C103.2 Information on construction documents. Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, the following as applicable:

1. Energy compliance path.
2. Insulation materials and their R-values.
3. Fenestration *U*-factors and solar heat gain coefficients (SHGCs).
4. Area-weighted *U*-factor and solar heat gain coefficient (SHGC) calculations.
5. Mechanical system design criteria.
6. Mechanical and service water heating systems and equipment types, sizes, and efficiencies.
7. Economizer description.
8. Equipment and system controls.
9. Fan motor horsepower (hp) and controls.
10. Duct sealing, duct and pipe insulation and location.
11. Lighting fixture schedule with wattage and control narrative.
12. Location of *daylight* zones on floor plans.
13. Air barrier and air sealing details, including the location of the air barrier.
14. Details of additional electric infrastructure, including branch circuits, conduit, or pre-wiring, and panel capacity in compliance with the provisions of this code.
15. Location and size of the solar-ready zone.
16. Structural design loads of roof dead load and roof live load.
17. Pathways for routing of conduit from the solar-ready zone to the electrical service panel.
18. Number and location of EV capable light spaces.
19. Number and location of EV capable spaces.
20. Number and location of EV ready spaces.
21. Number and location of EVSE installed spaces.
22. Locations of conduit and termination points serving the aforementioned parking spaces.
23. Location for condensate drainage where combustion equipment for space heating and water heating is installed.
24. Additional Conservation measures selected for compliance with C406.

C103.2.1 Building thermal envelope depiction. The *building thermal envelope* shall be represented on the construction drawings in both plan and trans-sectional views and shall outline the extent of the *building thermal* envelope.

C103.3 Examination of documents. The *code official* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances. The *code official* is authorized to utilize a registered design professional, or other *approved* entity not affiliated with the building design or construction, in conducting the review of the plans and specifications for compliance with the code.

C103.3.1 Approval of construction documents. When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.

One set of construction documents so reviewed shall be retained by the *code official*. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official* or a duly authorized representative.

C103.3.2 Previous approvals. This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

C103.3.3 Phased approval. The *code official* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided that adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

C103.4 Amended construction documents. Changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.

C103.5 Retention of construction documents. One set of *approved* construction documents shall be retained by the *code official* for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.

C103.6 Building documentation and closeout submittal requirements. The construction documents shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the certificate of occupancy.

C103.6.1 Record documents. Construction documents shall be updated to convey a record of the completed work. Such updates shall include mechanical, electrical and control drawings that indicate all changes to size, type and location of components, equipment, and assemblies.

C103.6.2 Compliance documentation. Energy code compliance documentation and supporting calculations shall be delivered in one document to the building owner as part of the project record documents or manuals, or as a standalone document. This document shall include the specific energy code edition utilized for compliance determination for each system, documentation demonstrating compliance with Section C303.1.3 for each fenestration product installed, and the interior lighting power compliance path, building area or space-by-space, used to calculate the lighting power allowance.

For projects complying with the Prescriptive Pathway per Section C401.2, the documentation shall include:

1. The envelope insulation compliance path.
2. All compliance calculations including those required by Sections C402.1.5, C403.8.1, C405.3 and C405.5.

C103.6.3 Systems operation control. Training shall be provided by the builder or design professional to those responsible for maintaining and operating equipment included in the manuals required by Section C103.6.2.

The training shall include:

1. Review of manuals and permanent certificate.
2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and startup procedures.
3. Training completion report.

SECTION C104
FEES

C104.1 Fees. A permit shall not be issued until the fees prescribed in Section C104.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

C104.2 Schedule of permit fees. A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

C104.3 Work commencing before permit issuance. Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official* that shall be in addition to the required permit fees.

C104.4 Related fees. The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

C104.5 Refunds. The *code official* is authorized to establish a refund policy.

SECTION C105
INSPECTIONS

C105.1 General. Construction or work for which a permit is required shall be subject to inspection by the code official, his or her designated agent or an approved agency, and such construction or work shall remain visible and able to be accessed for inspection purposes until *approved*. Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this code or of other ordinances of the jurisdiction shall not be valid. It shall be the duty of the permit applicant to cause the work to remain visible and able to be accessed for inspection purposes. Neither the code official nor the jurisdiction shall be liable for the expense entailed in the removal or replacement of any material, product, system or building component required to allow inspection to validate compliance with this code.

C105.2 Required inspections. The *code official,* his or her designated agent or an approved agency, upon notification, shall make the inspections set forth in Sections C105.2.1 through C105.2.6.

C105.2.1 Footing and foundation insulation. Inspections shall verify the footing and foundation insulation *R*-value, location, thickness, depth of burial and protection of insulation as required by the code, *approved* plans and specifications.

C105.2.2 Thermal envelope. Inspections shall verify the correct type of insulation, *R*-values, location of insulation, fenestration, *U*-factor, SHGC and VT, and that air leakage controls are properly installed, as required by the code, *approved* plans and specifications.

C105.2.3 Plumbing system. Inspections shall verify the type of insulation, *R*-values, protection required, controls and heat traps as required by the code, *approved* plans and specifications.

C105.2.4 Mechanical system. Inspections shall verify the installed HVAC equipment for the correct type and size, controls, insulation, R-values, system and damper air leakage, minimum fan efficiency, energy recovery and economizer as required by the code, *approved* plans and specifications.

C105.2.5 Electrical system. Inspections shall verify lighting system controls, components, meters, and additional electric infrastructure as required by the code, *approved* plans, and specifications.

C105.2.6 Solar ready. As required by the code, approved plans and specifications, inspections shall verify the location and size of the *solar-ready zone* or the capacity of an installed on-site renewable energy system and the electrical capacity and reserved physical space for circuit breakers in the main electrical service panel that are properly labeled.

R105.2.7 Electric Vehicle Ready. As required by this code, approved plans and specifications, inspections shall verify the EV power transfer infrastructure requirements, the branch circuits, conduit and/or raceway, junction boxes, receptacles and EVSE are properly labeled and installed for each parking space type. The electrical capacity and reserved physical space for circuit breakers in the main electrical service panel are properly labeled, if applicable shall also be verified.

R105.2.8 Electric ready. As required by this code, approved plans and specifications, inspections shall verify the branch circuits, conduit and/or raceways, wiring, junction boxes and receptacles for *future electric equipment* or appliances are properly labeled and installed, as applicable. Reserved physical space for *future electric equipment* or appliances as well as electrical capacity and reserved physical space for circuit breakers in the main electrical service panel are properly labeled shall also be verified.

C105.2.9 Final inspection. The final inspection shall include verification of the installation and proper operation of all required building controls, proper labeling, and documentation verifying activities associated with required *building commissioning* have been conducted in accordance with Section C408.

C105.3 Reinspection. A building shall be reinspected where determined necessary by the *code official*.

C105.4 Approved inspection agencies. The *code official* is authorized to accept reports of third-party inspection agencies not affiliated with the building design or construction, provided that such agencies are *approved* as to qualifications and reliability relevant to the building components and systems that they are inspecting.

C105.5 Inspection requests. It shall be the duty of the holder of the permit or their duly authorized agent to notify the *code official* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.

C105.6 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* for inspection and testing.

SECTION C106
NOTICE OF APPROVAL

C106.1 Approval. After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official*.

C106.2 Revocation. The *code official* is authorized to suspend or revoke, in writing, a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the *building* or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.

SECTION C107
VALIDITY

C107.1 General. If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

SECTION C108
REFERENCED STANDARDS

C108.1 Referenced codes and standards. The codes and standards referenced in this code shall be those listed in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections C108.1.1 and C108.1.2.

C108.1.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

C108.1.2 Provisions in referenced codes and standards. Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

C108.2 Application of references. References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section or provision of this code.

C108.3 Other laws. The provisions of this code shall not be deemed to nullify any provisions of local, state, or federal law. This code is intended to comply with and be interpreted and enforced so as to comply with 42 U.S.C. Section 6297(f)(3) and any other federal requirements to avoid pre-emption. For purposes of 42 U.S.C. Section 6297(f)(3), “new construction” shall be interpreted to include all work that triggers the requirements established by this code.

SECTION C109
STOP WORK ORDER

C109.1 Authority. Where the *code official* finds any work regulated by this code being performed in a manner contrary to the provisions of this code or in a dangerous or unsafe manner, the *code official* is authorized to issue a stop work order.

C109.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property, the owner’s authorized agent, or the person performing the work. Upon

issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order and the conditions under which the cited work is authorized to resume.

C109.3 Emergencies. Where an emergency exists, the *code official* shall not be required to give a written notice prior to stopping the work.

C109.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to fines established by the authority having jurisdiction.

SECTION C110
BOARD OF BUILDING APPEALS

C110.1 General. Appeals of orders, decisions or determinations made by the *code official* relative to the application and interpretation of this code, shall be heard by the board of building appeals established under Section 2-3-4, "Board of Building Appeals," B.R.C. 1981, unless the city manager determines that, due to the nature of the issues in a particular appeal, to appoint a hearing officer under Section 1-3-5, "Hearings and Determinations," B.R.C. 1981.

C110.2 Limitations on authority. An application for appeal shall be based on a claim that the provisions of this code or the rules legally adopted thereunder have been incorrectly interpreted or applied or that an equally good or better material, design, or method of construction is proposed. The board or hearing officer has no authority to waive the requirements of this code.

C110.3 Application. Application for appeal must be filed in writing with the city manager within fourteen days after the date of refusal of the building permit or refusal of approval of the work performed under the permit or revocation or suspension of the building permit or certificate of occupancy or certificate of completion stating the basis for appeal.

C110.4 Fee. An applicant for an appeal shall pay the fee prescribed by Section 4-20-47, "Zoning Adjustment and Building Appeals Filing Fees," B.R.C. 1981. The fee for an appeal heard by a hearing officer shall be the same as the fee for an appeal heard by the board of building appeals.

SECTION C111
VIOLATIONS

C111.1 General. The provisions for violations set forth in Chapter 1 of the City of Boulder Building Code as part of Chapter 10-5, "Building Code," B.R.C 1981, shall apply to violations of this code.

CHAPTER 2 [CE]
DEFINITIONS

User note:

About this chapter: *Codes, by their very nature, are technical documents. Every word, term and punctuation mark can add to or change the meaning of a technical requirement. It is necessary to maintain a consensus on the specific meaning of each term contained in the code. Chapter 2 performs this function by stating clearly what specific terms mean for the purposes of the code.*

SECTION C201
GENERAL

C201.1 Scope. Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter and Section R202 when applicable.

C201.2 Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

C201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code* or the *International Residential Code* shall have the meanings ascribed to them in those codes.

C201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

SECTION C202
GENERAL DEFINITIONS

ABOVE-GRADE WALL. See "Wall, above-grade."

ACCESS (TO). That which enables a device, appliance or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel, or similar obstruction.

ADDITION. An extension or increase in the *conditioned space* floor area, number of stories or height of a building or structure.

AIR BARRIER. One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

AIR CURTAIN. A device, installed at the building entrance, generates, and discharges a laminar air stream intended to prevent the infiltration of external, unconditioned air into the conditioned spaces, or the loss of interior, conditioned air to the outside.

ALL-ELECTRIC. Refers to an energy source for a system, appliance or piece of equipment that is fueled by electricity.

ALL-ELECTRIC BUILDING. A building that uses a permanent supply of electricity as the source of energy for all space heating, water heating (including pools and spas), cooking appliances, and clothes drying appliances, and has no natural gas, propane or fuel-oil plumbing installed in the building.

ALTERATION. Any construction, retrofit or renovation to an existing structure other than repair or addition. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ALTERATION, LEVEL 1. An *alteration* that includes the removal and replacement or the covering of existing materials, elements, equipment or fixtures using new materials, elements, equipment or fixtures that serve the same purpose.

ALTERATION, LEVEL 2. An *alteration* that includes the reconfiguration of space, the addition or elimination of any door or window, the reconfiguration or extension of any system, or the installation of any additional equipment.

ALTERATION, LEVEL 3. An *alteration* where the work exceeds 50 percent of the building floor area.

APPROVED. Acceptable to the code official.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests or furnishing inspection services, or furnishing product certification, where such agency has been approved by the *code official*.

AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, such as, for example, a change in current strength, pressure, temperature or mechanical configuration (see "Manual").

BELOW-GRADE WALL. See "Wall, below-grade."

BIOGAS. A mixture of hydrocarbons that is a gas at 60°F (15.5°C) and 1 atmosphere of pressure that is produced through the anaerobic digestion of organic matter.

BIOMASS. Nonfossilized and biodegradable organic material originating from plants, animals and/or microorganisms, including products, by-products, residues and waste from agriculture, forestry, and related industries as well as the nonfossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of nonfossilized and biodegradable organic material.

BOILER, MODULATING. A boiler that is capable of more than a single firing rate in response to a varying temperature or heating load.

BOILER SYSTEM. One or more boilers, their piping and controls that work together to supply steam or hot water to heat output devices remote from the boiler.

BUBBLE POINT. The refrigerant liquid saturation temperature at a specified pressure.

BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building.

BUILDING COMMISSIONING. A process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner's project requirements and construction documents, and to minimum code requirements.

BUILDING ENTRANCE. Any door, set of doors, doorway, or other form of portal that is used to gain access to the building from the outside by the public.

BUILDING SITE. A contiguous area of land that is under the ownership or control of one entity.

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floors, ceilings, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

CAPTIVE KEY OVERRIDE. A lighting control that will not release the key that activates the override when the lighting is on.

CAVITY INSULATION. Insulating material located between framing members.

***C*-FACTOR (THERMAL CONDUCTANCE).** The coefficient of heat transmission (surface to surface) through a building component or assembly, equal to the time rate of heat flow per unit area and the unit temperature difference between the warm side and cold side surfaces (Btu/h • ft^2 • °F) [W/(m^2 • K)].

CHANGE OF OCCUPANCY. A change in the use of a building or a portion of a building that results in any of the following:

1. A *change of occupancy* classification.
2. A change from one group to another group within an occupancy classification.
3. Any change in use within a group for which there is a change in the application of the requirements of this code.

CHIEF BUILDING OFFICIAL. The authority responsible for the administration and enforcement of building codes as well as interpretation of policy and procedure as adopted by the city; head code official.

CIRCULATING HOT WATER SYSTEM. A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to the fixture supply and back to the water-heating equipment.

CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CODE OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

COEFFICENT OF PERFORMANCE (COP) – COOLING. The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

COEFFICIENT OF PERFORMANCE (COP) – HEATING. The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

COMBUSTION EQUIPMENT. Any equipment or appliances used for space heating, cooling, water heating (including pools and spas), cooking, clothes drying or lighting that uses natural gas, propane, other fuel gas, or fuel oil.

COMMERCIAL BUILDING. For this code, all buildings that are not included in the definition of "Residential building."

COMMISSIONING. See *building commissioning*.

COMPUTER ROOM. A room whose primary function is to house equipment for the processing and storage of electronic data which has a design total information technology equipment (ITE) equipment power density greater than or equal to 20 watts per square foot (20 watts per 0.092 m^2) of conditioned area or a design total ITE equipment load less than or equal to 10 kW.

CONDENSING UNIT. A factory-made assembly of refrigeration components designed to compress and liquefy a specific refrigerant. The unit consists of one or more refrigerant compressors, refrigerant condensers (air-cooled, evaporatively cooled, or water-cooled), condenser fans and motors (where used) and factory-supplied accessories.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the *conditioned space*.

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

CONSTRUCTION VALUATION. The total value of work requiring building, mechanical, plumbing and electrical permits; to be determined consistent with the standards of Subsection 4-20-4(d), B.R.C. 1981. The higher of the two valuations considered under Subsection 4-20-4(d), B.R.C. 1981, shall be the total value of work.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CURTAIN WALL. Fenestration products used to create an external nonload-bearing wall that is designed to separate the exterior and interior environments.

DATA CENTER. A room or series of rooms that share data center systems, whose primary function is to house equipment for the processing and storage of electronic data and that has a design total ITE equipment power density

exceeding 20 watts per square foot (20 watts per 0.092 m^2) of conditioned area and a total design ITE equipment load greater than 10 kW.

DATA CENTER SYSTEMS. HVAC systems and equipment, or portions thereof, used to provide cooling or ventilation in a data center.

DAYLIGHT RESPONSIVE CONTROL. A device or system that provides automatic control of electric light levels based on the amount of daylight in a space.

DAYLIGHT ZONE. That portion of a building's interior floor area that is illuminated by natural light.

DEMAND CONTROL VENTILATION (DCV). A ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

DEMAND RECIRCULATION WATER SYSTEM. A water distribution system where one or more pumps prime the service hot water piping with heated water upon demand for hot water.

DIRECT CURRENT FAST CHARGER (DCFC) EVSE. Equipment capable of fast charging on a 100A or higher 480VAC three-phase branch circuit. AC power is converted into a controlled DC voltage and current within the EVSE that will then directly charge the electric vehicle.

DIRECT DIGITAL CONTROL (DDC). A type of control where controlled and monitored analog or binary data, such as temperature and contact closures, are converted to a digital format for manipulation and calculations by a digital computer or microprocessor, then converted back to analog or binary form to control physical devices.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

DWELLING UNIT. A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

DWELLING UNIT ENCLOSURE AREA. See "*Testing Unit Enclosure Area*".

DYNAMIC GLAZING. Any fenestration product that has the fully reversible ability to change its performance properties, including *U*-factor, solar heat gain coefficient (SHGC), or visible transmittance (VT).

ECONOMIZER, AIR. A duct and damper arrangement and automatic control system that allows a cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

ECONOMIZER, WATER. A system where the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling.

ELECTRIC VEHICLE (EV). A motorized vehicle registered for on-road use, powered by an electric motor that draws current from rechargeable storage that is charged by being plugged into an electrical source.

ELECTRIC VEHICLE CAPABLE LIGHT SPACE (EV CAPABLE LIGHT SPACE). A designated vehicle parking space that has conduit and/or raceway installed to support future implementation of electric vehicle charging installation and has sufficient physical space adjacent to the existing electrical equipment for future electric upgrades.

ELECTRIC VEHICLE CAPABLE SPACE (EV CAPABLE SPACE). A designated vehicle parking space that has the electric panel capacity and conduit and/or raceway installed to support future implementation of *electric vehicle* charging.

ELECTRIC VEHICLE READY SPACE (EV READY SPACE). A designated vehicle parking space that has the electric panel capacity, raceway wiring, receptacle, and circuit overprotection devices installed to support future implementation of *electrical vehicle* charging.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). An *electric vehicle* charging system or device that is used to provide electricity to a plug-in *electric vehicle* or *plug-in hybrid electric vehicle*, is designed to ensure that a safe connection has been made between the electrical grid and the vehicle, and is able to communicate with the vehicle's control system so that electricity flows at an appropriate voltage and current level.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) INSTALLED SPACE. A vehicle parking space that is provided with a dedicated EVSE connection and a circuit capable of supplying a minimum current of 40 amps at 208/ 220 volt.

ENCLOSED SPACE. A volume surrounded by solid surfaces such as walls, floors, roofs, and openable devices such as doors and operable windows.

ENERGY ANALYSIS. A method for estimating the annual energy use of the *proposed design* and *standard reference design* based on estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

ENERGY IMPACT OFFSET FUND. A city-approved and city-managed offset fund providing a payment option in lieu of complying with city program renewable energy and/or offset requirements.

ENERGY RECOVERY VENTILATION SYSTEM. Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.

ENERGY SIMULATION TOOL. An *approved* software program or calculation-based methodology that projects the annual energy use of a building.

ENERGY USE INTENSITY (EUI). The annual building site energy use per square foot of gross floor area in units of kBTU/sq ft.

ENTHALPY RECOVERY RATIO. Change in the enthalpy of the *outdoor air* supply divided by the difference

between the *outdoor air* and entering exhaust air enthalpy, expressed as a percentage.

ENTRANCE DOOR. A vertical fenestration product used for occupant ingress, egress and access in nonresidential buildings, including, but not limited to, exterior entrances utilizing latching hardware and automatic closers and containing over 50 percent glazing specifically designed to withstand heavy-duty usage.

EQUIPMENT POWER DENSITY (EPD). The power per unit area of equipment serving plug and process loads of the building or space, expressed in W/ft^2 of building gross floor area.

EQUIPMENT ROOM. A space that contains either electrical equipment, mechanical equipment, machinery, water pumps or hydraulic pumps that are a function of the building's services.

EXTERIOR WALL. Walls including both above-grade walls and basement walls.

FAN, EMBEDDED. A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.

FAN ARRAY. Multiple fans in parallel between two plenum sections in an air distribution system.

FAN BRAKE HORSEPOWER (BHP). The horsepower delivered to the fan's shaft. Brake horsepower does not include the mechanical drive losses such as that from belts and gears.

FAN ENERGYH INDEX (FEI). The ratio of the electrical input power of a reference fan to the electric input power of the actual fan as calculated in accordance with AMCA 208.

FAN NAMEPLATE ELECTRICAL INPUT POWER. The nominal electrical input power rating stamped on a fan assembly nameplate.

FAN SYSTEM BHP. The sum of the fan brake horsepower of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

FAN SYSTEM DESIGN CONDITIONS. Operating conditions that can be expected to occur during normal system operation that result in the highest supply fan airflow rate to conditioned spaces served by the system, other than during air economizer operation.

FAN SYSTEM ELECTRICAL INPUT POWER. The sum of the fan electrical power of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the conditioned spaces and/or return it to the source or exhaust it to the outdoors.

FAN SYSTEM MOTOR NAMEPLATE HP. The sum of the motor nameplate horsepower of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the *conditioned spaces* and return it to the source or exhaust it to the outdoors.

FAULT DETECTION AND DIAGNOSTICS (FDD) SYSTEM. A software platform that utilizes building analytic algorithms to convert data provided by sensors and devices to automatically identify faults in building systems and provide a prioritized list of actionable resolutions to those faults based on cost or energy avoidance, comfort, and maintenance impact.

FENESTRATION. Products classified as either skylights or vertical fenestration.

Skylights. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal, including unit skylights, tubular daylighting devices and glazing materials in solariums, sunrooms, roofs and sloped walls.

Vertical fenestration. Windows that are fixed or operable, opaque doors, glazed doors, glazed block and combination opaque and glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of not less than 60 degrees (1.05 rad) from horizontal.

FENESTRATION PRODUCT, FIELD-FABRICATED. A fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-built fenestration.

FENESTRATION PRODUCT, SITE-BUILT. A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory- formed framing and glazing units. Examples of site-built fenestration include storefront systems, curtain walls, and atrium roof systems.

***F*-FACTOR.** The perimeter heat loss factor for slab-on-grade floors (Btu/h • ft • °F) [W/(m • K)].

FLOOR AREA, NET. The actual occupied area not including unoccupied accessory areas such as corridors, stairways, toilet rooms, mechanical rooms and closets.

GENERAL LIGHTING. Interior lighting that provides a substantially uniform level of illumination throughout a space.

GREENHOUSE. A structure or a thermally isolated area of a building that maintains a specialized sunlit environment exclusively used for, and essential to, the cultivation, protection or maintenance of plants. *Greenhouses* are those that are erected for a period of 180 days or more.

GROUP R. Buildings or portions of buildings that contain any of the following occupancies as established in the *International Building Code*:

1. *Group R*-1.
2. *Group R*-2 where located more than three stories in height above grade plane.
3. *Group R*-4 where located more than three stories in height above grade plane.

HEAT TRAP. An arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents thermosyphoning of hot water during standby periods.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.

HIGH-END TRIM. Also known as "Task Tuning", this is a strategy that utilizes the built-in dimming features found in the majority of LED lighting to allow for customization of light level to match the task needs of the occupant preferences.

HIGH SPEED DOOR. A nonswinging door used primarily to facilitate vehicular access or material transportation, with a minimum opening rate of 32 inches (813 mm) per second, a minimum closing rate of 24 inches (610 mm) per second and that includes an automatic-closing device.

HISTORIC BUILDING, DESIGNATED. Any building or structure that is locally designated by ordinance as an individual landmark or recognized as a contributing resource within a historic district.

HORTICULTURAL LIGHTING. Electric lighting used for horticultural production, cultivation or maintenance.

IEC DESIGN H MOTOR. An electric motor that meets all of the following:

1. It is an induction motor designed for use with three-phase power.
2. It contains a cage rotor.
3. It is capable of direct-on-line starting.
4. It has four, six or eight poles.
5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 hertz.

IEC DESIGN N MOTOR. An electric motor that meets all of the following:

1. It is an induction motor designed for use with three-phase power.
2. It contains a cage rotor.
3. It is capable of direct-on-line starting.
4. It has two, four, six or eight poles.
5. It is rated from 0.4 kW to 1600 kW at a frequency of 60 hertz.

INDUSTRY-WIDE TYPE III ENVIRONMENTAL PRODUCT DECLARATION (IW-EPD). Type III environmental product declaration (EPD) that estimates the average global warming potential of a specific product within an industry. Complies with the goal and scope for the production stage of at least cradle-to-gate in accordance with ISO Standards 14025 and 21930 and be available in a publicly accessible database. The EPD results represent production weighted average data across multiple manufacturers.

INFILTRATION. The uncontrolled inward air leakage into a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INFORMATION TECHNOLOGY EQUIPMENT (ITE). Items including computers, data storage devices, servers and network and communication equipment.

INTEGRATED PART LOAD VALUE (IPLV). A single-number figure of merit based on part-load EER, COP or kW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for equipment.

INTEGRATED CURTAIN SYSTEM. A system consisting of movable panels of fabric or plastic film used to cover and uncover the space enclosed in a greenhouse on a daily basis.

ISOLATION DEVICES. Devices that isolate HVAC zones so that they can be operated independently of one another. *Isolation devices* include separate systems, isolation dampers, and controls providing shutoff at terminal boxes.

LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, approved agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LARGE DIAMETER CEILING FAN. A ceiling fan that is greater than 7 feet (2134 mm) in diameter. These fans are sometimes referred to as High-Volume, Low-Speed (HVLS) fans.

LINER SYSTEM (Ls). A system that includes the following:

1. A continuous vapor barrier liner membrane that is installed below the purlins and that is uninterrupted by framing members.
2. An uncompressed, unfaced insulation resting on top of the liner membrane and located between the purlins.

For multilayer installations, the last rated *R*-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the *code official* and concerned with evaluation of products or services that maintains periodic inspection of production of *listed* equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LOW-SLOPED ROOF. A roof having a slope less than 2 units vertical in 12 units horizontal.

LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMER. A transformer that is air-cooled, does not use oil as a coolant, has an input voltage less than or equal to 600 volts and is rated for operation at a frequency of 60 hertz.

LUMINAIRE-LEVEL LIGHTING CONTROLS. A lighting system consisting of one or more luminaires with em-bedded lighting control logic, occupancy and ambient light sensors, wireless networking capabilities and local override switching capability, where required.

MANUAL. Capable of being operated by personal intervention (see "Automatic").

MIXED-FUEL BUILDING. A *building* and building site that contains *combustion equipment*, or plumbing for *combustion equipment*, for space heating, cooling, water heating (including pools and spas), cooking, or clothes drying.

NAMEPLATE HORSEPOWER. The nominal motor output power rating stamped on the motor nameplate.

NEMA DESIGN A MOTOR. A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting and develop locked-rotor torque as shown in paragraph 12.38.1 of NEMA MG 1.
2. It has pull-up torque not less than the values shown in paragraph 12.40.1 of NEMA MG 1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.1 of NEMA MG 1.
4. It has a locked-rotor current higher than the values shown in paragraph 12.35.1 of NEMA MG 1 for 60 hertz and paragraph 12.35.2 of NEMA MG 1 for 50 hertz.
5. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

NEMA DESIGN B MOTOR. A squirrel-cage motor that meets all of the following:

1. It is designed to withstand full-voltage starting.
2. It develops locked-rotor, breakdown, and pull-up torques adequate for general application as specified in Sections 12.38, 12.39 and 12.40 of NEMA MG1.
3. It draws locked-rotor current not to exceed the values shown in Section 12.35.1 for 60 hertz and Section 12.35.2 for 50 hertz of NEMA MG1.
4. It has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

NEMA DESIGN C MOTOR. A squirrel-cage motor that meets all of the following:

1. Designed to withstand full-voltage starting and develop locked-rotor torque for high-torque applications up to the values shown in paragraph 12.38.2 of NEMA MG1 (incorporated by reference, see A§431.15).
2. It has pull-up torque not less than the values shown in paragraph 12.40.2 of NEMA MG1.
3. It has breakdown torque not less than the values shown in paragraph 12.39.2 of NEMA MG1.
4. It has a locked-rotor current not to exceed the values shown in paragraph 12.35.1 of NEMA MG1 for 60 hertz and paragraph 12.35.2 for 50 hertz.
5. It has a slip at rated load of less than 5 percent.

NETWORKED GUESTROOM CONTROL SYSTEM. A control system, with access from the front desk or other central location associated with a *Group R*-1 building, that is capable of identifying the rented and unrented status of each guestroom according to a timed schedule, and is capable of controlling HVAC in each hotel and motel guestroom separately.

NONSTANDARD PART LOAD VALUE (NPLV). A single-number part-load efficiency figure of merit calculated and referenced to conditions other than IPLV conditions, for units that are not designed to operate at AHRI standard rating conditions.

OCCUPANT SENSOR CONTROL. An automatic control device or system that detects the presence or absence of people within an area and causes lighting, equipment or appliances to be regulated accordingly.

ON-SITE RENEWABLE ENERGY. Energy from renewable energy resources harvested at the building project site.

OPAQUE DOOR. A door that is not less than 50-percent opaque in surface area.

PHOTOSYNTHETIC PHOTON EFFICACY (PPE). Photosynthetic photon flux emitted by a light source divided by its electrical input power in units of micromoles per second per watt, or micromoles per joule (µmol/J) between 400-700nm as defined by ANSI/ASABE S640.

PHOTOVOLTAIC MODULE. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate DC power.

PHOTOVOLTAIC PANEL. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.

PHOTOVOLTAIC PANEL SYSTEM. A system that incorporates discrete photovoltaic panels, that converts solar radiation into electricity, including rack support systems.

POWER PURCHACE AGREEMENT (PPA). A contract for the purchase of power and associated renewable energy from a specific renewable energy generator to a purchaser of renewable electricity.

PLUG-IN HYBRID ELECTRIC VEHICLE. An electric vehicle having a second source of motive power.PHOTOSYNTHETIC PHOTON EFFICACY (PPE). Photosynthetic photon flux emitted by a light source divided by its electrical input power in units of micromoles per second per watt, or micromoles per joule (µmol/J) between 400-700nm as defined by ANSI/ASABE S640.

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POWER PURCHACE AGREEMENT (PPA). A contract for the purchase of power and associated renewable energy from a specific renewable energy generator to a purchaser of renewable electricity.

PLUG-IN HYBRID ELECTRIC VEHICLE. An *electric vehicle* having a second source of motive power.

POWERED ROOF/WALL VENTILATORS. A fan consisting of a centrifugal or axial impeller with an integral driver in a weather-resistant housing and with a base designed to fit, usually by means of a curb, over a wall or roof opening.

PROCESS HEAT. The thermal energy used directly in the preparation or production of basic materials and commodities; excludes space and water heating.

PRODUCT-SPECIFIC TYPE III, ENVIRONMENTAL PRODUCT DECLARATION aka EPD. Also known as manufacturer specific EPD. Type III environmental product declaration (EPD) complying with the goal and scope for the production stage of at least cradle-to-gate in accordance with ISO Standards 14025 and 21930 and be available in a publicly accessible database. The data can represent the impacts of a specific design and manufacturers across multiple facilities or be facility specific.

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy use for determining compliance based on total building performance.

RADIANT HEATING SYSTEM. A heating system that transfers heat to objects and surfaces within a conditioned space, primarily by infrared radiation.

READY ACCESS (TO). That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel or similar obstruction.

REFRIGERANT DEW POINT. The refrigerant vapor saturation temperature at a specified pressure.

REFRIGERATED WAREHOUSE COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATED WAREHOUSE FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F (0°C), that can be walked into and has a total chilled storage area of not less than 3,000 square feet (279 m^2).

REFRIGERATION SYSTEM, LOW TEMPERATURE. Systems for maintaining food product in a frozen state in refrigeration applications.

REFRIGERATION SYSTEM, MEDIUM TEMPERATURE. Systems for maintaining food product above freezing in refrigeration applications.

REGISTERED DESIGN PROFESSIONAL. An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

RENEWABLE ENERGY RESOURCES. Energy derived from solar radiation, wind, waves, tides, landfill gas, biogas, biomass or extracted from hot fluid or steam heated within the earth.

REPAIR. The reconstruction or renewal of any part of an existing building for the purpose of its maintenance or to correct damage.

REROOFING. The process of recovering or replacing an existing roof covering. See "Roof recover" and "Roof replacement."

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and townhouses, and *Group* R-3 and R-4 buildings three stories or less in height above grade plane with separate means of egress.

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly includes the roof covering, underlayment, roof deck, insulation, vapor retarder and interior finish.

ROOF RECOVER. The process of installing an additional roof covering over an existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purpose of its maintenance.

ROOF REPLACMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.

ROOFTOP MONITOR. A raised section of a roof containing vertical fenestration along one or more sides.

***R*-VALUE (THERMAL RESISTANCE).** The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area (h • ft^2 • °F/Btu) [(m^2 • K)/W].

SATURATED CONDENSING TEMPERATURE. The saturation temperature corresponding to the measured refrigerant pressure at the condenser inlet for single component and azeotropic refrigerants, and the arithmetic average of the dew point and *bubble point* temperatures corresponding to the refrigerant pressure at the condenser entrance for zeotropic refrigerants.

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SLEEPING UNIT. A room or space in which people sleep, that can include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are part of a dwelling unit are not *sleeping units*.

SMALL ELECTRIC MOTOR. A general purpose, alternating current, single speed induction motor.

SOLAR HEAT GAIN COEFFICIENT (SHGC). The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, that is then reradiated, conducted or convected into the space.

SOLAR-READY ZONE. A section or sections of the roof or building overhang designated and reserved for future installation of a solar photovoltaic system or solar thermal system.

STANDARD REFERENCE DESIGN. A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

STOREFRONT. A system of doors and windows mulled as a composite fenestration structure that has been designed to resist heavy use. *Storefront* systems include, but are not limited to, exterior fenestration systems that span from the floor level or above to the ceiling of the same story on commercial buildings, with or without mulled windows and doors.

SUBSTANTIAL THERMAL ENVELOPE ALTERATION. An alteration greater than or equal to 50 percent of the building thermal envelope.

SUBSTANTIAL MECHANICAL ALTERATION. An *alteration* in which the *space conditioning equipment* or *service water heating equipment* is replaced.

TESTING UNIT ENCLOSURE AREA. The area sum of all the boundary surfaces that define the *dwelling unit*, *sleeping unit*, or occupiable *conditioned space* including top/ ceiling, bottom/floor, and all side walls. This does not include interior partition walls within the *dwelling unit*, *sleeping unit*, or *occupiable conditioned space*. Wall height shall be measured from the finished floor of the conditioned space to the finished floor or ceiling/roof above if the unit separation walls and corridor wall have blocking above in the ceiling/ roof cavity. If blocking is not present then the wall height shall be measured to the unit ceiling.

THERMAL DISTRIBUTION EFFICIENCY (TDE). The resistance to changes in air heat as air is conveyed through a distance of air duct. TDE is a heat loss calculation evaluating the difference in the heat of the air between the air duct inlet and outlet caused by differences in temperatures between the air in the duct and the duct material. TDE is expressed as a percent difference between the inlet and outlet heat in the duct.

THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable setpoint.

TIME SWITCH CONTROL. An automatic control device or system that controls lighting or other loads, including switching off, based on time schedules.

***U*-FACTOR (THERMAL TRANSMITTANCE).** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h • ft^2 • °F) [W/(m^2 • K)].

UNIVERSAL VEHICLE CHARGING SPACES. Parking spaces provided for electric vehicle charging stations that can be utilized for all users and complies with Chapter 11 of the *International Building Code* as amended by the City of Boulder.

VARIABLE REFRIGERANT FLOW SYSTEM. An engineered direct-expansion (DX) refrigerant system that incorporates a common condensing unit, at least one variable-capacity compressor, a distributed refrigerant piping network to multiple indoor fan heating and cooling units each capable of individual zone temperature control, through integral zone temperature control devices and a common communications network. Variable refrigerant flow utilizes three or more steps of control on common interconnecting piping.

VEGETATIVE ROOF. An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation, and related landscape elements.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

VISIBLE TRANSMITTANCE [VT]. The ratio of visible light entering the space through the fenestration product assembly to the incident visible light. Visible transmittance includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

VISIBLE TRANSMITTANCE, ANNUAL (VT_{annual}). The ratio of visible light entering the space through the fenestration product assembly to the incident visible light, which includes the effects of glazing material, frame, and light well or tubular conduit, and is expressed as a number between 0 and 1.

VOLTAGE DROP. A decrease in voltage caused by losses in the wiring systems that connect the power source to the load.

WALK-IN COOLER. An enclosed storage space capable of being refrigerated to temperatures above 32°F (0°C) and less than 55°F (12.8°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m^2).

WALK-IN FREEZER. An enclosed storage space capable of being refrigerated to temperatures at or below 32°F (0°C) that can be walked into, has a ceiling height of not less than 7 feet (2134 mm) and has a total chilled storage area of less than 3,000 square feet (279 m^2).

WALL, ABOVE-GRADE. A wall associated with the *building thermal envelope* that is more than 15 percent above grade and is on the exterior of the building or any wall that is associated with the *building thermal envelope* that is not on the exterior of the building. This includes, but is not limited to, between-floor spandrels, peripheral edges of floors, roof knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

WALL, BELOW-GRADE. A wall associated with the basement or first story of the building that is part of the *building thermal envelope*, is not less than 85 percent below grade and is on the exterior of the building.

WATER HEATER. Any heating appliance or equipment that heats potable water and supplies such water to the potable hot water distribution system.

ZONE. A space or group of spaces within a building with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

CHAPTER 3 [CE]
GENERAL REQUIREMENTS

User note:

About this chapter: *Chapter 3 addresses broadly applicable requirements that would not be at home in other chapters having more specific coverage of subject matter. This chapter contains product rating, marking and installation requirements for materials such as insulation, windows, doors and siding.*

SECTION C301
LOCATION

C301.1 General. This code applies to projects located in the City of Boulder and the City Boulder is located in *Climate Zone* 5B.

SECTION C302
DESIGN CONDITIONS

C302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

SECTION C303
MATERIALS, SYSTEMS AND EQUIPMENT

C303.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

C303.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternatively, the insulation installers shall provide a certification listing the type, manufacturer and *R*-value of insulation installed in each element of the *building thermal envelope*. For blown-in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be *listed* on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be *listed* on the certification. For insulated siding, the *R*-value shall be labeled on the product's package and shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

Exception: For roof insulation installed above the deck, the *R*-value shall be labeled as required by the material standards specified in Table 1508.2 of the *International Building Code*.

C303.1.1.1 Blown-in or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed fiberglass and cellulose roof/ceiling insulation shall be written in inches (mm) on markers and one or more of such markers shall be installed for every 300 square feet (28 m^2) of attic area throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch (25 mm) in height. Each marker shall face the attic *access* opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

C303.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection. For insulation materials that are installed without an observable manufacturer's R-value mark, such as blown or draped products, an insulation certificate complying with Section C303.1.1 shall be left immediately after installation by the installer, in a conspicuous location within the building, to certify the installed R-value of the insulation material.

C303.1.3 Fenestration product rating. *U*-factors of fenestration products shall be determined as follows:

1. For windows, doors and skylights, *U*-factor ratings shall be determined in accordance with NFRC 100.
2. Where required for garage doors and rolling doors, *U*-factor ratings shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

U-factors shall be determined by an accredited, independent laboratory, and *labeled* and certified by the manufacturer.

Products lacking such a *labeled U*-factor shall be assigned a default *U*-factor from Table C303.1.3(1) or C303.1.3(2). The solar heat gain coefficient (SHGC) and

TABLE C303.1.3(1)
DEFAULT GLAZED WINDOW, GLASS DOOR, AND SKYLIGHT *U*-FACTORS

FRAME TYPE	WINDOW AND GLASS DOOR		SKYLIGHT	
	Single	Double	Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

TABLE C303.1.3(2)
DEFAULT OPAQUE DOOR *U*-FACTORS

DOOR TYPE	OPAQUE *U*-FACTOR
Uninsulated Metal	1.20
Insulated Metal (Rolling)	0.90
Insulated Metal (Other)	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

TABLE C303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

visible transmittance (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and *labeled* and certified by the manufacturer. Products lacking such a *labeled* SHGC or VT shall be assigned a default SHGC or VT from Table C303.1.3(3).

C303.1.4 Insulation product rating. The thermal resistance (*R*-value) of insulation shall be determined in accordance with the U.S. Federal Trade Commission *R*-value rule (CFR Title 16, Part 460) in units of h • ft^2 • °F/Btu at a mean temperature of 75°F (24°C).

C303.1.4.1 Insulated siding. The thermal resistance (*R*-value) of insulated siding shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer's instructions.

C303.2 Installation. Materials, systems and equipment shall be installed in accordance with the manufacturer's recommended installation instructions and the *International Building Code*.

C303.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawl space walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

C303.2.2 Multiple layers of continuous insulation board. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. Where the continuous insulation board manufacturer's instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

CHAPTER 4 [CE]
COMMERCIAL ENERGY EFFICIENCY

User note:

About this chapter: *Chapter 4 presents the paths and options for compliance with the energy efficiency provisions. Chapter 4 contains energy efficiency provisions for the building envelope, mechanical and service water-heating systems, lighting, and other conservation requirements that reduce carbon emission overall. A prescriptive alternative is also provided for projects meeting the required criteria.*

SECTION C401
GENERAL

C401.1 Scope. The provisions in this chapter are applicable to commercial *buildings* and their *building sites.*

C401.2 Application. Commercial buildings shall comply with the requirements of Section C407. New buildings with a construction valuation less than $500,000 may alternatively follow the Prescriptive Pathway which requires compliance with Sections C401, C402, C403, C404, C405, C406, Table C407.2 and Section C408.

C401.2.1 Core and shell buildings. Commercial core and shell buildings may take credit for energy efficiency that is part of the future interior tenant finish design, provided that the efficiency measures are shown on the final tenant build-out drawings. A Letter of Completion shall be issued upon completion of the core and shell building. A permanent certificate of occupancy shall be issued once the tenant build out is completed and any tenant finishes that were credited towards the building's efficiency requirements are complete.

C401.3 Existing buildings. Alterations, repairs, additions, and changes of use to existing buildings shall comply with the requirements of Chapter 5 of this code.

C401.4 Thermal envelope certificate. A permanent thermal envelope certificate shall be completed by an *approved* party. Such certificate shall be posted on a wall in the space where the space conditioning equipment is located, a utility room or other *approved* location. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. A copy of the certificate shall also be included in the construction files for the project. The certificate shall include the following:

1. R-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, basement walls, crawl space walls and floor and ducts outside *conditioned spaces*.
2. U-factors and *solar heat gain coefficients (SHGC)* of fenestrations.
3. Results from any *building* envelope air leakage testing performed on the building.

Where there is more than one value for any component of the building envelope, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.

SECTION C402
BUILDING ENVELOPE REQUIREMENTS

C402.1 General. Building thermal envelope assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the prescriptive compliance path described in Section C401.2, shall comply with the following:

1. The opaque portions of the building thermal envelope shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either the *R*-value-based method of Section C402.1.3; the *U*-, *C*- and *F*-factor-based method of Section C402.1.4; or the component performance alternative of Section C402.1.5.
2. Fenestration in building envelope assemblies shall comply with Section C402.4.
3. Air leakage of building envelope assemblies shall comply with Section C402.5.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.4, the building shall comply with Section C407.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.11.

C402.1.1 Low-energy buildings and greenhouses. The following low- energy buildings, or portions thereof separated from the remainder of the building by *building thermal envelope* assemblies complying with this section, shall be exempt from the *building thermal envelope* provisions of Section C402.

1. Those with a peak design rate of energy usage less than 3.4 Btu/h • ft^2 (10.7 W/m^2) or 1.0 watt per square foot (10.7 W/m^2) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.

C402.1.1.1 Greenhouses. Greenhouse structures or areas that are mechanically heated or cooled and that comply with all of the following shall be exempt from the building envelope requirements of this code:

1. Exterior opaque envelope assemblies comply with Sections C402.2 and C402.4.5.

Exception: Low energy greenhouses that comply with Section C402.1.1.

2. Interior partition *building thermal envelope* assemblies that separate the greenhouse from *conditioned space* comply with Sections C402.2, C402.4.3 and C402.4.5.
3. Fenestration assemblies that comply with the thermal envelope requirements in Table C402.1.1.1. The *U-factor* for a roof shall be for the roof assembly of a roof that includes the assembly and an internal curtain system.

Exception: Unconditioned greenhouses.

TABLE C402.1.1.1
FENESTRATION THERMAL ENVELOPE MAXIMUM REQUIREMENTS

COMPONENT	U-FACTOR (BTU/h × ft² × °F)
Skylight	0.5
Vertical Fenestration	0.7

C402.1.2 Equipment buildings. Buildings that comply with the following shall be exempt from the *building thermal envelope* provisions of this code:

1. Are separate buildings with floor area not more than 1,200 square feet (110 m^2).
2. Are intended to house electric equipment with installed equipment power totaling not less than 7 watts per square foot (75 W/m^2) and not intended for human occupancy.
3. Have a heating system capacity not greater than (17,000 Btu/h) (5 kW) and a heating thermostat setpoint that is restricted to not more than 50°F (10°C).
4. Have an average wall and roof *U*-factor less than 0.120.

C402.1.3 Insulation component *R*-value-based method. *Building thermal envelope* opaque assemblies shall comply with the requirements of Sections C402.2 and C402.4. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R-value* basis, the *R*-values for cavity insulation and continuous insulation shall be not less than that specified in Table C402.1.3. Where cavity insulation is installed in multiple layers, the cavity insulation R-values shall be summed to determine compliance with the cavity insulation R-value requirements. Where continuous insulation is installed in multiple layers, the continuous insulation R-values shall be summed to determine compliance with the continuous insulation R-value requirements. Cavity insulation R-values shall not be used to determine compliance with the continuous insulation R-value requirements in Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *R*-values from the "*Group R*" column of Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *R*-values from the "All other" column of Table C402.1.3.

C402.1.4 Assembly *U*-factor, *C*-factor, or *F*-factor-based method. Building thermal envelope opaque assemblies shall meet the requirements of Sections C402.2 and C402.4. Building thermal envelope opaque assemblies intended to comply on an assembly *U*-, *C*- or *F*-factor basis shall have a *U*-, *C*- or *F*-factor not greater than that specified in Table C402.1.4. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *U*-, *C*- or *F*-factor from the "*Group R*" column of Table C402.1.4. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *U*-, *C*- or *F*-factor from the "All other" column of Table C402.1.4

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]

	ALL OTHER	GROUP R
Roofs		
Insulation entirely above roof deck	R-33ci	R-33ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS
Attic and other	R-53	R-53
Walls, above grade		
Mass[g]	R-13.3ci	R-13.3ci
Metal building	R-13 + R-19.5ci	R-13 + R-13ci
Metal framed	R-13 + R-11ci	R-13 + R-11ci
Wood framed and other	R-13 + R-9ci or R-19 + R-5ci	R-13 + R-9ci or R-19 + + R-5ci
Walls, below grade		
Below-grade wall[d]	R-7.5ci	R-10ci
Floors		
Mass[e]	R-15ci	R-16.7ci
Joist/framing	R-30	R-30
Slab-on-grade floors		
Unheated slabs	R-15 for 24″ below	R-15 for 24″ below
Heated slabs[h]	R-20 for 48″ below + R-5 full slab	R-20 for 48″ below + R-5 full slab

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 90.1 Appendix A.
b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.
c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. Steel floor joist systems shall be insulated to R-38.
g. "Mass walls" shall be in accordance with Section C402.2.2.
h. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

C402.1.4.1 Roof/ceiling assembly. The maximum roof/ceiling assembly U-factor shall not exceed that specified in Table C402.1.4 based on construction materials used in the roof/ceiling assembly.

C402.1.4.1.1 Tapered, above-deck insulation based on thickness. Where used as a component of maximum roof/ ceiling assembly U-factor calculation, the sloped roof insulation R-value contribution to that calculation shall use the average thickness in inches (mm) along with the material R-value-per-inch (per-mm) solely for U-factor compliance as prescribed in Section C402.1.4.

C402.1.4.1.2 Suspended ceilings. Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly U-factor of the roof/ceiling construction.

C402.1.4.1.3 Joints staggered. Continuous insulation board shall be installed in not less than two layers, and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

	ALL OTHER	GROUP R
Roofs		
Insulation entirely above roof deck	U-0.030	U-0.030
Metal buildings	U-0.035	U-0.035
Attic and other	U-0.020	U-0.020
Walls, above grade		
Mass[f]	U-0.086	U-0.076
Metal building	U-0.048	U-0.048
Metal framed	U-0.052	U-0.052
Wood framed and other[c]	U-0.048	U-0.042
Walls, below grade		
Below-grade wall[c]	C-0.119	C-0.092
Floors		
Mass[d]	U-0.057	U-0.051
Joist/framing	U-0.033	U-0.033
Slab-on-grade floors		
Unheated slabs	F-0.52	F-0.51
Heated slabs[e]	F-0.62	F-0.62
Opaque doors		
Nonswinging door[h]	U-0.31	U-0.31
Swinging door	U-0.37	U-0.37

For SI: 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.
ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. Where assembly *U*-factors, *C*-factors, and *F*-factors are established in ANSI/ASHRAE/IESNA 90.1 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ ASHRAE/ISNEA 90.1 Appendix A.

b. Where *U*-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *U*-factor requirements for above-grade mass walls.

d. "Mass floors" shall be in accordance with Section C402.2.3.

e. The first value is for perimeter insulation and the second value is for full under-slab insulation.

f. "Mass walls" shall be in accordance with Section C402.2.2.

g. Swinging door U-factors shall be determined in accordance with NFRC-100.

h. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.44, provided that the fenestration area is not more than 25 percent of the total door area.

C402.1.4.2 Thermal resistance of cold-formed steel walls. *U*-factors of walls with cold-formed steel studs shall be permitted to be determined in accordance with Equation 4-1:

$$U = 1/[R_s + (ER)] \quad \textbf{(Equation 4-1)}$$

where:

R_s = The cumulative *R*-value of the wall components along the path of heat transfer, excluding the *cavity insulation* and steel studs.

ER = The effective *R*-value of the *cavity insulation* with steel studs as specified in Table C402.1.4.2.

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be an alternative to compliance with the *U*-, *F*- and *C*-factors in Tables C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.4.3.

$$A + B + C + D + E \le \text{Zero} \quad \textbf{(Equation 4-2)}$$

where:

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls.

UA Dif = UA Proposed - UA Table.

UA Proposed = Proposed *U*-value × Area.

UA Table = (*U*-factor from Table C402.1.3, C402.1.4 or C402.4) × Area.

B = Sum of the (FL Dif) values for each distinct slab-on-grade perimeter condition of the building thermal envelope.

FL Dif = FL Proposed - FL Table.

FL Proposed = Proposed *F*-value × Perimeter length.

FL Table = (*F*-factor specified in Table C402.1.4) × Perimeter length.

C = Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.

CA Dif = CA Proposed - CA Table.

CA Proposed = Proposed *C*-value × Area.

CA Table = (Maximum allowable *C*-factor specified in Table C402.1.4) × Area.

Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.4.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:

D = (DA × UV) - (DA × U Wall), but not less than zero.

DA = (Proposed Vertical Glazing Area) - (Vertical Glazing Area allowed by Section C402.4.1).

UA Wall = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall.

U Wall = Area-weighted average *U*-value of all above-grade wall assemblies.

UAV = Sum of the (UA Proposed) values for each vertical glazing assembly.

UV = UAV/total vertical glazing area.

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.4.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:

E = (EA × US) - (EA × U Roof), but not less than zero.

EA = (Proposed Skylight Area) - (Allowable Skylight Area as specified in Section C402.4.1).

U Roof = Area-weighted average *U*-value of all roof assemblies.

UAS = Sum of the (UA Proposed) values for each skylight assembly.

US = UAS/total skylight area.

C402.2 Specific building thermal envelope insulation requirements. Insulation in building thermal envelope opaque assemblies shall comply with Sections C402.2.1 through C402.2.8 and Table C402.1.3.

C402.2.1 Roof assembly. The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.1.3, based on construction materials used in the roof assembly.

C402.2.1.1 Tapered, above-deck insulation based on thickness. Where used as a component of a roof/ceiling assembly R-value calculation, the sloped roof insulation R-value contribution to that calculation shall use the average thickness in inches (mm) along with the material R-value-per-inch (per-mm) solely for R-value compliance as prescribed in Section 402.1.3.

C402.2.1.2 Minimum thickness, lowest point. The minimum thickness above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be not less than 1 inch (25 mm).

C402.2.1.3 Suspended ceilings. Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (R-value) of roof insulation in roof/ceiling construction.

C402.2.1.4 Joists staggered. Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

C402.2.1.5 Skylight curbs. Skylight curbs shall be insulated to the level of roofs with insulation entirely above the deck or R-5, whichever is less.

Exception: Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.

C402.2.2 Above-grade walls. The minimum thermal resistance (*R*-value) of materials installed in the wall cavity between framing members and continuously on the walls shall be as specified in Table C402.1.3, based on framing type and construction materials used in the wall assembly. The *R*-value of integral insulation installed in concrete masonry units shall not be used in determining compliance with Table C402.1.3 except as otherwise noted in the table. In determining compliance with Table C402.1.4, the use of the *U*-factor of concrete masonry units with integral insulation shall be permitted.

"Mass walls" where used as a component in the thermal envelope of a building shall comply with one of the following:

1. Weigh not less than 35 pounds per square foot (171 kg/m^2) of wall surface area.

TABLE C402.1.4.2
EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY *R*-VALUE (insulation)	CORRECTION FACTOR (F_c)	EFFECTIVE *R*-VALUE (ER) (Cavity *R*-Value × F_c)
3 1/2	16	13	0.46	5.98
		15	0.43	6.45
3 1/2	24	13	0.55	7.15
		15	0.52	7.80
6	16	19	0.37	7.03
		21	0.35	7.35
6	24	19	0.45	8.55
		21	0.43	9.03
8	16	25	0.31	7.75
	24	25	0.38	9.50

2. Weigh not less than 25 pounds per square foot (122 kg/m^2) of wall surface area where the material weight is not more than 120 pcf (1900 kg/m^3).
3. Have a heat capacity exceeding 7 Btu/ft^2 • °F (144 kJ/m^2 • K).
4. Have a heat capacity exceeding 5 Btu/ft^2 • °F (103 kJ/m^2 • K), where the material weight is not more than 120 pcf (1900 kg/m^3).

C402.2.3 Floors. The thermal properties (component *R*-values or assembly *U*-, *C*- or *F*-factors) of floor assemblies over outdoor air or unconditioned space shall be as specified in Table C402.1.3 or C402.1.4 based on the construction materials used in the floor assembly. Floor framing *cavity insulation* or structural slab insulation shall be installed to maintain permanent contact with the underside of the subfloor decking or structural slabs.

"Mass floors" where used as a component of the thermal envelope of a building shall provide one of the following weights:

1. 35 pounds per square foot (171 kg/m^2) of floor surface area.
2. 25 pounds per square foot (122 kg/m^2) of floor surface area where the material weight is not more than 120 pounds per cubic foot (1923 kg/m^3).

Exceptions:

1. The floor framing *cavity insulation* or structural slab insulation shall be permitted to be in contact with the top side of sheathing or continuous insulation installed on the bottom side of floor assemblies where combined with insulation that meets or exceeds the minimum *R*-value in Table C402.1.3 for "Metal framed" or "Wood framed and other" values for "Walls, Above Grade" and extends from the bottom to the top of all perimeter floor framing or floor assembly members.
2. Insulation applied to the underside of concrete floor slabs shall be permitted an airspace of not more than 1 inch (25 mm) where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope.*

C402.2.4 Slabs-on-grade. The minimum thermal resistance (*R*-value) of the insulation for unheated or heated slab-on-grade floors designed in accordance with the *R*-value method of Section C402.1.3 shall be as specified in Table C402.1.3.

C402.2.4.1 Insulation installation. Where installed, the perimeter insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. The perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table or to the top of the footing, whichever is less, or downward to not less than the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by not less than of 10 inches (254 mm) of soil. Where installed, full slab insulation shall be continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Insulation required at the heated slab perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

Exception: Where the slab-on-grade floor is greater than 24 inches (61mm) below the finished exterior grade, perimeter insulation is not required.

C402.2.5 Below-grade walls. The *C*-factor for the below-grade exterior walls shall be in accordance with Table C402.1.4. The *R*-value of the insulating material installed continuously within or on the below-grade exterior walls of the building envelope shall be in accordance with Table C402.1.3. The *C*-factor or *R*-value required shall extend to a depth of not less than 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor of the conditioned space enclosed by the below-grade wall, whichever is less.

C402.2.6 Insulation of radiant heating systems. *Radiant heating system* panels, and their associated components that are installed in interior or exterior assemblies shall be insulated to an *R*-value of not less than R-3.5 on all surfaces not facing the space being heated. *Radiant heating system* panels that are installed in the *building thermal envelope* shall be separated from the exterior of the building or unconditioned or exempt spaces by not less than the *R*-value of insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section C402.1.4.

Exception: Heated slabs on grade insulated in accordance with Section C402.2.4.

C402.2.7 Airspaces. Where the R-value of an airspace is used for compliance in accordance with Section C402.1, the airspace shall be enclosed in an unventilated cavity constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where the enclosed airspace is located on the interior side of the continuous air barrier and is bounded on all sides by building components.

Exception: The thermal resistance of airspaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall-covering material shall be determined in accordance with ASTM C1363 modified with an airflow entering the bottom and exiting the top of the airspace at an air movement rate of not less than 70 mm/second.

C402.3 Reserved.

C402.4 Fenestration. Fenestration shall comply with Sections C402.4.1 through C402.4.5 and Table C402.4. Daylight responsive controls shall comply with this section and Section C405.2.4.

C402.4.1 Maximum area. The vertical fenestration area, not including opaque doors and opaque spandrel panels, shall be not greater than 30 percent of the gross above-grade wall area. The skylight area shall be not greater than 3 percent of the gross roof area.

TABLE C402.4
BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS

VERTICAL FENESTRATION		
***U*-factor for vertical curtain walls, storefronts and site-built fenestration products**		
Fixed fenestration	0.36	
Operable fenestration	0.45	
***U*-factor for entrance doors**		
0.63		
***U*-factor for all other vertical fenestration**		
0.30		
SHGC		
Orientation	Fixed	Operable
PF < 0.2	0.38	0.33
0.2 ≤ PF < 0.5	0.46	0.40
PF ≥ 0.5	0.61	0.53
Skylights		
U-factor	0.50	
SHGC	0.40	

PF = Projection Factor.

C402.4.1.1 Increased vertical fenestration area with daylight responsive controls. Not more than 40 percent of the gross above-grade wall area shall be vertical fenestration, provided that all of the following requirements are met:

1. In buildings not greater than two stories above grade, not less than 50 percent of the net floor area is within a *daylight zone.*
2. In buildings three or more stories above grade, not less than 25 percent of the net floor area is within a *daylight zone.*
3. *Daylight responsive controls* are installed in *daylight zones.*
4. Visible transmittance (VT) of vertical fenestration is not less than 1.1 times solar heat gain coefficient (SHGC).

   Exception: Fenestration that is outside the scope of NFRC 200 is not required to comply with Item 4.

C402.4.1.2 Increased skylight area with daylight responsive controls. The skylight area shall be not more than 6 percent of the roof area provided that *daylight responsive controls* are installed in *toplit daylight zones*.

C402.4.2 Minimum skylight fenestration area. Skylights shall be provided in enclosed spaces greater than 2,500 square feet (232 m^2) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot or workshop. The total *toplit daylight zone* shall be not less than half the floor area and shall comply with one of the following:

1. A minimum skylight area to *toplit daylight zone* of not less than 3 percent where all skylights have a VT of not less than 0.40, or VT_{annual} of not less than 0.26 as determined in accordance with Section C303.1.3.
2. A minimum skylight effective aperture, determined in accordance with Equation 4-3, of:
   2.1. Not less than 1 percent, using a skylight's VT or
   2.2. Not less than 0.66 percent using a Tubular Daylighting Device's VT_{annual} rating.

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF}}{\text{Toplit Zone}} \quad \textbf{(Equation 4-3)}$$

where:

Skylight area = Total fenestration area of skylights.

Skylight VT = Area weighted average visible transmittance of skylights.

WF = Area weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for Tubular Daylight Devices with VT_{annual} ratings.

Light well depth = Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight.

Exception: Skylights above *daylight zones* of enclosed spaces are not required in:

1. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft^2 (5.4 W/m^2).
2. Areas where it is documented that existing structures or natural objects block direct beam sunlight on not less than half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.
3. Spaces where the *daylight zone* under rooftop monitors is greater than 50 percent of the enclosed space floor area.
4. Spaces where the total area minus the area of sidelit *daylight zones* is less than 2,500 square feet (232 m^2), and where the lighting is controlled in accordance with Section C405.2.4.
5. Spaces designed as storm shelters complying with ICC 500.

C402.4.2.1 Lighting controls in toplit daylight zones. *Daylight responsive controls* shall be provided in *toplit daylight zones*.

C402.4.2.2 Haze factor. Skylights in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store and distribution/sorting area spaces shall have a glazing material or diffuser with a

haze factor greater than 90 percent when tested in accordance with ASTM D1003.

Exception: Skylights and tubular daylighting devices designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles, the geometry of skylight and light well or the use of optical diffuser components.

C402.4.3 Maximum *U*-factor and SHGC. The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.4.

The window projection factor shall be determined in accordance with Equation 4-4.

$PF = A/B$ **(Equation 4-4)**

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the farthest continuous extremity of any overhang, eave or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave or permanently attached shading device.

Where different windows or glass doors have different *PF* values, they shall each be evaluated separately.

C402.4.3.1 Increased skylight SHGC. Skylights shall be permitted a maximum SHGC of 0.60 where located above *daylight zones* provided with *daylight responsive controls*.

C402.4.3.2 Increased skylight *U*-factor. Where skylights are installed above *daylight zones* provided with *daylight responsive controls*, a maximum *U*-factor of 0.75 shall be permitted.

C402.4.3.3 Dynamic glazing. Where dynamic glazing is intended to satisfy the SHGC and VT requirements of Table C402.4, the ratio of the higher to lower labeled SHGC shall be greater than or equal to 2.4, and the *dynamic glazing* shall be automatically controlled to modulate the amount of solar gain into the space in multiple steps. Dynamic glazing shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing shall not be permitted.

Exception: Dynamic glazing is not required to comply with this section where both the lower and higher labeled SHGC already comply with the requirements of Table C402.4.

C402.4.3.4 Area-weighted *U*-factor. An area-weighted average shall be permitted to satisfy the *U*-factor requirements for each fenestration product category listed in Table C402.4. Individual fenestration products from different fenestration product categories listed in Table C402.4 shall not be combined in calculating area-weighted average *U*-factor.

C402.4.4 Daylight zones. Daylight zones referenced in Sections C402.4.1.1 through C402.4.3.2 shall comply with Sections C405.2.4.2 and C405.2.4.3, as applicable. Daylight zones shall include *toplit daylight zones* and *sidelit daylight zones*.

C402.4.5 Doors. Opaque swinging doors shall comply with Table C402.1.4. Opaque nonswinging doors shall comply with Table C402.1.4. Opaque doors shall be considered as part of the gross area of above-grade walls that are part of the building thermal envelope. Opaque doors shall comply with Section C402.4.5.1 or C402.4.5.2. Other doors shall comply with the provisions of Section C402.4.3 for vertical fenestration.

C402.4.5.1 Opaque swinging doors. Opaque swinging doors shall comply with Table C402.1.4.

C402.4.5.2 Nonswinging doors. Opaque nonswinging doors that are horizontally hinged sectional doors with a single row of fenestration shall have an assembly U-factor less than or equal to 0.440 provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

Exception: Other doors shall comply with the provisions of Section C402.4.3 for vertical fenestration.

C402.5 Air leakage—thermal envelope. The *building thermal envelope* shall comply with Sections C402.5.1 through C402.5.9.

C402.5.1 Air barriers. A continuous *air barrier* shall be provided throughout the *building thermal envelope*. The continuous *air barrier* shall be located on the inside or outside of the *building thermal envelope*, located within the assemblies composing the *building thermal envelope*, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1, C402.5.1.2 and C402.5.1.3.

C402.5.1.1 Air barrier construction. The *continuous air barrier* shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.
2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.
3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Joints and seams associated with penetrations shall be sealed in the same manner or taped. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants

shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.

4. Recessed lighting fixtures shall comply with Section C402.5.8. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

C402.5.1.2 Building thermal envelope testing. The *building thermal envelope* shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158 or ASTM E1827 or an equivalent method *approved* by the *code official.* The measured air leakage shall not exceed 0.25 cfm/ft^2 (1.27 L/s • m^2) of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa). Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the *building thermal envelope* in each portion. The weighted- average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.
2. The entire envelope area of all stories that have a building entrance, exposed floor or loading dock, or are below grade.
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.
4. For R-2 occupancies, *dwelling units* when tested in accordance with Section C402.5.1.3.

Testing and inspection shall be conducted by a third-party *approved agency*. A written report of the test results shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after completion of all penetrations of the *building thermal envelope*.

Exception: Where the measured air leakage rate exceeds 0.25cfm/ft^2 (1.27 L/s × m^2) but does not exceed 0.40 cfm/ft^2 (2.03 L/s × m^2), a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner and shall be deemed to comply with the requirements of this section.

C402.5.1.3 Dwelling and sleeping unit enclosure installation. The components of the *dwelling unit enclosure* as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer's installation instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction. The enclosure shall also be tested per section C402.5.1.2 or C402.5.1.4. Where required by the *code official*, an *approved* third party shall inspect all components and verify compliance.

C402.5.1.4 Dwelling and sleeping unit enclosure testing. The dwelling or sleeping unit envelope shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.20 cfm/ft^2 (1.02 L/s • m^2) of the testing unit enclosure area at a pressure differential of 0.2-inch water gauge (50Pa). Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where the buildings have fewer than eight testing units, each testing unit shall be tested.
2. For buildings with eight or more testing units, the greater of seven or 20 percent of the testing units in the building shall be tested evenly across all floors and shall encompass each unique unit type in the building. For each unit that exceeds the maximum air leakage rate, an additional two units shall be tested.

C402.5.2 Air leakage of fenestration. The air leakage of fenestration assemblies shall meet the provisions of Table C402.5.2. Testing shall be in accordance with the applicable reference test standard in Table C402.5.2 by an accredited, independent testing laboratory and *labeled* by the manufacturer.

Exceptions:

1. Field-fabricated fenestration assemblies that are sealed in accordance with Section C402.5.1.
2. Fenestration in buildings that comply with the testing alternative of Section C402.5 are not required to meet the air leakage requirements in Table C402.5.2.

C402.5.3 Rooms containing fuel-burning appliances. Where combustion air is supplied through openings in an exterior wall to a room or space containing a space-conditioning fuel-burning appliance, one of the following shall apply:

1. The room or space containing the appliance shall be located outside of the *building thermal envelope*.
2. The room or space containing the appliance shall be enclosed and isolated from conditioned spaces inside the building thermal envelope. Such rooms shall comply with all of the following:

    2.1. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be insulated to be not less than equivalent to the insulation requirement of below-grade walls as specified in Table C402.1.3 or C402.1.4.

2.2. The walls, floors and ceilings that separate the enclosed room or space from conditioned spaces shall be sealed in accordance with Section C402.5.1.1.

2.3. The doors into the enclosed room or space shall be fully gasketed.

2.4. Water lines and ducts in the enclosed room or space shall be insulated in accordance with Section C403.

2.5. Where an air duct supplying combustion air to the enclosed room or space passes through conditioned space, the duct shall be insulated to an *R*-value of not less than R-8.

Exception: Fireplaces and stoves complying with Sections 901 through 905 of the *International Mechanical Code*, and Section 2111.14 of the *International Building Code*.

TABLE C402.5.2
MAXIMUM AIR LEAKAGE RATE
FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT²)	TEST PROCEDURE
Windows	0.20 [a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20 [a]	
Swinging doors	0.20 [a]	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 [a]	
Curtain walls	0.06	NFRC 400 or ASTM E283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Power-operated sliding doors and power-operated folding doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-speed doors	1.30	

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093 m^2.

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

C402.5.4 Doors and *access* openings to shafts, chutes, stairways and elevator lobbies. Doors and *access* openings from conditioned space to shafts, chutes stairways and elevator lobbies not within the scope of the fenestration assemblies covered by Section C402.5.2 shall be gasketed, weatherstripped or sealed.

Exceptions:

1. Door openings required to comply with Section 716 of the *International Building Code.*
2. Doors and door openings required to comply with UL 1784 by the *International Building Code.*

C402.5.5 Air intakes, exhaust openings, stairways and shafts. Stairway enclosures, elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be provided with dampers in accordance with Section C403.7.7.

C402.5.6 Loading dock weather seals. Cargo door openings and loading door openings shall be equipped with weather seals that restrict infiltration and provide direct contact along the top and sides of vehicles that are parked in the doorway.

C402.5.7 Vestibules. Building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. The installation of one or more revolving doors in the building entrance shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors.

Exceptions: Vestibules are not required for the following:

1. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
2. Doors opening directly from a *sleeping unit* or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
4. Revolving doors.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
6. Doors that have an air curtain with a velocity of not less than 6.56 feet per second (2 m/s) at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C408.2.3.

C402.5.8 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be all of the following:

1. IC-rated.
2. Labeled as having an air leakage rate of not more 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a 1.57 psf (75 Pa) pressure differential.
3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

C402.5.9 Operable openings interlocking. Where occupancies utilize operable openings to the outdoors that are larger than 40 square feet (3.7 m^2) in area, such openings shall be interlocked with the heating and cooling system so as to raise the cooling setpoint to 90°F (32°C) and lower the heating setpoint to 55°F (13°C) whenever the operable opening is open. The change in heating and cool-

ing setpoints shall occur within 10 minutes of opening the operable opening.

Exceptions:

1. Separately zoned areas associated with the preparation of food that contain appliances that contribute to the HVAC loads of a restaurant or similar type of occupancy.
2. Warehouses that utilize overhead doors for the function of the occupancy, where approved by the *code official*.
3. The first entrance doors where located in the exterior wall and are part of a vestibule system.

C402.5.9.1 Operable Controls. Controls shall comply with Section C403.14.

SECTION C403
BUILDING MECHANICAL SYSTEMS

C403.1 General. Mechanical systems and equipment serving the building's heating, cooling, ventilating or refrigerating needs shall comply with this section.

Exception: Data center systems are exempt from the requirements of Sections C403.4 and C403.5.

C403.1.1 Calculation of heating and cooling loads. Design loads associated with heating, ventilating and air conditioning of the building shall be determined in accordance with ANSI/ASHRAE/ACCA Standard 183 or by an *approved* equivalent computational procedure using the design parameters specified in Chapter 3. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook* by an approved equivalent computational procedure.

C403.1.2 Data centers. Data center systems shall comply with Sections 6 and 8 of ASHRAE 90.4 with the following changes:

1. Replace design mechanical load component (MLC) values specified in Table 6.2.1.1 of the ASHRAE 90.4 with maximum 0.23 Design MLC at 100% and at 50% ITE load.
2. Replace annualized MLC values specified in Table 6.2.1.2 of the ASHRAE 90.4 with maximum 0.16 HVAC annualized MLC at 100% and at 50% ITE load.

C403.2 System design. Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.3. Where elements of a building's mechanical systems are addressed in Sections C403.3 through C403.13, such elements shall comply with the applicable provisions of those sections.

C403.2.1 Zone isolation required. HVAC systems serving *zones* that are over 25,000 square feet (2323 m^2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas. Each isolation area shall be equipped with *isolation devices* and controls configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section C403.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. Exhaust air and outdoor air connections to isolation areas where the fan system to which they connect is not greater than 5,000 cfm (2360 L/s).
2. Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.
3. Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a *zone* are inoperative.

C403.2.2 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *International Mechanical Code*. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *International Mechanical Code*.

C403.2.3 Fault detection and diagnostics. New buildings with an HVAC system serving a gross conditioned floor area of 25,000 square feet (2,322.5 m^2) or larger shall include a fault detection and diagnostics (FDD) system to monitor the HVAC system's performance and automatically identify faults. The FDD system shall:

1. Include permanently installed sensors and devices to monitor the HVAC system's performance.
2. Sample the HVAC system's performance at least once every 15 minutes.
3. Automatically identify and report HVAC system faults.
4. Automatically notify authorized personnel of identified HVAC system faults.
5. Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of HVAC system performance.
6. Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.

Exception: R-1 and R-2 occupancies.

C403.3 Mechanical system energy source. All mechanical systems such as for heating, cooling, water heating, clothes drying and cooking shall be all-electric or fueled by other non-fossil fuel derived energy sources.

Exceptions:

1. systems serving laboratories.
2. systems serving hospitals.
3. systems serving large industrial S-1 occupancies, with constant vehicle traffic
4. emergency generators
5. commercial cooking equipment

For all systems serving the exceptions listed where the energy source is not electric, fossil fuel energy usage shall be 100 percent offset by on-site renewable energy. The power generated to offset the fossil fuel energy source for the exceptions shall not offset greater than 10 percent of the building's total energy use for the purposes of complying with Section C407. Fossil fuel energy sources for emergency generators, commercial cooking appliances and scientific or industrial process loads are exempt from the offset requirements.

C403.3.1 Heating and cooling equipment efficiencies (Mandatory). Heating and cooling equipment installed in mechanical systems shall be sized in accordance with Section C403.3.2 and shall be not less efficient in the use of energy than as specified in Section C403.3.3.

C403.3.2 Equipment sizing (Mandatory). The output capacity of heating and cooling equipment shall not be greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.1. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that are configured to sequence the operation of each unit based on load.

C403.3.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through C403.3.2(16) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of AHRI 400. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

C403.3.3.1 Water-cooled centrifugal chilling packages. Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F leaving and 54°F entering chilled fluid temperatures and with 85°F entering and 94.3°F leaving condenser fluid temperatures shall have maximum full-load kW/ton (FL) and part-load ratings requirements adjusted using the following equations:

$$FL_{adj} = FL/K_{adj} \quad \textbf{(Equation 4-5)}$$

$$PLV_{adj} = IPLV/K_{adj} \quad \textbf{(Equation 4-6)}$$

where:

K_{adj}	=	A × B
FL	=	Full-load kW/ton value from Table C403.3.2(3).
FL_{adj}	=	Maximum full-load kW/ton rating, adjusted for nonstandard conditions.
$IPLV$	=	Value from Table C403.3.2(3).
PLV_{adj}	=	Maximum $NPLV$ rating, adjusted for nonstandard conditions.
A	=	$0.00000014592 \times (\text{LIFT})^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302$
B	=	$0.0015 \times L_{vg}E_{vap} + 0.934$
$LIFT$	=	$L_{vg}Cond - L_{vg}E_{vap}$
$L_{vg}Cond$	=	Full-load condenser leaving fluid temperature (°F).
$L_{vg}E_{vap}$	=	Full-load evaporator leaving temperature (°F).

The FL_{adj} and PLV_{adj} values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

- 36°F < $L_{vg}E_{vap}$ < 60°F.
- 115°F.
- 20°F ≤ LIFT ≤ 80°F.

Manufacturers shall calculate the FL_{adj} and PLV_{adj} before determining whether to label the chiller. Centrifugal chillers designed to operate outside of these ranges are not covered by this code.

TABLE C403.3.2(1)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split system[b]	13.0 SEER[d] 13.4 SEER2	before 1/1/2023 AHRI 210/240-2017 after 1/1/2023 AHRI 210/240-2023
			Single package[b]	14.0 SEER[d] 13.4 SEER2	
Space constrained, air cooled	≤ 30,000 Btu/h[b]	All	Split System and Single Package[b]	12.0 SEER[d] 11.7 SEER2	
Small-duct high-velocity, air cooled	< 65,000 Btu/h[b]	All	Split System[b]	12.0 SEER[d] 12.1 SEER2	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER[d] 12.9 IEER[d] 14.8 IEER	AHRI 340/360
		All other		11.0 EER[d] 12.7 IEER[d] 14.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)		11.0 EER[d] 12.4 IEER[d] 14.2 IEER	
		All other		10.8 EER[d] 12.2 IEER[d] 14.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER[d] 11.6 IEER[d] 13.2 IEER	
		All other		9.7 EER[d] 11.42 IEER[d] 12.5 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)		9.8 EER[d] 11.4 IEER[d] 13.0 IEER	
		All other		9.5 EER[d] 11.0 IEER[d] 12.3 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)		12.1 EER 13.9 IEER	AHRI 340/360
		All other		11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)		12.5 EER 13.9 IEER	
		All other		12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)		12.4 EER 13.6 IEER	
		All other		12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)		12.2 EER 13.5 IEER	
		All other		12.0 EER 13.3 IEER	

(continued)

TABLE C403.3.2(1)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)		12.1 EER 12.3 IEER	AHRI 340/360
		All other		11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)		12.0 EER 12.2 IEER	
		All other		11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)		11.9 EER 12.1 IEER	
		All other		11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)		11.7 EER 11.9 IEER	
		All other		11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h	—	—	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

b. Single-phase, US air-cooled air conditioners less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER and SEER2 values for single-phase products are set by the US Department of Energy.

c. This table is a replica of ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units-Minimum Efficiency Requirements less the values for equipment for applications outside the US.

d. This efficiency value shall be used for equipment manufactured prior to January 1, 2023.

TABLE C403.3.2(2)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 66,000 Btu/h	All	Split System[b]	14.0 SEER[d] 14.3 SEER2	before 1/1/2023 AHRI 210/240-2017 after 1/1/2023 AHRI 210/240-2023
			Single Package[b]	14.0 SEER[d] 13.4 SEER2	
Space constrained, air cooled (cooling mode)	≤ 30,000 Btu/h	All	Split System and Single Package[b]	12.0 SEER[d] 11.7 SEER2	
Single-duct high-velocity, air cooled (cooling mode)	< 65,000 Btu/h	All	Split System[b]	12.0 SEER[d] 12.0 SEER2	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.0 EER[d] 12.2 IEER[d] 14.1 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER[d] 12.0 IEER[d] 13.9 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER[d] 11.6 IEER[d] 13.5 IEER	
		All other	Split System and Single Package	10.4 EER[d] 11.4 IEER[d] 13.3 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER[d] 10.6 IEER[d] 12.5 IEER	
		All other	Split System and Single Package	9.3 EER[d] 10.4 IEER[d] 12.3 IEER	
Air cooled (heating mode)	< 65,000 Btu/h	All	Split System[b]	8.2 HSPF[d] 7.5 HSPF2	before 1/1/2023 AHRI 210/240-2017 after 1/1/2023 AHRI 210/240-2023
		All	Single Package[b]	8.0 HSPF[d] 6.7 HSPF2	
Space constrained, air cooled (heating mode)	≤ 30,000 Btu/h	All	Split System and Single Package[b]	7.4 HSPF[d] 6.3 HSPF2	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h	All	Split System[b]	7.4 HSPF[d] 6.1 HSPF2	

(continued)

TABLE C403.3.2(2)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	All	47ºF db/43ºF wb outdoor air	3.30 COP_H[d] 3.40 COP_H	AHRI 340/360
			17ºF db/15ºF wb outdoor air	2.25 COP_H	
	≥ 135,000 Btu/h < 240,000 Btu/h (cooling capacity)	All	47ºF db/43ºF wb outdoor air	3.20 COP_H[d] 3.30 COP_H	
			17ºF db/15ºF wb outdoor air	2.05 COP_H	
	≥ 240,000 Btu/h (cooling capacity)	All	47ºF db/43ºF wb outdoor air	3.20 COP_H	
			17ºF db/15ºF wb outdoor air	2.05 COP_H	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER, SEER2 and HSPF values for single-phase products are set by the US Department of Energy.

c. This table is a replica of ASHRAE 90.1 Table 6.8.1-2 Electrically Operated Air-cooled Unitary Heat Pumps-Minimum Efficiency Requirements less the values for equipment for applications outside the US.

d. This efficiency value shall be used for equipment manufactured prior to January 1, 2023.

TABLE C403.3.2(3)
WATER CHILLING PACKAGES—EFFICIENCY REQUIREMENTS[a, b, e, f]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	PATH A	PATH B	TEST PROCEDURE[a]
Air-cooled chillers	< 150 Tons	EER (Btu/Wh)	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 13.700 IPLV.IP	≥ 15.800 IPLV.IP	
	≥ 150 Tons		≥ 10.100 FL	≥ 9.700 FL	
			≥ 14.000 IPLV.IP	≥ 16.100 IPLV.IP	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/Wh)	Air-cooled chillers without condenser shall be rated with matching condensers and comply with air-cooled chiller efficiency requirements.		
Water cooled, electrically operated positive displacement	< 75 Tons	kW/ton	≤ 0.750 FL	≤ 0.780 FL	
			≤ 0.600 IPLV.IP	≤ 0.500 IPLV.IP	
	≥ 75 tons and < 150 tons		≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.560 IPLV.IP	≤ 0.490 IPLV.IP	
	≥ 150 tons and < 300 tons		≤ 0.660 FL	≤ 0.680 FL	
			≤ 0.540 IPLV.IP	≤ 0.440 IPLV.IP	
	≥ 300 tons and < 600 tons		≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.520 IPLV.IP	≤ 0.410 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
Water cooled, electrically operated centrifugal	< 150 Tons	kW/ton	≤ 0.610 FL	≤ 0.695 FL	
			≤ 0.550 IPLV.IP	≤ 0.440 IPLV.IP	
	≥ 150 tons and < 300 tons		≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.550 IPLV.IP	≤ 0.400 IPLV.IP	
	≥ 300 tons and < 400 tons		≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.520 IPLV.IP	≤ 0.390 IPLV.IP	
	≥ 400 tons and < 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
Air cooled, absorption, single effect	All capacities	COP (W/W)	≥ 0.600 FL	NA[d]	AHRI 560
Water cooled absorption, single effect	All capacities	COP (W/W)	≥ 0.700 FL	NA[d]	
Absorption, double effect, indirect fired	All capacities	COP (W/W)	≥ 1.000 FL	NA[d]	
			≥ 0.150 IPLV.IP		
Absorption, double effect direct fired	All capacities	COP (W/W)	≥ 1.000 FL	NA[d]	
			≥ 1.000 IPLV		

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. The requirements for centrifugal chiller shall be adjusted for nonstandard rating conditions in accordance with Section C403.3.2.1 and are only applicable for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

c. Both the full-load and IPLV.IP requirements shall be met or exceeded to comply with this standard. Where there is a Path B, compliance can be with either Path A or Path B for any application.

d. NA means the requirements are not applicable for Path B and only Path A can be used for compliance.

e. FL is the full-load performance requirements and IPLV.IP the part-load performance requirements.

f. This table is a replica of ASHRAE 90.1 Table 6.8.1-3 Water-Chilling Packages- Minimum Efficiency Requirements less the values for equipment for applications outside the US.

TABLE C403.3.2(4)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS,
PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,
SINGLE PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d]	TEST PROCEDURE[a]
PTAC (cooling mode) standard size	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 - (0.300 × Cap/1000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTAC (cooling mode) nonstandard size[a]	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	4 EER	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.9 - (0.213 × Cap/1000) EER[d]	
	> 15,000 Btu/h		7.7 EER	
PTHP (cooling mode) standard size	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	11.9 EER	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 - (0.300 × Cap/1000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTHP (cooling mode) nonstandard size[b]	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	9.3 EER	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.8 - (0.213 × Cap/1000) EER[d]	
	> 15,000 Btu/h		7.6 EER	
PTHP (heating mode) standard size	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	3.3 COP_H	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		3.7 - (0.052 × Cap/1000) COP_H[d]	
	> 15,000 Btu/h		2.90 COP_H	
PTHP (heating mode) nonstandard size[b]	< 7,000 Btu/h	95°F/75°F wb outdoor air[c]	2,7 COP_H	
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		2.9 - (0.026 × Cap/1000) COP_H[d]	
	> 15,000 Btu/h		2.5 COP_H	
SPVAC (cooling mode) single and three phase	< 65,000 Btu/h	95°F db/75°F wb outdoor air	11.0 EER	AHRI 390
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h	95°F db/75°F wb outdoor air	10.0 EER	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h	95°F db/75°F wb outdoor air	10.0 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air	11.0 EER	
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h	95°F db/75°F wb outdoor air	10.0 EER	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h	95°F db/75°F wb outdoor air	10.1 EER	
SPVHP (heating mode)	< 65,000 Btu/h	47°F db/43°F wb outdoor air	3.3 COP_H	AHRI 390
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP_H	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h	47°F db/75°F wb outdoor air	3.0 COP_H	
Room air conditioners, without louvered sides	< 6,000 Btu/h	—	10.0 CEER	ANSI/ AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	10.0 CEER	
	≥ 8,000 Btu/h and < 11,000 Btu/h	—	9.6 CEER	
	≥ 11,000 Btu/h and < 14,000 Btu/h	—	9.5 CEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	9.3 CEER	
	≥ 20,000 Btu/h	—	9.4 CEER	

(continued)

TABLE C403.3.2(4)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS,
PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS,
SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) –– 32]/1.8, wb = wet bulb, db = dry bulb.
"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 inches (406 mm) high or less than 42 inches (1067 mm) wide and having a cross-sectional area less than 670 square inches (0.43 m^2).

c. The cooling-mode wet bulb temperature requirements only applies for units that reject condensate to the condenser coil.

d. "Cap" in EER and COPH equations for PTACs and PTHPs means cooling capacity in Btu/h at 95°F outdoor dry-bulb temperature.

e. This table is a replica of ASHRAE 90.1 Table 6.8.1-4 Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air-Conditioner Heat Pumps—Minimum Efficiency Requirements less the values for equipment for applications outside the US.

TABLE C403.3.2(5)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS,
WARM-AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS[g]

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d, e]	TEST PROCEDURE[a]
Warm-air furnaces, gas fired	< 225,000 Btu/h	Maximum capacity[c]	before 1/1/2023 80% E_t[b,d] After 1/1/2023 81%E_t[b, d]	ANSI Z21.47
Warm-air furnaces, oil fired	< 225,000 Btu/h	Maximum capacity[c]	before 1/1/2023 80% E_t After 1/1/2023 82%E_t[d]	Section 42, Combustion, UL 727
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[c]	80%E_c[e]	Section 2.10, Efficiency ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[c]	80%E_c[e, f]	
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[c]	80%E_c[e, f]	Section 40, Combustion, UL 731

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Combination units (i.e., furnaces contained within the same cabinet as an air conditioner) not covered by DOE 10 CFR 430 (i.e., three-phase power or with cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating. All other units greater than 225,000 Btu/h sold in the US must meet the AFUE standards for consumer products and test using USDOE's AFUE test procedure at DOE 10 CFR 430, Subpart B, Appendix N.

c. Compliance of multiple firing rate units shall be at the maximum firing rate.

d. Et = Thermal efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

e. Ec = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

f. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.

g. This table is a replica of ASHRAE 90.1 Table 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum Efficiency Requirements less the values for equipment for applications outside the US.

TABLE C403.3.2(6)
MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

EQUIPMENT TYPE[b]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY	EFFICIENCY AS OF 3/2/2022	TEST PROCEDURE[a]
Boilers, hot water	Gas-fired	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	80% E_t^d	80% E_t^d	DOE 10 CFR Part 431.86
		> 2,500,000 Btu/h[b]	82% E_c^c	82% E_c^c	
	Oil-fired[f]	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t^d	82% E_t^d	
		> 2,500,000 Btu/h[a]	84% E_c^c	84% E_c^c	
Boilers, steam	Gas-fired- all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	79% E_t^d	79% E_t^d	
		> 2,500,000 Btu/h[a]	79% E_t^d	79% E_t^d	
	Gas-fired-natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t^d	79% E_t^d	
		> 2,500,000 Btu/h[a]	77% E_t^d	79% E_t^d	
	Oil-fired[f]	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t^d	81% E_t^d	
		> 2,500,000 Btu/h[a]	81% E_t^d	81% E_t^d	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

c. Ec = Combustion efficiency (100 percent less flue losses).

d. Et = Thermal efficiency.

e. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.

f. Includes oil-fired (residual).

g. Boilers shall not be equipped with a constant-burning pilot light.

h. A boiler not equipped with a tankless domestic water heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.

i. This table is a replica of ASHRAE 90.1 Table 6.8.1-6 Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements less the values for equipment for applications outside the US.

TABLE C403.3.2(7)
MINIMUM EFFICIENCY REQUIREMENTS:
HEAT REJECTION EQUIPMENT [i]

EQUIPMENT TYPE[a]	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[h]	PERFORMANCE REQUIRED[b, c, d, f, g]	TEST PROCEDURE[a, e]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 60 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed- circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan dry coolers (air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering wb	≥ 4.5 gpm/hp	CTI ATC-105DS
Propeller or axial fan evaporative condensers	All	R-448A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 160,000 Btu/h × hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	R-448A test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h × hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-448A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥137,000 Btu/h × hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia Test Fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 110,000 Btu/h × hp	CTI ATC-106
Air-cooled condensers	All	125°F Condensing Temperature 190°F Entering Gas Temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h × hp	AHRI 460

For SI: °C = [(°F) - 32]/1.8, L/s • kW = (gpm/hp)/(11.83), COP = (Btu/h • hp)/(2550.7), db = dry bulb temperature, °F, wb = wet bulb temperature, °F.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in the table, divided by the fan motor nameplate power.

c. For purposes of this table, closed-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in the table, divided by the sum of the fan motor nameplate power and the spray pump motor nameplate power.

d. For purposes of this table, dry-cooler performance is defined as the process water-flow rating of the unit at the thermal rating condition listed in the table divided by the total fan motor nameplate power of the unit, and air-cooled condenser performance is defined as the heat rejected form the refrigerant divided by the total fan motor nameplate power of the unit.

e. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers.

f. All cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories or options included in the capacity of the cooling tower.

g. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power.

h. Requirements for evaporative condensers are listed with ammonia (R-717) and R-448A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-448A shall meet the minimum efficiency requirements listed in this table with R-448A as the test fluid. For Ammonia, the condensing temperature is defined as the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For R-448A, which is a zeotropic refrigerant, the condensing temperature is defined as the arithmetic average of the dew point and the bubble point temperatures corresponding to the refrigerant pressure at the condenser entrance.

i. This table is a replica of ASHRAE 90.1 Table 6.8.1-7 Performance Requirements for Heat Rejection Equipment—Minimum Efficiency Requirements.

TABLE C403.3.2(8)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS—MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF air conditioners, air cooled	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.2 EER 13.1 IEER 15.5 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER 12.9 IEER 14.9 IEER	
	≥ 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	10.0 EER 11.6 IEER 13.9 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-8 Electrically Operated Variable-Refrigerant-Flow Air Conditioners—Minimum Efficiency Requirements.

TABLE C403.3.2(9)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF air cooled (cooling mode)	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)		11.0 EER 12.9 IEER 14.6 IEER	
			VRF multisplit system with heat recovery	10.8 EER 12.7 IEER 14.4 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit system	10.6 EER 12.3 IEER 13.9 IEER	
			VRF multisplit system with heat recovery	10.4 EER 12.1 IEER 13.7 IEER	
	≥ 240,000 Btu/h		VRF multisplit system	9.5 EER 11.0 IEER 12.7 IEER	
			VRF multisplit system with heat recovery	9.3 EER 10.8 IEER 12.5 IEER	
VRF water source (cooling mode)	< 65,000 Btu/h	All	VRF multisplit systems 86°F entering water	12.0 EER 16.0 IEER	AHRI 1230
			VRF multisplit systems with heat recovery 86°F entering water	11.8 EER 15.8 IEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h		VRF multisplit systems 86°F entering water	12.0 EER 16.0 IEER	
			VRF multisplit systems with heat recovery 86°F entering water	11.8 EER 15.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit systems 86°F entering water	10.0 EER 14.0 IEER	
			VRF multisplit systems with heat recovery 86°F entering water	9.8 EER 13.8 IEER	

(continued)

TABLE C403.3.2(9)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[b]—continued

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF water source (cooling mode) (cont.)	≥ 240,000 Btu/h	All	VRF multisplit systems 86°F entering water	10.0 EER 12.0 IEER	AHRI 1230
			VRF multisplit systems with heat recovery 86°F entering water	9.8 EER 11.8 IEER	
VRF groundwater source (cooling mode)	< 135,000 Btu/h	All	VRF multisplit systems 59°F entering water	16.2 EER	AHRI 1230
			VRF multisplit systems with heat recovery 59°F entering water	16.0 EER	
	≥ 135,000 Btu/h		VRF multisplit systems 59°F entering water	13.8 EER	
			VRF multisplit systems with heat recovery 59°F entering water	13.6 EER	
VRF ground source (cooling mode)	< 135,000 Btu/h		VRF multisplit systems 77°F entering water	13.4 EER	AHRI 1230
			VRF multisplit systems with heat recovery 77°F entering water	13.2 EER	
	≥ 135,000 Btu/h		VRF multisplit systems 77°F entering water	11.0 EER	
			VRF multisplit systems with heat recovery 77°F entering water	10.8 EER	
VRF air cooled (heating mode)	< 65,000 Btu/h (cooling capacity)		VRF multisplit system	7.7 HSPF	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF multisplit systems 47°F db/ 43°F wb outdoor air	3.3 COP_H	
			17°F db/ 15°F wb outdoor air	2.25 COP_H	
	≥ 135,000 Btu/h (cooling capacity		VRF multisplit systems 47°F db/ 43°F wb outdoor air	3.2 COP_H	
			17°F db/ 15°F wb outdoor air	2.05 COP_H	
VRF water source (heating mode)	< 65,000 Btu/h (cooling capacity)		VRF multisplit systems 68°F entering water	4.2 COP_H 4.3 COP_H	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF multisplit systems 68°F entering water	4.2 COP_H 4.3 COP_H	
	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)		VRF multisplit systems 68°F entering water	3.9 COP_H 4.0 COP_H	
	≥ 240,000 Btu/h		VRF multisplit systems 68°F entering water	3.9 COP_H	

(continued)

TABLE C403.3.2(9)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[b]—continued

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)	All	VRF multisplit systems 50°F entering water	3.6 COP_H	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit systems 50°F entering water	3.3 COP_H	
VRF ground source (heating mode)	< 135,000 Btu/h (cooling capacity)		VRF multisplit systems 32°F entering water	3.1 COP_H	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit systems 32°F entering water	2.8 COP_H	

For SI: °C = [(°F)-32]/1.8, 1 British thermal unit per hour = 0.2931 W, db = dry bulb temperature, wb = wet bulb temperature.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-9 Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps—Minimum Efficiency Requirements.

TABLE C403.3.2(10)
FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS—MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 2)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow-ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow-nonducted	< 65,000 Btu/h	2.16	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.04		
		≥ 240,000 Btu/h	1.89		
	Horizontal	< 65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.55		
		≥ 240,000 Btu/h	2.47		
Air cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 1)	
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow-ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow-nonducted	< 65,000 Btu/h	2.09	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.99		
		≥ 240,000 Btu/h	1.81		

(continued)

TABLE C403.3.2(10)
FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS—MINIMUM EFFICIENCY REQUIREMENTS[b]—continued

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled with fluid economizer (cont.)	Horizontal	< 65,000 Btu/h	2.65	95°F/52°F (Class 3)	AHRI 1360
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.55		
		≥ 240,000 Btu/h	2.47		
Water cooled economizer	Downflow	< 80,000 Btu/h	2.82	85°F/52°F (Class 1)	
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.73		
		≥ 295,000 Btu/h	2.67		
	Upflow-ducted	< 80,000 Btu/h	2.79		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.70		
		≥ 295,000 Btu/h	2.64		
	Upflow-nonducted	< 65,000 Btu/h	2.43	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.32		
		≥ 240,000 Btu/h	2.20		
	Horizontal	< 65,000 Btu/h	2.79	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.68		
		≥ 240,000 Btu/h	2.60		
Water cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.77	85°F/52°F (Class 1)	
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.68		
		≥ 295,000 Btu/h	2.61		
	Upflow-ducted	< 80,000 Btu/h	2.74		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.65		
		≥ 295,000 Btu/h	2.58		
	Upflow-nonducted	< 65,000 Btu/h	2.35	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.24		
		≥ 240,000 Btu/h	2.12		
	Horizontal	< 65,000 Btu/h	2.71	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.60		
		≥ 240,000 Btu/h	2.54		
Glycol cooled	Downflow	< 80,000 Btu/h	2.56	85°F/52°F (Class 1)	
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.24		
		≥ 295,000 Btu/h	2.21		
	Upflow-ducted	< 80,000 Btu/h	2.53		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.21		
		≥ 295,000 Btu/h	2.18		

(continued)

TABLE C403.3.2(10)
FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS—MINIMUM EFFICIENCY REQUIREMENTS[b]—continued

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Glycol cooled (cont.)	Upflow-nonducted	< 65,000 Btu/h	2.08	75°F/52°F (Class 1)	AHRI 1360
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.90		
		≥ 240,000 Btu/h	1.81		
	Horizontal	< 65,000 Btu/h	2.48	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.18		
		≥ 240,000 Btu/h	2.18		
Glycol cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.51	85°F/52°F (Class 1)	
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.19		
		≥ 295,000 Btu/h	2.15		
	Upflow-ducted	< 80,000 Btu/h	2.48		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.16		
		≥ 295,000 Btu/h	2.12		
	Upflow-nonducted	< 65,000 Btu/h	2.00	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.82		
		≥ 240,000 Btu/h	1.73		
	Horizontal	< 65,000 Btu/h	2.44	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.10		
		≥ 240,000 Btu/h	2.10		

For SI: 1 British thermal unit per hour = 0.2931 W, oC = [(oF)-32]/1.8, COP = (Btu/h x hp)/(2,550.7).

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-10 Floor-Mounted Air Conditioners and Condensing Units Serving Computer Rooms—Minimum Efficiency Requirements.

TABLE C403.3.2(11)
VAPOR-COMPRESSION-BASED INDOOR POOL DEHUMIDIFIERS—MINIMUM EFFICIENCY REQUIREMENT[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Single package indoor (with or without economizer)	Rating Conditions: A or C	3.5 MRE	AHRI 910
Single package indoor water cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Single package indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Split system indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-12 Vapor-Compression-Based Indoor Pool Dehumidifiers—Minimum Efficiency Requirements.

TABLE C403.3.2(12)
ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITHOUT ENERGY RECOVERY—MINIMUM EFFICIENCY REQUIREMENT[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled and Air-source heat pumps (dehumidification mode)	—	4.0 ISMRE	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.9 ISMRE	
	Chilled water	6.0 ISMRE	
Air-source heat pump (heating mode)	—	2.7 ISCOP	
Water-source heat pump (dehumidification mode)	Ground source, closed loop	4.8 ISMRE	
	Ground-water source	5.0 ISMRE	
	Water source	4.0 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	2.0 ISCOP	AHRI 920
	Ground-water source	3.2 ISCOP	
	Water source	3.5 ISCOP	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-13 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency Requirements.

TABLE C403.3.2(13)
ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITH ENERGY RECOVERY—MINIMUM EFFICIENCY REQUIREMENT[b]

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled and Air-source heat pumps (dehumidification mode)	—	5.2 ISMRE	AHRI 920
			AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	5.3 ISMRE	AHRI 920
	Chilled water	6.6 ISMRE	
Air-source heat pump (heating mode)	—	3.3 ISCOP	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed loop	5.2 ISMRE	AHRI 920
	Ground-water source	5.8 ISMRE	
	Water source	4.8 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	3.8 ISCOP	AHRI 920
	Ground-water source	4.0 ISCOP	
	Water source	4.8 ISCOP	

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-14 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery—Minimum Efficiency Requirements.

TABLE C403.3.2(14)
ELECTRICALLY OPERATED WATER-SOURCE HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[c]

EQUIPMENT TYPE	SIZE CATEGORY[b]	HEAT SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Water-to-air, water loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h			13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h			13.0 EER	
Water-to-air, ground water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine-to-air, ground loop (cooling mode)			77°F entering water	14.1 EER	
Water-to-water, water loop (cooling mode)			86°F entering water	10.6 EER	ISO 13256-2
Water-to-water, ground water (cooling mode)			59°F entering water	16.3 EER	
Brine-to-water, ground loop (cooling mode)			77°F entering water	12.1 EER	
Water-to-water, water loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP_H	ISO 13256-1
Water-to-air, ground water (heating mode)			50°F entering water	3.7 COP_H	
Brine-to-air, ground loop (heating mode)			32°F entering water	3.2 COP_H	
Water-to-water, water loop (heating mode)			68°F entering water	3.7 COP_H	
Water-to-water, ground water (heating mode)			50°F entering water	3.1 COP_H	ISO 13256-2
Brine-to-water, ground loop (heating mode)			32°F entering water	2.5 COP_H	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F)-32]/1.8.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps less than 19 kW are regulated as consumer products by DOE 10 CFR 430. SCOPC, SCOP2C, SCOPH and SCOP2H values for single-phase products are set by the USDOE.

c. This table is a replica of ASHRAE 90.1 Table 6.8.1-15 Electrically Operated Water-Source Heat Pumps—Minimum Efficiency Requirements.

TABLE C403.3.2(15)
HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES- MINIMUM EFFICIENCY REQUIREMENTS[g]

HEATING OPERATION													
EQUIPMENT TYPE	SIZE CATEGORY, ton_R	COOLING-ONLY OPERATION COOLING EFFICIENCY[c] AIR-SOURCE EER (FL/IPLV), Btu/W × h WATER-SOURCE POWER INPUT PER CAPACITY (FL/IPLV), kW/ton_R		HEATING SOURCE CONDITIONS (entering/ leaving water) OR OAT (db/wb), °F	HEAT-PUMP HEATING FULL-LOAD EFFICIENCY (COP_H)[b], W/W				HEAT RECOVERY CHILLER FULL-LOAD EFFICIENCY (COP_{HR})[c, d], W/W SIMULTANEOUS COOLING AND HEATING FULL-LOAD EFFICIENCY (COP_{SHC})[c], W/W				TEST PROCEDURE[a]
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		105°F	120°F	140°F	140°F	105°F	120°F	140°F	140°F	
Air source	All sizes	≥ 9.595 FL ≥ 13.02 IPLV.IP	≥ 9.215 FL ≥ 15.01 IPLV.IP	47 db 43 wb[e]	≥ 3.290	≥ 2.770	≥ 2.310	NA	NA	NA	NA	NA	AHRI 550/590
		≥ 9.595 FL ≥ 13.30 IPLV.IP	≥ 9.215 FL ≥ 15.30 IPLV.IP	17 db 15 wb[e]	≥ 2.230	≥ 1.950	≥ 1.630	NA	NA	NA	NA	NA	
Water-source electrically operated positive displace-ment	< 75	≤ 0.7885 FL ≤ 0.6316 IPLV.IP	≤ 0.7875 FL ≤ 0.5145 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 75 and < 150	≤ 0.7579 FL ≤ 0.5895 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 150 and < 300	≤ 0.6947 FL ≤ 0.5684 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 300 and < 600	≤ 0.6421 FL ≤ 0.5474 IPLV.IP	≤ 0.6563 FL ≤ 0.4305 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
	≥ 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6143 FL ≤ 0.3990 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
Water-source electrically operated centrifugal	< 75	≤ 0.6421 FL ≤ 0.5789 IPLV.IP	≤ 0.7316 FL ≤ 0.4632 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 75 and < 150	≤ 0.5895 FL ≤ 0.5474 IPLV.IP	≤ 0.6684 FL ≤ 0.4211 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 150 and < 300	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6263 FL ≤ 0.4105 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 300 and < 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
	≥ 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	

(continued)

TABLE C403.3.2(15)—continued
HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES- MINIMUM EFFICIENCY REQUIREMENTS[g]

For SI: °C = [(°F)-32]/1.8.

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. Cooling-only rating conditions are standard rating conditions defined in AHRI 550/590, Table 1.
c. Heating full-load rating conditions are at rating conditions defined in AHRI 550/590, Table 1.
d. For water-cooled heat recovery chillers that have capabilities for heat rejection to a heat recovery condenser and a tower condenser, the COPHR applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table C403.3.2(3).
e. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.
f. Source-water entering and leaving water temperature.
g. This table is a replica of ASHRAE 90.1 Table 6.8.1-16 Heat-Pump and Heat Recovery Chiller Packages —Minimum Efficiency Requirements.

TABLE C403.3.2(16)
CEILING-MOUNTED COMPUTER-ROOM AIR CONDITIONERS—MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point	TEST PROCEDURE[a]
Air cooled with free air discharge condenser	Ducted	< 29,000 Btu/h	2.05	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.02		
		≥ 65,000 Btu/h	1.92		
	Nonducted	< 29,000 Btu/h	2.08		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.05		
		≥ 65,000 Btu/h	1.94		
Air cooled with free air discharge condenser with fluid economizer	Ducted	< 29,000 Btu/h	2.01		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.97		
		≥ 65,000 Btu/h	1.87		
	Nonducted	< 29,000 Btu/h	2.04		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.00		
		≥ 65,000 Btu/h	1.89		
Air cooled with ducted condenser	Ducted	< 29,000 Btu/h	1.86		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.83		
		≥ 65,000 Btu/h	1.73		
	Nonducted	< 29,000 Btu/h	1.89		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.86		
		≥ 65,000 Btu/h	1.75		
Air cooled with fluid economizer and ducted condenser	Ducted	< 29,000 Btu/h	1.82		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.78		
		≥ 65,000 Btu/h	1.68		
	Nonducted	< 29,000 Btu/h	1.85		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.81		
		≥ 65,000 Btu/h	1.70		
Water cooled	Ducted	< 29,000 Btu/h	2.38		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.38		
		≥ 65,000 Btu/h	2.18		
	Nonducted	< 29,000 Btu/h	2.41		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.31		
		≥ 65,000 Btu/h	2.20		

(continued)

TABLE C403.3.2(16)—continued
CEILING-MOUNTED COMPUTER-ROOM AIR CONDITIONERS—MINIMUM EFFICIENCY REQUIREMENTS[b]

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/ dew point	TEST PROCEDURE[a]
Water cooled with fluid economizer	Ducted	< 29,000 Btu/h	2.33	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.23		
		≥ 65,000 Btu/h	2.13		
	Nonducted	< 29,000 Btu/h	2.36		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.26		
		≥ 65,000 Btu/h	2.16		
Glycol cooled	Ducted	< 29,000 Btu/h	1.97		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.93		
		≥ 65,000 Btu/h	1.78		
	Nonducted	< 29,000 Btu/h	2.00		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.98		
		≥ 65,000 Btu/h	1.81		
Glycol cooled with fluid economizer	Ducted	< 29,000 Btu/h	1.92		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.88		
		≥ 65,000 Btu/h	1.73		
	Nonducted	< 29,000 Btu/h	1.95		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.93		
		≥ 65,000 Btu/h	1.76		

For SI: 1 British thermal unit per hour = 0.2931 W, oC = [(oF)-32]/1.8, COP = (Btu/h x hp)/(2,550.7).

a. Chapter 6 contains a complete specification of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. This table is a replica of ASHRAE 90.1 Table 6.8.1-17 Ceiling-Mounted Computer-Room Air Conditioners—Minimum Efficiency Requirements.

C403.3.3.2 Positive displacement (air- and water-cooled) chilling packages. Equipment with a leaving fluid temperature higher than 32°F (0°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature below 115°F (46°C) shall meet the requirements of the tables in Section C403.3.2 when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.3.3.3 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.3.3, as limited by Section C403.5.1.

TABLE C403.3.3
MAXIMUM HOT GAS BYPASS CAPACITY

RATED CAPACITY	MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)
≤ 240,000 Btu/h	50
> 240,000 Btu/h	25

For SI: 1 British thermal unit per hour = 0.2931 W.

C403.3.4 Boiler turndown. *Boiler systems* with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown ratio specified in Table C403.3.4.

The system turndown requirement shall be met through the use of multiple single-input boilers, one or more *modulating boilers* or a combination of single-input and *modulating boilers*.

TABLE C403.3.4
BOILER TURNDOWN

BOILER SYSTEM DESIGN INPUT (Btu/h)	MINIMUM TURNDOWN RATIO
≥ 1,000,000 and ≤ 5,000,000	3 to 1
> 5,000,000 and ≤ 10,000,000	4 to 1
> 10,000,000	5 to 1

For SI: 1 British thermal unit per hour = 0.2931 W.

C403.4 Heating and cooling system controls. Each heating and cooling system shall be provided with controls in accordance with Sections C403.4.1 through C403.4.5.

C403.4.1 Thermostatic controls. The supply of heating and cooling energy to each *zone* shall be controlled by individual thermostatic controls capable of responding to temperature within the *zone*. Where humidification or dehumidification or both is provided, not fewer than one humidity control device shall be provided for each humidity control system.

Exception: Independent perimeter systems that are designed to offset only building envelope heat losses, gains or both serving one or more perimeter *zones* also

served by an interior system provided that both of the following conditions are met:

1. The perimeter system includes not fewer than one thermostatic control *zone* for each building exposure having exterior walls facing only one orientation (within ± 45 degrees) (0.8 rad) for more than 50 contiguous feet (15 240 mm).
2. The perimeter system heating and cooling supply is controlled by thermostats located within the *zones* served by the system.

C403.4.1.1 Climate-appropriate equipment. Equipment that provides heating and cooling shall be able to adequately function in Boulder's climate zone, including demonstrated performance of at least 70 percent capacity with outdoor temperatures of 5°F.

C403.4.1.2 Heat pump supplementary heat. Heat pumps having supplementary electric resistance heat shall have controls that limit supplemental heat operation to only those times when one of the following applies:

1. The vapor compression cycle cannot provide the necessary heating energy to satisfy the thermostat setting.
2. The heat pump is operating in defrost mode.
3. The vapor compression cycle malfunctions.

The thermostat malfunctions.

C403.4.1.3 Deadband. Where used to control both heating and cooling, *zone* thermostatic controls shall be configured to provide a temperature range or deadband of not less than 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is shut off or reduced to a minimum.

Exceptions:

1. Thermostats requiring manual changeover between heating and cooling modes.
2. Occupancies or applications requiring precision in indoor temperature control as *approved* by the *code official*.

C403.4.1.4 Setpoint overlap restriction. Where a *zone* has a separate heating and a separate cooling thermostatic control located within the *zone*, a limit switch, mechanical stop or direct digital control system with software programming shall be configured to prevent the heating setpoint from exceeding the cooling setpoint and to maintain a deadband in accordance with Section C403.4.1.3.

C403.4.1.5 Heated or cooled vestibules. The heating system for heated vestibules and air curtains with integral heating shall be provided with controls configured to shut off the source of heating when the outdoor air temperature is greater than 45°F (7°C). Vestibule heating and cooling systems shall be controlled by a thermostat located in the vestibule configured to limit heating to a temperature not greater than 60°F (16°C) and cooling to a temperature not less than 85°F (29°C).

Exception: Control of heating or cooling provided by site-recovered energy or transfer air that would otherwise be exhausted.

C403.4.1.6 Hot water boiler outdoor temperature setback control. Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

C403.4.2 Off-hour controls. Each *zone* shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

Exceptions:

1. *Zones* that will be operated continuously.
2. *Zones* with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a manual shutoff switch located with *ready access*.

C403.4.2.1 Thermostatic setback. Thermostatic setback controls shall be configured to set back or temporarily operate the system to maintain zone temperatures down to 55°F (13°C) or up to 85°F (29°C).

C403.4.2.2 Automatic setback and shutdown. Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for not fewer than 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer configured to operate the system for up to 2 hours; or an occupancy sensor.

C403.4.2.3 Automatic start and stop. Automatic start controls shall be provided for each HVAC system. The automatic start controls shall be configured to automatically adjust the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. Automatic stop controls shall be provided for each HVAC system with direct digital control of individual zones. The automatic stop controls shall be configured to reduce the HVAC system's heating temperature setpoint and increase the cooling temperature setpoint by not less than 2°F (-16.6ºC) before scheduled unoccupied periods based on the thermal lag and acceptable drift in space temperature that is within comfort limits.

C403.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and

designed to deliver conditioned water or steam into a common distribution system shall include automatic controls configured to sequence operation of the boilers. Hydronic heating systems composed of a single boiler and greater than 500,000 Btu/h (146.5 kW) input design capacity shall include either a multistaged or modulating burner.

C403.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

C403.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a deadband between changeover from one mode to the other of not less than 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for not less than 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be not more than 30°F (16.7°C) apart.

C403.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.

C403.4.3.3.1 Temperature deadband. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are configured to provide a heat pump water supply temperature deadband of not less than 20°F (11°C) between initiation of heat rejection and heat addition by the central devices.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real-time conditions of demand and capacity, deadbands of less than 20°F (11°C) shall be permitted.

C403.4.3.3.2 Heat rejection. The following shall apply to hydronic water loop heat pump systems:

1. Where a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass the flow of water around the closed-circuit cooling tower, except for any flow necessary for freeze protection, or low-leakage positive-closure dampers shall be provided.
2. Where an open-circuit cooling tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the open-circuit cooling tower.
3. Where an open-circuit or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the open-circuit cooling tower from the heat pump loop, heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception: Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

C403.4.3.3.3 Two-position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 hp (7.5 kW) shall have a two-position automatic valve interlocked to shut off the water flow when the compressor is off..

C403.4.4 Part-load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87.9 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that are configured to do all of the following:

1. Automatically reset the supply-water temperatures in response to varying building heating and cooling demand using coil valve position, zone-return water temperature, building-return water temperature or outside air temperature. The temperature shall be reset by not less than 25 percent of the design supply-to-return water temperature difference.
2. Automatically vary fluid flow for hydronic systems with a combined pump motor capacity of 2 hp (1.5 kW) or larger with three or more control valves or other devices by reducing the system design flow rate by not less than 50 percent or the maximum reduction allowed by the equipment manufacturer for proper operation of equipment by valves that modulate or step open and close, or pumps that modulate or turn on and off as a function of load.
3. Automatically vary pump flow on heating-water systems, chilled-water systems and heat rejection loops serving water-cooled unitary air conditioners as follows:
   3.1. Where pumps operate continuously or operate based on a time schedule, pumps with nominal output motor power of 2 hp or more shall have a variable speed drive.
   3.2. Where pumps have automatic direct digital control configured to operate pumps only when zone heating or cooling is required, a variable speed drive shall be provided for pumps with motors having the same or greater nominal output power indicated in Table C403.4.4 based on the system served.
4. Where a variable speed drive is required by Item 3 of this Section, pump motor power input shall be not more than 30 percent of design wattage at 50 percent of the design water flow. Pump flow shall be controlled to maintain one control valve nearly wide open or to satisfy the minimum differential pressure.

Exceptions:

1. Supply-water temperature reset is not required for chilled-water systems supplied by off-site dis-

trict chilled water or chilled water from ice storage systems.

2. Variable pump flow is not required on dedicated coil circulation pumps where needed for freeze protection.
3. Variable pump flow is not required on dedicated equipment circulation pumps where configured in primary/secondary design to provide the minimum flow requirements of the equipment manufacturer for proper operation of equipment.
4. Variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by an electric boiler.

TABLE C403.4.4
VARIABLE SPEED DRIVE (VSD) REQUIREMENTS FOR DEMAND-CONTROLLED PUMPS

TYPES OF DEMAND CONTROLLED PUMPS	VSD REQUIRED FOR MOTORS WITH RATED OUTPUT OF:
Chilled water and heat rejection loop pumps	≥ 7.5 hp
Heating water pumps	≥ 10 hp

C403.4.5 Pump isolation. Chilled water plants including more than one chiller shall be capable of and configured to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler systems including more than one boiler shall be capable of and configured to reduce flow automatically through the boiler system when a boiler is shut down.

C403.5 Economizers. Economizers shall comply with Sections C403.5.1 through C403.5.5. An air or water economizer shall be provided for the following cooling systems:

1. Chilled water systems with a total cooling capacity, less cooling capacity provided with air economizers specified in Table C403.5.
2. Individual fan systems with cooling capacity greater than or equal to 36,000 Btu/h (10.5 kW) in buildings having other than a *Group R* occupancy,

   The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.
3. Individual fan systems with cooling capacity greater than or equal to 270,000 Btu/h (79.1 kW) in buildings having a *Group R* occupancy.

   The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 1,500,000 Btu/h (440 kW), whichever is greater.

Exceptions: Economizers are not required for the following systems.

1. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (1.7°C) dewpoint temperature to satisfy process needs.
2. Systems serving supermarket areas with open refrigerated casework.
3. Systems that include a heat recovery system in accordance with Section C403.9.5.
4. VRF systems installed with a dedicated outdoor air system.

C403.5.1 Integrated economizer control. Economizer systems shall be integrated with the mechanical cooling system and be configured to provide partial cooling even where additional mechanical cooling is required to provide the remainder of the cooling load. Controls shall not be capable of creating a false load in the mechanical cooling systems by limiting or disabling the economizer or any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:

1. Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the

TABLE C403.5
MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
Local Water-cooled Chilled-water Systems	Air-cooled Chilled-water Systems or District Chilled-Water Systems
1,320,000 Btu/h	1,720,000 Btu/h

For SI: 1 British thermal unit per hour = 0.2931 W.

TABLE C403.5.1
DX COOLING STAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% of full load
≥ 240,000 Btu/h	4 stages	≤ 25% of full load

For SI: 1 British thermal unit per hour = 0.2931 W.

a. For mechanical cooling stage control that does not use variable compressor displacement, the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

100-percent open position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).

2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages of mechanical cooling capacity.
3. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with Table C403.5.1.

C403.5.2 Economizer heating system impact. HVAC system design and economizer controls shall be such that economizer operation does not increase building heating energy use during normal operation.

Exception: Economizers on variable air volume (VAV) systems that cause zone level heating to increase because of a reduction in supply air temperature.

C403.5.3 Air economizers. Where economizers are required by Section C403.5, air economizers shall comply with Sections C403.5.3.1 through C403.5.3.5.

C403.5.3.1 Design capacity. Air economizer systems shall be configured to modulate *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.

C403.5.3.2 Control signal. Economizer controls and dampers shall be configured to sequence the dampers with the mechanical cooling equipment and shall not be controlled by only mixed-air temperature.

Exception: The use of mixed-air temperature limit control shall be permitted for systems controlled from space temperature (such as single-*zone* systems).

C403.5.3.3 High-limit shutoff. Air economizers shall be configured to automatically reduce *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will not reduce cooling energy usage. High-limit shutoff control types shall be chosen from Table C403.5.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.5.3.3.

C403.5.3.4 Relief of excess outdoor air. Systems shall be capable of relieving excess *outdoor air* during air economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building.

C403.5.3.5 Economizer dampers. Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.7.7.

C403.5.4 Water-side economizers. Where economizers are required by Section C403.5, water-side economizers shall comply with Sections C403.5.4.1 and C403.5.4.2.

C403.5.4.1 Design capacity. Water economizer systems shall be configured to cool supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at *outdoor air* temperatures of not greater than 50°F (10°C) dry bulb/45°F (7°C) wet bulb.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at 40°F (4°C) dry bulb/35°F (1.7°C) wet bulb is met with evaporative water economizers.
2. Systems primarily serving computer rooms with dry cooler water economizers that satisfy 100 percent of the expected system cooling load at 35°F (1.7°C) dry bulb.
3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb is met with evaporative water economizers.

C403.5.4.2 Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15 feet (45 kPa) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.

TABLE C403.5.3.3
HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]

DEVICE TYPE	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
	Equation	Description
Fixed dry bulb	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
Differential dry bulb	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Differential enthalpy with fixed dry-bulb temperature	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds return air enthalpy OR Outdoor air temperature exceeds 75°F

For SI: 1 foot = 305 mm, °C = (°F - 32)/1.8, 1 Btu/lb = 2.33 kJ/kg.

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50-percent relative humidity. As an example, at approximately 6,000 feet elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

C403.5.5 Economizer fault detection and diagnostics (Mandatory). Air-cooled unitary direct-expansion units listed in the tables in Section C403.3.2 and variable refrigerant flow (VRF) units that are equipped with an economizer in accordance with Sections C403.5 through C403.5.4 shall include a fault detection and diagnostics system complying with the following:

1. The following temperature sensors shall be permanently installed to monitor system operation:
    1.1. Outside air.
    1.2. Supply air.
    1.3. Return air.
2. Temperature sensors shall have an accuracy of ±2°F (1.1°C) over the range of 40°F to 80°F (4°C to 26.7°C).
3. Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.
4. The unit controller shall be configured to provide system status by indicating the following:
    4.1. Free cooling available.
    4.2. Economizer enabled.
    4.3. Compressor enabled.
    4.4. Heating enabled.
    4.5. Mixed air low limit cycle active.
    4.6. The current value of each sensor.
5. The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.
6. The unit shall be configured to report faults to a fault management application available for *access* by day-to-day operating or service personnel, or annunciated locally on zone thermostats.
7. The fault detection and diagnostics system shall be configured to detect the following faults:
    7.1. Air temperature sensor failure/fault.
    7.2. Not economizing when the unit should be economizing.
    7.3. Economizing when the unit should not be economizing.
    7.4. Damper not modulating.
    7.5. Excess outdoor air.

C403.6 Requirements for mechanical systems serving multiple zones. Sections C403.6.1 through C403.6.9 shall apply to mechanical systems serving multiple zones.

C403.6.1 Variable air volume and multiple-zone systems. Supply air systems serving multiple zones shall be variable air volume (VAV) systems that have zone controls configured to reduce the volume of air that is reheated, recooled or mixed in each zone to one of the following:

1. Twenty percent of the zone design peak supply for systems with direct digital control (DDC) and 30 percent for other systems.
2. Systems with DDC where all of the following apply:
    2.1. The airflow rate in the deadband between heating and cooling does not exceed 20 percent of the zone design peak supply rate or higher allowed rates under Items 3, 4 and 5 of this section.
    2.2. The first stage of heating modulates the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the deadband flow rate.
    2.3. The second stage of heating modulates the airflow rate from the deadband flow rate up to the heating maximum flow rate that is less than 50 percent of the zone design peak supply rate.
3. The outdoor airflow rate required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
4. Any higher rate that can be demonstrated to reduce overall system annual energy use by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system as approved by the *code official*.
5. The airflow rate required to comply with applicable codes or accreditation standards such as pressure relationships or minimum air change rates.

Exception: The following individual zones or entire air distribution systems are exempted from the requirement for VAV control:

1. *Zones* or supply air systems where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered, including condenser heat, or site-solar energy source.
2. Systems that prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

C403.6.2 Single-duct VAV systems, terminal devices. Single-duct VAV systems shall use terminal devices capable of and configured to reduce the supply of primary supply air before reheating or recooling takes place.

C403.6.3 Dual-duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices that are configured to reduce the flow from one duct to a minimum before mixing of air from the other duct takes place.

C403.6.4 Single-fan dual-duct and mixing VAV systems, economizers. Individual dual-duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26.4 kW) 7.5 tons] shall not be equipped with air economizers.

C403.6.5 Supply-air temperature reset controls. Multiple-*zone* HVAC systems shall include controls that are capable of and configured to automatically reset the sup-

ply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be configured to reset the supply air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity are allowed. HVAC zones that are expected to experience relatively constant loads, shall have maximum airflow designed to accommodate the fully reset supply-air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy-five percent of the energy for reheating is from site-recovered or site-solar energy sources.
3. *Zones* with peak supply air quantities of 300 cfm (142 L/s) or less.

C403.6.6 Multiple-zone VAV system ventilation optimization control. Multiple-zone VAV systems with direct digital control of individual zone boxes reporting to a central control panel shall have automatic controls configured to reduce outdoor air intake flow below design rates in response to changes in system *ventilation* efficiency (E_v) as defined by the *International Mechanical Code*.

Exceptions:

1. VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.
2. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

C403.6.7 Parallel-flow fan-powered VAV air terminal control. Parallel-flow fan-powered VAV air terminals shall have automatic controls configured to:

1. Turn off the terminal fan except when space heating is required or where required for ventilation.
2. Turn on the terminal fan as the first stage of heating before the heating coil is activated.
3. During heating for warmup or setback temperature control, either:
    3.1. Operate the terminal fan and heating coil without primary air.
    3.2. Reverse the terminal damper logic and provide heating from the central air handler by primary air.

C403.6.8 Setpoints for direct digital control. For systems with direct digital control of individual zones reporting to the central control panel, the static pressure setpoint shall be reset based on the *zone* requiring the most pressure. In such case, the setpoint is reset lower until one *zone* damper is nearly wide open. The direct digital controls shall be capable of monitoring zone damper positions or shall have an alternative method of indicating the need for static pressure that is configured to provide all of the following:

1. Automatic detection of any *zone* that excessively drives the reset logic.
2. Generation of an alarm to the system operational location.
3. Allowance for an operator to readily remove one or more *zones* from the reset algorithm.

C403.6.9 Static pressure sensor location. Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is not greater than 1.2 inches w.c. (299 Pa). Where this results in one or more sensors being located downstream of major duct splits, not less than one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch.

C403.7 Ventilation and exhaust systems. In addition to other requirements of Section C403 applicable to the provision of ventilation air or the exhaust of air, ventilation and exhaust systems shall be in accordance with Sections C403.7.1 through C403.7.7.

C403.7.1 Demand control ventilation. Demand control ventilation (DCV) shall be provided for all single-zone systems required to comply with Sections C403.5 through C403.5.3 and spaces larger than 500 square feet (46.5 m^2) and with an average occupant load of 15 people or greater per 1,000 square feet (93 m^2) of floor area, as established in Table 403.3.1.1 of the *International Mechanical Code*, and served by systems with one or more of the following:

1. An air-side economizer.
2. Automatic modulating control of the outdoor air damper.
3. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

Exceptions:

1. Systems with energy recovery complying with Section C403.7.5.2.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. Multiple-zone systems with a design outdoor airflow less than 750 cfm (354 L/s).
4. Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer air that is required for makeup air that is exhausted from other spaces.
5. Spaces with one of the following occupancy classifications as defined in Table 403.3.1.1 of the International Mechanical Code: correctional cells, education laboratories, barber, beauty and nail salons, and bowling alley seating areas.

C403.7.2 Dwelling unit mechanical ventilation. Dwelling units shall be provided with mechanical ventilation that complies with the requirements of the *International Mechanical Code*, as applicable, or with other *approved*

means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

C403.7.2.1 Whole-dwelling mechanical ventilation system fan efficacy. Fans used to provide whole-dwelling mechanical ventilation shall meet the efficacy requirements of Table C403.7.2.1 at one or more rating points. Fans shall be tested in accordance with HVI 916 and listed. The airflow shall be reported in the product listing or on the label. Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERC, balanced, and in-line fans shall be determined at a static pressure of not less than 0.2-inch w.c. (49.85 Pa). Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure of not less than 0.1-inch w.c. (24.91 Pa).

TABLE C403.7.2.1
WHOLE-DWELLING MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

FAN LOCATION	AIRFLOW RATE MINMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)
HRV, ERV	Any	1.2 cfm/watt
In-line supply or exhuast fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
Other exhaust fan	≥ 90	3.5 cfm/watt
Air-handler integrated to tested and listed HVAC equipment	Any	1.2 cfm/watt

For SI: 1 cubic foot per minute = 28.3 L/min.

C403.7.2.2 Testing. Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by Section C403.7.2 and shall meet the efficacy requirements as per Table C403.7.2.1. Testing shall be performed according to the ventilation equipment manufacturer's instructions, or by using a flow hood or box, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles, or in the connected ventilation ducts. Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Units shall be tested as follows:

1. Where the buildings have fewer than eight testing units, each unit shall be tested.
2. For buildings with eight or more units, the greater of seven or 20 percent of the units in the building shall be tested evenly across all floors and shall encompass each unique unit type in the building. For each unit that does not meet the required ventilation/exhaust rate, an additional two units shall be tested.

Exception: Kitchen range hoods that are ducted to the outside with 6-inch (152 mm) or larger duct and not more than one 90-degree (1.57 rad) elbow or equivalent in the duct run.

C403.7.3 Enclosed parking garage ventilation controls. Enclosed parking garages used for storing or handling automobiles operating under their own power shall employ carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors and automatic controls configured to stage fans or modulate fan average airflow rates to 50 percent or less of design capacity, or intermittently operate fans less than 20 percent of the occupied time or as required to maintain acceptable contaminant levels in accordance with *International Mechanical Code* provisions. Failure of contamination-sensing devices shall cause the exhaust fans to operate continuously at design airflow.

Exceptions:

1. Garages with a total exhaust capacity of less than 8,000 cfm (3,755 L/s) with ventilation systems that do not utilize heating or mechanical cooling.
2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 1125 cfm/hp (710 L/s/kW) and do not utilize heating or mechanical cooling.

C403.7.4 Ventilation air heating control. Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air to a temperature greater than 60°F (16°C) when representative building loads or outdoor air temperatures indicate that the majority of zones require cooling.

C403.7.5 Energy recovery systems. Energy recovery ventilation systems shall be provided as specified in either Section C403.7.5.1 or C403.7.5.2, as applicable.

C403.7.5.1 Nontransient dwelling units. Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems with an enthalpy recovery ratio of not less than 60 percent at heating design condition.

C403.7.5.2 Spaces other than nontransient dwelling units. Where the supply airflow rate of a fan system serving a space other than a nontransient dwelling unit exceeds the values specified in Table C403.7.4.2, the system shall include an energy recovery system. The energy recovery system shall provide an enthalpy recovery ratio of not less than 50 percent at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass or controls that permit operation of the economizer as required by Section C403.5.

Exception: An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Laboratory fume hood systems that include not fewer than one of the following features:

2.1. Variable-air-volume hood exhaust and room supply systems configured to reduce exhaust and mt warmer than 2°F (1.1°C) above room setpoint, cooled to not cooler than 3°F (1.7°C) belakeup air volume to 50 percent or less of design values.

2.2. Direct makeup (auxiliary) air supply equal to or greater than 75 percent of the exhaust rate, heated noow room setpoint, with no humidification added, and no simultaneous heating and cooling used for dehumidification control.

3. Systems serving spaces that are heated to less than 60°F (15.5°C) and that are not cooled.
4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site-solar energy.
5. Enthalpy recovery ratio requirements are at the cooling design condition.
6. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
7. Where the largest source of air exhausted at a single location at the building exterior is less than 75 percent of the design *outdoor air* flow rate.
8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.
9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

C403.7.6 Kitchen exhaust systems. Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate. Conditioned supply air delivered to any space shall not exceed the greater of the following:

1. The ventilation rate required to meet the space heating or cooling load.
2. The hood exhaust flow minus the available transfer air from adjacent space where available transfer air is considered to be that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces.

Where total kitchen hood exhaust airflow rate is greater than 5,000 cfm (2360 L/s), each hood shall be a factory-built commercial exhaust hood listed by a nationally recognized testing laboratory in compliance with UL 710. Each hood shall have a maximum exhaust rate as specified in Table C403.7.5 and shall comply with one of the following:

1. Not less than 50 percent of all replacement air shall be transfer air that would otherwise be exhausted.
2. Demand ventilation systems on not less than 75 percent of the exhaust air that are configured to provide not less than a 50-percent reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.
3. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust airflow.

TABLE C403.7.4.2
ENERGY RECOVERY REQUIREMENT
(Ventilation systems operating not less than 8,000 hours per year)

PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
Design Supply Fan Airflow Rate (cfm)							
≥ 2,500	≥ 2,000	≥ 1,000	≥ 500	≥ 140	≥ 120	≥ 100	≥ 80

For SI: 1 cfm = 0.4719 L/s.

TABLE C403.7.5
MAXIMUM NET EXHAUST FLOW RATE,
CFM PER LINEAR FOOT OF HOOD LENGTH

TYPE OF HOOD	LIGHT-DUTY EQUIPMENT	MEDIUM-DUTY EQUIPMENT	HEAVY-DUTY EQUIPMENT	EXTRA-HEAVY-DUTY EQUIPMENT
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/Pass-over	210	210	280	NA

For SI:1 cfm = 0.4719 L/s; 1 foot = 305 mm.
NA = Not Allowed.

Where a single hood, or hood section, is installed over appliances with different duty ratings, the maximum allowable flow rate for the hood or hood section shall be based on the requirements for the highest appliance duty rating under the hood or hood section.

Exception: Where not less than 75 percent of all the replacement air is transfer air that would otherwise be exhausted.

C403.7.7 Automatic control of HVAC systems serving guestrooms. In *Group R*-1 buildings containing more than 50 guestrooms, each guestroom shall be provided with controls complying with the provisions of Sections C403.7.6.1 and C403.7.6.2. Card key controls comply with these requirements.

C403.7.7.1 Temperature setpoint controls. Controls shall be provided on each HVAC system that are capable of and configured with three modes of temperature control.

1. When the guestroom is rented but unoccupied, the controls shall automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom.
2. When the guestroom is unrented and unoccupied, the controls shall automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C). Unrented and unoccupied guestroom mode shall be initiated within 16 hours of the guestroom being continuously occupied or where a networked guestroom control system indicates that the guestroom is unrented and the guestroom is unoccupied for more than 20 minutes. A networked guestroom control system that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65-percent relative humidity during unoccupied periods is not precluded by this section.
3. When the guestroom is occupied, HVAC setpoints shall return to their occupied setpoints once occupancy is sensed.

C403.7.7.2 Ventilation controls. Controls shall be provided on each HVAC system that are capable of and configured to automatically turn off the ventilation and exhaust fans within 20 minutes of the occupants leaving the guestroom, or *isolation devices* shall be provided to each guestroom that are capable of automatically shutting off the supply of outdoor air to and exhaust air from the guestroom.

Exception: Guestroom ventilation systems are not precluded from having an automatic daily pre-occupancy purge cycle that provides daily outdoor air ventilation during unrented periods at the design ventilation rate for 60 minutes, or at a rate and duration equivalent to one air change.

C403.7.8 Shutoff dampers. Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class I motorized dampers. The dampers shall have an air leakage rate not greater than 4 cfm/ft^2 (20.3 L/s • m^2) of damper surface area at 1.0 inch water gauge (249 Pa) and shall be labeled by an approved agency when tested in accordance with AMCA 500D for such purpose.

Outdoor air intake and exhaust dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the systems served require outdoor or exhaust air in accordance with the *International Mechanical Code* or the dampers are opened to provide intentional economizer cooling.

Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

Exception: Nonmotorized gravity dampers shall be an alternative to motorized dampers for exhaust and relief openings as follows:

1. In buildings less than three stories in height above grade plane.
2. Where the design exhaust capacity is not greater than 300 cfm (142 L/s).

Nonmotorized gravity dampers shall have an air leakage rate not greater than 20 cfm/ft^2 (101.6 L/s • m^2) where not less than 24 inches (610 mm) in either dimension or 40 cfm/ft^2 (203.2 L/s • m^2) where less than 24 inches (610 mm) in either dimension. The rate of air leakage shall be determined at 1.0 inch water gauge (249 Pa) when tested in accordance with AMCA 500D for such purpose. The dampers shall be labeled by an approved agency.

C403.7.9 Occupied standby controls. Occupied standby controls are required for *zones* and systems serving *zones* where all spaces served by the *zone* are required to have occupancy sensor lighting controls by Section C405.2.1 and are an ASHRAE Standards 62.1 occupancy category where the ASHRAE Standard 62.1 Ventilation Rate Procedure allows the ventilation to be reduced to zero when the space is in occupied standby mode. Spaces meeting these criteria include:

1. Post-secondary classrooms/lecture/training rooms
2. Conference/meeting/multipurpose rooms
3. Lounges/breakrooms
4. Enclosed offices
5. Open plan office areas
6. Corridors

C403.7.9.1 Occupied standby zone controls. For *zones* meeting the occupied-standby control criteria, within five (5) minutes of all rooms in that *zone* entering occupied-standby model, the zone control shall operate as follows:

1. Active heating setpoint shall be setback at least 1 ºF.
2. Active cooling setpoint shall be setup at least 1ºF.
3. All airflow supplied to the zone shall be shut off whenever the space temperature is between the active heating and cooling setpoints.

C403.7.9.2 Occupied standby system controls. Multiple zone systems that can automatically reset the effective minimum outdoor setpoint and that serve zones with occupied-standby zone controls shall reset the effective minimum outdoor air setpoint based on a *zone* outdoor air requirements of zero for all *zones* in occupied standby mode. Sequences of operation for system outside air reset shall comply with an approved method.

C403.8 Fans and fan controls. Fans in HVAC systems shall comply with Sections C403.8.1 through C403.8.6.1.

C403.8.1 Allowable fan horsepower. Each HVAC system having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW) at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) shown in Table C403.8.1(1). This includes supply fans, exhaust fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation.

Exceptions:

1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.746 kW) or less are exempt from the allowable fan horsepower requirement.

C403.8.2 Motor nameplate horsepower. For each fan, the fan brake horsepower shall be indicated on the construction documents and the selected motor shall be not larger than the first available motor size greater than the following:

1. For fans less than 6 bhp (4476 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (4476 W) and larger, 1.3 times the fan brake horsepower.

Exceptions:

1. Fans equipped with electronic speed control devices to vary the fan airflow as a function of load.
2. Fans with a fan nameplate electrical input power of less than 0.89 kW.
3. Systems complying with Section C403.8.1 *fan system motor nameplate hp* (Option 1).
4. Fans with motor nameplate horsepower less than 1 hp (746 W).

C403.8.3 Fan efficiency. Each fan and fan array shall have a fan energy index (FEI) of not less than 1.00 at the design point of operation, as determined in accordance with AMCA 208 by an *approved*, independent testing laboratory and labeled by the manufacturer. Each fan and fan array used for a variable-air-volume system shall have an FEI of not less than 0.95 at the design point of operation as determined in accordance with AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C.

Exceptions: The following fans are not required to have a fan energy index:

1. Fans that are not embedded fans with motor nameplate horsepower of less than 1.0 hp (0.75 kW) or with a nameplate electrical input power of less than 0.89 kW.
2. Embedded fans that have a motor nameplate horsepower of 5 hp (3.7 kW) or less, or with a fan system electrical input power of 4.1 kW or less.
3. Multiple fans operated in series or parallel as the functional equivalent of a single fan that have a combined motor nameplate horsepower of 5 hp

TABLE C403.8.1(1)
FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	$hp \le CFM_S \times 0.0011$	$hp \le CFM_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \le CFM_S \times 0.00094 + A$	$bhp \le CFM_S \times 0.0013 + A$

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.

where:

CFM_S = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.
hp = The maximum combined motor nameplate horsepower.
bhp = The maximum combined fan brake horsepower.
A = Sum of $[PD \times CFM_D / 4131]$.

where:

PD = Each applicable pressure drop adjustment from Table C403.8.1(2) in. w.c.
CFM_D = The design airflow through each applicable device from Table C403.8.1(2) in cubic feet per minute.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

DEVICE	ADJUSTMENT
CREDITS	
Return air or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)
Return and exhaust airflow control devices	0.5 inch w.c.
Exhaust filters, scrubbers or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 thru 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 thru 15	0.9 inch w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Biosafety cabinet	Pressure drop of device at fan system design condition.
Energy recovery device, other than coil runaround loop	For each airstream, (2.2 × energy recovery effectiveness – 0.5) inch w.c.
Coil runaround loop	0.6 inch w.c. for each airstream.
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions.
Sound attenuation section (fans serving spaces with design background noise goals below NC35)	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.
DEDUCTIONS	
Systems without central cooling device	- 0.6 inch w.c.
Systems without central heating device	- 0.3 inch w.c.
Systems with central electric resistance heat	- 0.2 inch w.c.

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm.
w.c. = water column, NC = Noise criterion.

(3.7 kW) or less or with a fan system electrical input power of 4.1 kW or less.

1. Fans that are part of equipment covered in Section C403.3.3.
2. Fans included in an equipment package certified by an *approved agency* for air or energy performance.
3. Ceiling fans, which are defined as non-portable devices suspended from a ceiling or overhead structure for circulating air via the rotation of the blades.
4. Fans used for moving gases at temperatures above 425°F (250°C).
5. Fans used for operation in explosive atmospheres.
6. Reversible fans used for tunnel ventilation
7. Fans that are intended to operate only during emergency conditions.
8. Fans outside the scope of AMCA 208.

C403.8.4 Fractional hp fan motors. Motors for fans that are not less than $^{1}/_{12}$ hp (0.062 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent, rated in accordance with DOE 10 CFR 431. These motors shall have the means to adjust motor speed for either balancing or remote control. The use of belt-driven fans to sheave adjustments for airflow balancing instead of a varying motor speed shall be permitted.

Exceptions: The following motors are not required to comply with this section:

1. Motors in the airstream within fan coils and terminal units that only provide heating to the space served.
2. Motors in space-conditioning equipment that comply with Section C403.3.3 or Sections C403.8.1. through C403.8.3.
3. Motors that comply with Section C405.8.

C403.8.5 Low-capacity ventilation fans. Mechanical ventilation system fans less than $^{1}/_{12}$ horsepower (0.062 kW) in capacity shall meet the efficacy requirements of Table C403.8.5 at one or more rating points.

Exceptions:

1. Where ventilation fans are a component of a listed heating or cooling appliance.

2. Dryer exhaust duct power ventilators, domestic range hoods and domestic range booster fans that operate intermittently.

TABLE C403.8.5
LOW-CAPACITY VENTILATION FAN EFFICACY[a]

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
In-line fan	Any	3.8 cfm/watt	Any
Bathroom, utility room	10	2.8 cfm/watt	< 90
Bathroom, utility room	90	3.5 cfm/watt	Any

For SI: 1cfm/ft = 47.82 W

a. Airflow shall be tested in accordance with HVI 916 and listed. Efficacy shall be listed or shall be derived from listed power and airflow. Fan efficacy for fully ducted HRV, ERV, balanced and in-line fans shall be determined at a static pressure not less than 0.2-inch w.c. Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure not less than 0.1-inch w.c.

C403.8.6 Fan control. Controls shall be provided for fans in accordance with Section C403.8.6.1 and as required for specific systems provided in Section C403.

C403.8.6.1 Fan airflow control. Each cooling system listed in Table C403.8.6.1 shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

1. Direct expansion (DX) and chilled water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have not fewer than two stages of fan control.
2. Low or minimum speed shall not be greater than 66 percent of full speed. At low or minimum speed, the fan system shall draw not more than 40 percent of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
3. Other units including DX cooling units and chilled water units that control the space temperature by modulating the airflow to the space shall have modulating fan control. Minimum speed shall be not greater than 50 percent of full speed. At minimum speed the fan system shall draw not more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
4. Units that include an air-side economizer in accordance with Section C403.5 shall have not fewer than two speeds of fan control during economizer operation.

Exceptions:

1. Modulating fan control is not required for chilled water and evaporative cooling units with fan motors of less than 1 hp (0.746 kW) where the units are not used to provide *ventilation air* and the indoor fan cycles with the load.
2. Where the volume of outdoor air required to comply with the ventilation requirements of the *International Mechanical Code* at low speed exceeds the air that would be delivered at the speed defined in Section C403.8.6, the minimum speed shall be selected to provide the required *ventilation air*.

TABLE C403.8.6.1
COOLING SYSTEMS

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	≥ 65,000 Btu/h
Chilled water and evaporative cooling	≥ 1/4 hp	Any

For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

C403.9 Large-diameter ceiling fans. Where provided, large-diameter ceiling fans shall be tested and labeled in accordance with AMCA 230.

C403.10 Heat rejection equipment. Heat rejection equipment, including air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers, shall comply with this section.

Exception: Heat rejection devices where energy usage is included in the equipment efficiency ratings listed in Tables C403.3.2(1) and C403.3.2(3).

C403.10.1 Fan speed control. Each fan system powered by an individual motor or array of motors with connected power, including the motor service factor, totaling 5 hp (3.7 kW) or more shall have controls and devices configured to automatically modulate the fan speed to control the leaving fluid temperature or condensing temperature and pressure of the heat rejection device. Fan motor power input shall be not more than 30 percent of design wattage at 50 percent of the design airflow.

Exceptions:

1. Fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

C403.10.2 Multiple-cell heat rejection equipment. Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled to operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components and so that all fans operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged on and off operation. The minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer's recommendations.

C403.10.3 Limitation on centrifugal fan open-circuit cooling towers. Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1,100 gpm (4164 L/m) or greater at 95°F (35°C) condenser water return, 85°F (29°C) condenser water supply, and 75°F (24°C) outdoor air wet-bulb temperature shall meet the energy efficiency

requirement for axial fan open-circuit cooling towers listed in Table C403.3.2(8).

Exception: Centrifugal open-circuit cooling towers that are designed with inlet or discharge ducts or require external sound attenuation.

C403.10.4 Tower flow turndown. Open-circuit cooling towers used on water-cooled chiller systems that are configured with multiple- or variable-speed condenser water pumps shall be designed so that all open- circuit cooling tower cells can be run in parallel with the larger of the flow that is produced by the smallest pump at its minimum expected flow rate or at 50 percent of the design flow for the cell.

C403.10.5 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheating of service hot water provided that the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr (1758 kW) of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h (293 kW).

The required heat recovery system shall have the capacity to provide the smaller of the following:

1. Sixty percent of the peak heat rejection load at design conditions.
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

C403.11 Refrigeration equipment performance. Refrigeration equipment performance shall be determined in accordance with Sections C403.11.1 and C403.11.2 for commercial refrigerators, freezers, refrigerator-freezers, walk-in coolers, walk-in freezers, and refrigeration equipment. The energy use shall be verified through certification under an approved certification program or, where a certification program does not exist, the energy use shall be supported by data furnished by the equipment manufacturer.

Exception: Walk-in coolers and walk-in freezers regulated under federal law in accordance with Subpart R of DOE 10 CFR 431.

C403.11.1 Commercial refrigerators, refrigerator-freezers, and refrigeration. Refrigeration equipment, defined in DOE 10 CFR Part 431.62, shall have an energy use in kWh/day not greater than the values of Table C403.11.1 when tested and rated in accordance with AHRI Standard 1200.

C403.11.2 Walk-in coolers and walk-in freezers. Walk-in cooler and walk-in freezer refrigeration systems, except for walk-in process cooling refrigeration systems as defined in DOE 10 CFR 431.302, shall meet the requirements of Tables C403.11.2.1(1), C403.11.2.1(2) and C403.11.2.1(3).

TABLE C403.11.1
MINIMUM EFFICIENCY REQUIREMENTS:
COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP. °F	OPERTING TEMP. °F	EQUIPMENT CLASSIFICATION[a, c]	MAXIMUM DAILY ENERGY CONSUMPTION kWh/day[d, e]	TEST STANDARD
Remote condensing commercial refrigerators and commercial freezers	Remote (RC)	Vertical Open (VOP)	38 (M)	> 32	VOP.RC.M	0.64 × TDA + 4.07	AHRI 1200
			0 (L)	< 32	VOP.RC.L	2.20 × TDA + 6.85	
		Semivertical open (SVO)	38 (M)	> 32	SVO.RC.M	0.66 × TDA + 3.18	
			0 (L)	< 32	SVO.RC.L	2.20 × TDA +6.85	
		Horizontal open (HZO)	38 (M)	> 32	HZO.RC.M	0.35 × TDA + 2.88	
			0 (L)	< 32	HZO.RC.L	0.55 × TDA + 6.88	
		Vertical closed transparent (VCT)	38 (M)	> 32	VCT.RC.M	0.15 × TDA + 1.95	
			0 (L)	< 32	VCT.RC.L	0.49 × TDA + 2.61	
		Horizontal closed transparent (HCT)	38 (M)	> 32	HCT.RC.M	0.16 × TDA + 0.13	
			0 (L)	< 32	HCT.RC.L	0.34 × TDA + 0.26	
		Vertical closed solid (VCS)	38 (M)	> 32	VCS.RC.M	0.10 × V + 0.26	
			0 (L)	< 32	VCS.RC.L	0.21 × V + 0.54	
		Horizontal closed solid (HCS)	38 (M)	> 32	HCS.RC.M	0.10 × V + 0.26	
			0 (L)	< 32	HCS.RC.L	0.21 × V + 0.54	
		Service over counter (SOC)	38 (M)	> 32	SOC.RC.M	0.44 × TDA + 0.11	
			0 (L)	< 32	SOC.RC.L	0.93 × TDA + 0.22	

(continued)

TABLE C403.11.1—continued
MINIMUM EFFICIENCY REQUIREMENTS:
COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP. °F	OPERTING TEMP. °F	EQUIPMENT CLASSIFICATION[a, c]	MAXIMUM DAILY ENERGY CONSUMPTION kWh/day[d, e]	TEST STANDARD
Self-contained commercial refrigerators and commercial freezers with and without doors	Self-contained (SC)	Vertical open (VOP)	38 (M)	> 32	VOP.SC.M	1.69 × TDA + 4.71	AHRI 1200
			0 (L)	< 32	VOP.SC.L	4.25 × TDA + 11.82	
		Semivertical open (SVO)	38 (M)	> 32	SVO.SC.M	1.70 × TDA + 4.59	
			0 (L)	< 32	SVO.SC.L	4.26 × TDA + 11.51	
		Horizontal open (HZO)	38 (M)	> 32	HZO.SC.M	0.72 × TDA + 5.55	
			0 (L)	< 32	HZO.SC.L	1.90 × TDA + 7.08	
		Vertical closed transparent (VCT)	38 (M)	> 32	VCT.SC.M	0.10 × V + 0.86	
			0 (L)	< 32	VCT.SC.L	0.29 × V +2.95	
		Vertical closed solid (VCS)	38 (M)	> 32	VCS.SC.M	0.05 × V + 1.36	
			0 (L)	< 32	VCS.SC.L	0.22 × V + 1.38	
		Horizontal closed transparent (HCT)	38 (M)	> 32	HCT.SC.M	0.06 × V + 0.37	
			0 (L)	< 32	HCT.SC.L	0.08 × V + 1.23	
		Horizontal closed solid (HCS)	38 (M)	> 32	HCS.SC.M	0.05 × V + 0.91	
			0 (L)	< 32	HCS.SC.L	0.06 × V + 1.12	
		Service over counter (SOC)	38 (M)	> 32	SOC.SC.M	0.52 × TDA + 1.00	
			0 (L)	< 32	SOC.SC.L	1.10 × TDA + 2.10	
Self-contained commercial refrigerators with transparent doors for pull-down temperature applications	Self-contained (SC)	Pull-down (PD)	38 (M)	> 32	PD.SC.M	0.11 x V + 0.81	AHRI 1200
Commercial ice cream freezers	Remote (RC)	Vertical open (VOP)	15 (I)	< -5b	VOP.RC.I	2.79 × TDA + 8.70	AHRI 1200
		Semivertical open (SVO)			SVO.RC.I	2.79 × TDA + 8.70	
		Horizontal open (HZO)			HZO.RC.I	0.70 × TDA + 8.74	
		Vertical closed transparent (VCT)			VCT.RC.I	0.58 × TDA + 3.05	
		Horizontal closed transparent (HCT)			HCT.RC.I	0.40 × TDA + 0.31	
		Vertical closed solid (VCS)			VCS.RC.I	0.25 × V + 0.63	
		Horizontal closed solid (HCS)			HCS.RC.I	0.25 × V + 0.63	
		Service over counter (SOC)			SOC.RC.I	1.09 × TDA + 0.26	

(continued)

TABLE C403.11.1—continued
MINIMUM EFFICIENCY REQUIREMENTS:
COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP. °F	OPERTING TEMP. °F	EQUIPMENT CLASSIFICATION[a, c]	MAXIMUM DAILY ENERGY CONSUMPTION kWh/day[d, e]	TEST STANDARD
Commercial ice cream freezers (cont.)	Self-contained (SC)	Vertical open (VOP)	- 15 (I)	< -5b	VOP.SC.I	5.40 × TDA + 15.02	AHRI 1200
		Semivertical open (SVO)			SVO.SC.I	5.41 × TDA + 14.63	
		Horizontal open (HZO)			HZO.SC.I	2.42 × TDA + 9.00	
		Vertical closed transparent (VCT)			VCT.SC.I	0.62 × TDA + 3.29	
		Horizontal closed transparent (HCT)			HCT.SC.I	0.56 × TDA + 0.43	
		Vertical closed solid (VCS)			VCS.SC.I	0.34 × V + 0.88	
		Horizontal closed solid (HCS)			HCS.SC.I	0.34 × V + 0.88	
		Service over counter (SOC)			SOC.SC.I	1.53 × TDA + 0.36	

For SI: 1 square foot = 0.0929 m2, 1 cubic foot = 0.02832 m3, °C = (°F – 32)/1.8.

a. The meaning of the letters in this column is indicated in the columns to the left.

b. Ice cream freezer is defined in DOE 10 CFR 431.62 as a commercial freezer that is designed to operate at or below -5 °F and that the manufacturer designs, markets or intends for the storing, displaying, or dispensing of ice cream.

c. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of the following:
- (AAA)—An equipment family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical closed transparent doors, VCS = vertical closed solid doors, HCT = horizontal closed transparent doors, HCS = horizontal closed solid doors, and SOC = service over counter);
- (BB)—An operating mode code (RC = remote condensing and SC = self-contained); and
- (C)—A rating temperature code [M = medium temperature (38°F), L = low temperature (0°F), or I = ice cream temperature (-15°F)].
- For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class.

d. V is the volume of the case (ft3) as measured in AHRI 1200, Appendix C.

e. TDA is the total display area of the case (ft2) as measured in AHRI 1200, Appendix D.

TABLE C403.11.2.1(1)
WALK-IN COOLER AND FREEZER DISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Display door, medium temperature	DD, M	$0.04 \times A_{dd} + 0.41$
Display door, low temperature	DD, L	$0.15 \times A_{dd} + 0.29$

a. A_{dd} is the surface area of the display door.

TABLE C403.11.2.1(2)
WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS[a]

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]
Passage door, medium temperature	PD, M	$0.05 \times A_{nd} + 1.7$
Passage door, low temperature	PD, L	$0.14 \times A_{nd} + 4.8$
Freight door, medium temperature	FD, M	$0.04 \times A_{nd} + 1.9$
Freight door, low temperature	FD, L	$0.12 \times A_{nd} + 5.6$

a. A_{nd} is the surface area of the nondisplay door.

TABLE C403.11.2.1(3)
WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS

CLASS DESCRIPTOR	CLASS	MINIMUM ANNUAL WALK-IN ENERGY FACTOR AWEF (Btu/W-h)[a]	TEST PROCEDURE
Dedicated condensing, medium temperature, indoor system	DC.M.I	5.61	AHRI 1250
Dedicated condensing, medium temperature, outdoor system	DC.M.O	7.60	
Dedicated condensing, medium temperature, indoor system, net capacity (q_{net})	DC.L.I, < 6,500 Btu/h	9.091 × 10-5 × q_{net} + 1.81	
Dedicated condensing, low temperature, indoor system, net capacity (q_{net})	DC.L.I, ≥ 6,500 Btu/h	2.40	
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net})	DC.L.O, < 6,500 Btu/h	6.522 × 10-5 × q_{net} + 2.73	
Dedicated condensing, medium temperature, outdoor system, net capacity (q_{net})	DC.L.O, ≥ 6,500 Btu/h	3.15	
Unit cooler, medium	UC.M	9.00	
Unit cooler, low temperature, net capacity (q_{net})	UC.L, < 15,500 Btu/h	1.575 × 10-5 × q_{net} + 3.91	
Unit cooler, low temperature, net capacity (q_{net})	UC.L, ≥ 15,500 Btu/h	4.15	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. q_{net} is net capacity (Btu/h) as determined in accordance with AHRI 1250.

C403.11.2.1 Performance standards. *Walk-in coolers* and *walk-in freezers* shall meet the requirements of Tables C403.11.2.1(1), C403.11.2.1(2) and C403.11.2.1(3).

C403.11.3 Refrigeration systems. Refrigerated display cases, *walk-in coolers* or *walk-in freezers* that are served by remote compressors and remote condensers not located in a condensing unit, shall comply with Sections C403.11.3.1 and C403.11.3.2.

Exception: Systems where the working fluid in the refrigeration cycle goes through both subcritical and super-critical states (transcritical) or that use ammonia refrigerant are exempt.

C403.11.3.1 Condensers serving refrigeration systems. Fan-powered condensers shall comply with the following:

1. The design *saturated condensing temperatures* for air-cooled condensers shall not exceed the design dry-bulb temperature plus 10°F (5.6°C) for low-*temperature refrigeration systems*, and the design dry- bulb temperature plus 15°F (8°C) for *medium temperature refrigeration systems* where the *saturated condensing temperature* for blend refrigerants shall be determined using the average of liquid and vapor temperatures as converted from the condenser drain pressure.
2. Condenser fan motors that are less than 1 hp (0.75 kW) shall use electronically commutated motors, permanent split-capacitor-type motors, or 3-phase motors.
3. Condenser fans for air-cooled condensers, evaporatively cooled condensers, air- or water-cooled fluid coolers or cooling towers shall reduce fan motor demand to not more than 30 percent of design wattage at 50 percent of design air volume, and incorporate one of the following continuous variable speed fan control approaches:
   3.1. Refrigeration system condenser control for air-cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient dry-bulb temperature.
   3.2. Refrigeration system condenser control for evaporatively cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient wet-bulb temperature.
4. Multiple fan condensers shall be controlled in unison.
5. The minimum condensing temperature setpoint shall be not greater than 70°F (21°C).

C403.11.3.2 Compressor systems. Refrigeration compressor systems shall comply with the following:

1. Compressors and multiple-compressor system suction groups shall include control systems that use floating suction pressure control logic to reset the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

   Exception: Controls are not required for the following:

   1. Single-compressor systems that do not have variable capacity capability.
   2. Suction groups that have a design saturated suction temperature of 30°F (-1.1°C) or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups

that primarily serve chillers for secondary cooling fluids.

Liquid subcooling shall be provided for all low-temperature compressor systems with a design cooling capacity equal to or greater than 100,000 Btu/h (29.3 kW) with a design-saturated suction temperature of -10°F (-23°C) or lower. The sub-cooled liquid temperature shall be controlled at a maximum temperature setpoint of 50°F (10°C) at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compressor suction group operating at a saturated suction temperature of 18°F (-7.8°C) or higher.

2.1. Insulation for liquid lines with a fluid operating temperature less than 60°F (15.6°C) shall comply with Table C403.11.3.

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

C403.12 Construction of HVAC system elements. Ducts, plenums, piping and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections C403.12.1 through C403.12.4.1.

C403.12.1 Duct and plenum insulation and sealing. Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than R-12 insulation. Ducts located underground beneath buildings shall be insulated as required in this section or have an equivalent thermal distribution efficiency. Underground ducts utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-12 insulation.

Exceptions:

1. Where located within equipment.
2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the *International Mechanical Code*.

C403.12.2 Duct construction. Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*.

C403.12.2.1 Low-pressure duct systems. Longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (498 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

Exception: Locking-type longitudinal joints and seams, other than the snap-lock and button-lock types, need not be sealed as specified in this section.

C403.12.2.2 Medium-pressure duct systems (Mandatory). Ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (498 Pa) but less than 3 inches w.g. (747 Pa) shall be insulated and sealed in accordance with Section C403.12.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

C403.12.2.3 High-pressure duct systems. Ducts and plenums designed to operate at static pressures equal to or greater than 3 inches of water gauge (747 Pa) shall be insulated and sealed in accordance with Section C403.12.1. In addition, ducts and plenums shall be leak tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual and shown to have a rate of air leakage (CL) less than or equal to 4.0 as determined in accordance with Equation 4-7.

$$CL = F/P^{0.65} \qquad \textbf{(Equation 4-7)}$$

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished demonstrating that representative sections totaling not less than 25 percent of the duct area have been tested and that all tested sections comply with the requirements of this section.

C403.12.3 Dwelling and sleeping unit duct systems. The dwelling or sleeping unit duct system shall be tested in accordance with ANSI/RESNET/ICC 380 or an equivalent method approved by the code official. Buildings with fewer than eight dwelling or sleeping units, each unit shall be tested. Buildings with eight or more dwelling or sleeping units, the greater of seven or 20 percent of the units shall be tested. Ducts shall be pressure tested to determine the air leakage by one of the following methods.:

1. Rough-in: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29m^2) of conditioned floor area when measured with a pressure differential of 0.1-inch w.g. (25 Pa) across the system. Where the air handlers is NOT installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85L/min) per 100 square feet (9.29m^2) of conditioned floor area. Registers shall be taped or otherwise sealed during the test.

2. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29m^2) of conditioned floor area when measured with a pressure differential of 0.1-inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All portions of the duct system, including air handler, filter box, supply and return boots shall be tested. Registers shall be taped or otherwise sealed during the test.
3. Test for ducts within unit envelope: Where all ducts and air handlers are located entirely within the building thermal envelope, total leakage shall be less than or equal to 8.0 cubic feet per minute (226.6 L/min) per 100 square feet (9.29 m^2) of conditioned floor area.

Exception: A duct-leakage test shall not be required for ducts serving a ventilation system that is not integrated with the heating or cooling system(s).

A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*.

C403.12.4 Piping insulation. Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.11.3.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and AHRI 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 105°F (41°C).
4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
6. Direct buried piping that conveys fluids at or below 60°F (15°C).
7. In radiant heating systems, sections of piping intended by design to radiate heat.

C403.12.4.1 Protection of piping insulation. Piping insulation exposed to the weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

C403.13 Mechanical systems located outside of the building thermal envelope. Mechanical systems providing heat outside of the thermal envelope of a building shall comply with Sections C403.13.1 through C403.13.3.

C403.13.1 Heating outside a building. Systems installed to provide heat outside a building shall be radiant systems.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically de-energized when occupants are

TABLE C403.12.4
MINIMUM PIPE INSULATION THICKNESS (in inches)[a, c]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu • in./(h • ft^2 • °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1 1/2	1 1/2 to < 4	4 to < 8	≥ 8
> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
105 – 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 – 0.26	50	0.5	1.0	1.0	1.0	1.5

For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.

a. For piping smaller than 1 1/2 inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch.

b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$T = r\,[(1 + t/r)^{K/k} - 1]$

where:

T = minimum insulation thickness,
r = actual outside radius of pipe,
t = insulation thickness listed in the table for applicable fluid temperature and pipe size,
K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu • in/h • ft^2 • °F) and
k = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

c. For direct-buried heating and hot water system piping, reduction of these thicknesses by 1 1/2 inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch.

not present. Energy use by an exterior radiant system shall be offset by on-site renewable energy generation equivalent to the energy use by the system. Plans shall be submitted that detail the type, size, and location of the on-site renewable energy generation equipment.

C403.13.2 Snow- and ice-melt system controls. Snow- and ice-melting systems shall include automatic controls configured to shut off the system when the pavement temperature is above 50°F (10°C) and precipitation is not falling, and an automatic or manual control that is configured to shut off when the outdoor temperature is above 40°F (4°C).

C403.13.3 Freeze protection system controls. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls configured to shut off the systems when outdoor air temperatures are above 40°F (4°C) or when the conditions of the protected fluid will prevent freezing.

C403.14 Operable opening interlocking controls. The heating and cooling systems shall have controls that will interlock these mechanical systems to the set temperatures of 90ºF (32ºC) for cooling and 55ºF (12.7ºC) for heating when the conditions of Section C402.5.8 exist. The controls shall configure to shut off the systems entirely when the outdoor temperatures are below 90ºF (32ºC) or above 55ºF (12.7ºC).

C403.14.1 Overhead door HVAC shutoff devices. Overhead doors, cargo doors, sliding doors, folding and accordion-style wall systems, and other loading dock-style doors that open to the outdoors shall be equipped with interlock controls that disable the heating, cooling and humidity control equipment that serves the area or zone adjacent to the door. The shutoff shall activate prior to the door being 25 percent open. A shutoff override, designed to be used when vehicles are parked in the doorway, may be included on doors equipped with weather seals. The override must automatically deactivate when the vehicle is removed.

Exceptions:

1. Areas where HVAC equipment must remain on for safety, sanitation or other health-related reasons.
2. Areas heated by radiant heating systems.
3. The shutoff override shall activate within 5 minutes in groups U, SI, and B motor vehicle showroom occupancies.

SECTION C404
SERVICE WATER HEATING (MANDATORY)

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

C404.2 Service water-heating energy source. All service water-heating systems shall be all-electric or fueled by other non-fossil fuel derived energy source.

Exceptions:

1. Systems serving laboratories
2. Systems serving hospitals
3. Systems serving large industrial S-1 occupancies, with constant vehicle traffic.

For the exceptions where an energy source is not electric, fossil fuel energy usage shall be 100 percent offset by onsite renewable energy. The power generated to offset the fossil fuel energy source shall not offset greater than 10 percent of the building's total energy use for the purposes of complying with Section C407.

C404.2.1 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

C404.2.2 High input service water-heating systems. Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E_t, of not less than 92 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, E_t, shall be not less than 90 percent.

Exceptions:

1. Where not less than 25 percent of the annual *service water-heating* requirement is provided by *on-site renewable energy* or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of *service water-heating* equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of *service water-heating* equipment for a building.

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a]	TEST PROCEDURE[b, c]
Water heaters, electric	≤ 12 kW[d]	Tabletop[f] ≥ 20 gallons and ≤ 120 gallons Resistance ≥ 20 gallons and ≤ 55 gallons Grid-enabled > 75 gallons and ≤ 120 gallons	This category is regulated as a consumer product by the U.S. DOE as defined in 10 CFR 430	DOE 10 CFR Part 430
	> 12 kW	Resistance	$(0.3 + 27/V_m)$, %/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump > 55 gallons and ≤ 120 gallons	$2.057 - 0.00113V$, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gallons and ≤ 55 gallons	$0.675 - 0.0015V$, EF	DOE 10 CFR Part 430
		> 55 gallons and ≤ 100 gallons	$0.8012 - 0.00078V$, EF	
	> 75,000 Btu/h and ≤ 105,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	ANSI Z21.10.3
	> 105,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 Btu/h/gal and < 2 gal	$0.82 - 0.0019V$, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal and ≤ 50 gallons	$0.68 - 0.0019V$, EF	DOE 10 CFR Part 430
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	$0.59 - 0.0019V$, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Hot water supply boilers, gas, and oil[e]	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
Hot water supply boilers, gas[e]	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$SL, Btu/h	
Pool heaters, gas, and oil	All	—	This category is regulated as a consumer product by the U.S. DOE as defined in 10 CFR 430	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160

(continued)

TABLE C404.2—continued
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a]	TEST PROCEDURE[b, c]
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h • ft^2 • °F)/Btu	(none)

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2,°C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Thermal *efficiency* (E_t) is a minimum requirement, while standby loss is a maximum requirement. In the EF standby loss equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h. V_b is the measured volume in the tank in gallons, Standby loss for electric water heaters is in terms of %/h and denoted by the term "S," and standby loss for gas and oil water heaters is in terms of Btu/h and denoted by the term "SL." Draw pattern (DP) refers to the water draw profile in the uniform energy factor (UEF) test. UEF and energy factor (EF) are minimum requirements. In UEF standard equations, V_r refers to the rated volume in gallons.

b. ASHRAE 90.1, section 13 contains a complete specification, including the year version, of the referenced test procedure.

c. Instantaneous water heaters with input rates below 200,000 Btu/h shall comply with these requirements where the water heater is designed to heat water to temperatures 180°F or higher.

d. Electric water heaters with an input rating of 12 kW (40,950 Btu/h) or less that are designed to heat water to temperatures of 180°F or greater shall comply with the requirements for electric water heaters that have an input rating greater than 12 kW (40,950 Btu/h).

e. Refer to section C402.2.2 for additional requirements for gas storage and instantaneous water heaters and gas hot-water supply boilers.

f. A tabletop water heater is a water heater that is enclosed in a rectangular cabinet with a flat top surface not more than 3 feet in height. A grid-enabled water heater is an electric resistance water heater that meets all of the following:
   1. Has a rated storage tank volume of more than 75 gallons.
   2. Was manufactured on or after April 16, 2015.
   3. Is equipped at the point of manufacture with an activation lock.
   4. Bears a permanent label applied by the manufacturer that complies with all of the following:
      4.1. Is made of material not adversely affected by water.
      4.2. Is attached by means of nonwater-soluble adhesive.
      4.3. Advises purchasers and end users of the intended and appropriate use of the product with the following notice printed in 16.5-point Arial Narrow Bold font: "IMPORTANT INFORMATION: This water heater is intended only for use as part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product."

C404.3 Heat traps for hot water storage tanks. Storage tank-type water heaters and hot water storage tanks that have vertical water pipes connecting to the inlet and outlet of the tank shall be provided with integral heat traps at those inlets and outlets or shall have pipe-configured heat traps in the piping connected to those inlets and outlets. Tank inlets and outlets associated with solar water-heating system circulation loops shall not be required to have heat traps.

C404.4 Insulation of piping. Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table C403.12.3. On both the inlet and outlet piping of a storage water heater or heated water storage tank, the piping to a heat trap or the first 8 feet (2438 mm) of piping, whichever is less, shall be insulated. Piping that is heat traced shall be insulated in accordance with Table C403.12.3 or the heat trace manufacturer's instructions. Tubular pipe insulation shall be installed in accordance with the insulation manufacturer's instructions. Pipe insulation shall be continuous except where the piping passes through a framing member. The minimum insulation thickness requirements of this section shall not supersede any greater insulation thickness requirements necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures on the insulation.

Exception: Tubular pipe insulation shall not be required on the following:

1. The tubing from the connection at the termination of the fixture supply piping to a plumbing fixture or plumbing appliance.
2. Valves, pumps, strainers and threaded unions in piping that is 1 inch (25 mm) or less in nominal diameter.
3. Piping from user-controlled shower and bath mixing valves to the water outlets.
4. Cold-water piping of a demand recirculation water system.
5. Tubing from a hot drinking-water heating unit to the water outlet.
6. Piping at locations where a vertical support of the piping is installed.
7. Piping surrounded by building insulation with a thermal resistance (*R*-value) of not less than R-3.

C404.5 Heated water supply piping. Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through $^1/_4$-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through $^5/_{16}$-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through $^3/_8$-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

C404.5.1 Maximum allowable pipe length method. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the "Public lavatory faucets" column in Table C404.5.1.

2. For all other plumbing fixtures and plumbing appliances, use the "Other fixtures and appliances" column in Table C404.5.1.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1 or from Table C404.5.2.1. The volume contained within fixture shut-off valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

C404.6 Heated-water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be in a location with *access*. Manual controls shall be in a location with *ready access*.

C404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall automatically turn off the pump when the water in the circulation loop is at the

TABLE C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
1/4	0.33	6	50
5/16	0.5	4	50
3/8	0.75	3	50
1/2	1.5	2	43
5/8	2	1	32
3/4	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
1 1/4	8	0.5	8
1 1/2	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

TABLE C404.5.2.1
INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING

OUNCES OF WATER PER FOOT OF TUBE									
Nominal Size (inches)	Copper Type M	Copper Type L	Copper Type K	CPVC CTS SDR 11	CPVC SCH 40	CPVC SCH 80	PERT SDR	Composite ASTM F1281	PEX CTS SDR 9
3/8	1.06	0.97	0.84	N/A	1.17	N/A	0.64	0.63	0.64
1/2	1.69	1.55	1.45	1.25	1.89	1.46	1.18	1.31	1.18
3/4	3.43	3.22	2.90	2.67	3.38	2.74	2.35	3.39	2.35
1	5.81	5.49	5.17	4.43	5.53	4.57	3.91	5.56	3.91
1 1/4	8.70	8.36	8.09	6.61	9.66	8.24	5.81	8.49	5.81
1 1/2	12.18	11.83	11.45	9.22	13.20	11.38	8.09	13.88	8.09
2	21.08	20.58	20.04	15.79	21.88	19.11	13.86	21.48	13.86

For SI: 1 foot = 304.8 mm, 1 inch = 25.4 mm, 1 liquid ounce = 0.030 L, 1 oz/ft = 305.15 g/m^2.
N/A = Not Available.

hot water. The controls shall limit the temperature of the water entering the cold-water piping to not greater than 104°F (40°C).

C404.6.1.1 Demand recirculation controls. Demand recirculation water systems shall have controls that start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance.

C404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

C404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

C404.7 Demand responsive water heating. Electric storage water heaters with a rated water storage volume of 40 gallons (150 L) to 120 gallons (450 L) and a nameplate input rating equal to or less than 12kW shall be provided with demand responsive controls in accordance with Table C404.10 or another equivalent approved standard.

Exceptions:

1. Water heaters that provide a hot water delivery temperature of 180F (82C) or greater.
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code.
3. Water heaters that use 3-phase electric power.

C404.8 Water heating equipment location. Water heaters with combustion equipment shall be located in a space meeting the following requirements:

1. Minimum dimensions of 3 feet by 3 feet by 7 feet high.
2. Minimum volume of 760 cubic feet, or the equivalent of one 16-inch by 24-inch grill to a heated space and one 8-inch duct of no more than 10 feet in length for cool exhaust air.
3. Contains a condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance, installed within 3 feet of the water heater.

Exceptions:

1. Instantaneous water heaters located within 10 feet of the point of use.
2. Water heats with an input capacity of more than 300,000 Btu/h.

C404.9 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For *Group R* occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

C404.10 Energy consumption of pools and permanent spas. The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.10.1 through C404.10.3.

TABLE 404.10
DEMAND RESPONSIVE CONTROLS FOR WATER HEATING

EQUIPMENT TYPE	CONTROLS	
	BEFORE 7/1/2025[a]	AFTER 7/1/2025[a]
Electric storage water heaters	ANSI/CTA and also capable of initiating water heating to meet the temperature set point in response to a demand response signal.	ANSI/CTA-2045, except "Price Stream Communication" functionality as defined in the standard.

a. Manufacture date.

C404.10.1 Heaters. The electric power to all heaters shall be controlled by an on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater in a location with *ready access*. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Only equipment that utilizes a non-fossil fuel derived energy source are permitted. Any heat pump shall be able to adequately function in Boulder's climate zone, 5b.

C404.10.2 Time switches. Time switches or other control methods that can automatically turn off and on heaters and pump motors according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate solar- and waste-heat-recovery pool heating systems.

C404.10.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other *approved* vapor-retardant means.

Exception: Where more than 75 percent of the energy for heating, computed over an operating season of not fewer than 3 calendar months, is from a heat pump or an on-site renewable energy system, covers or other vapor-retardant means shall not be required.

C404.11 Energy consumption of portable spas. The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

SECTION C405
ELECTRICAL POWER AND LIGHTING SYSTEMS

C405.1 General. Lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption shall comply with this section. *Sleeping units* shall comply with Section C405.2.4 and with either Section C405.1.1 or C405.3. *General lighting* shall consist of all lighting included when calculating the total connected interior lighting power in accordance with Section C405.3.1 and which does not require specific application controls in accordance with Section C405.2.5. Transformers, uninterruptable power supplies, motors and electrical power processing equipment in data center systems shall comply with Section 8 of ASHRAE 90.4 in addition to this code.

C405.1.1 Lighting for dwelling units. Dwelling units shall comply with Section R404.1.

C405.2 Lighting controls. Lighting systems shall be provided with controls that comply with one of the following.

1. Lighting controls as specified in Sections C405.2.1 through C405.2.8.
2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.5 and C405.2.6. The LLLC luminaire shall be independently capable of:
    2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
    2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.
    2.3. For each control strategy, configuration and reconfiguration of performance parameters including; bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

Exceptions: Lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency egress lighting that is normally off.
4. Emergency lighting required by the International Building Code in exit access components which are not provided with fire alarm systems.
5. Up to 0.02 Watts per square foot (0.06 W/m2) of lighting in exit access components which are provided with fire alarm systems.

C405.2.1 Occupant sensor controls. Occupant *sensor controls* shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges/breakrooms.
5. Enclosed offices.
6. Open plan office areas.
7. Restrooms.
8. Storage rooms.
9. Locker rooms.
10. Corridors.
11. Warehouse storage areas.
12. Other spaces 300 square feet (28 m^2) or less that are enclosed by floor-to-ceiling height partitions.

Exception: Luminaires that are required to have specific application controls in accordance with Section C405.2.5.

C405.2.1.1 Occupant sensor control function. Occupant sensor controls in warehouses shall comply with Section C405.2.1.2. Occupant sensor controls in open plan office areas shall comply with Section C405.2.1.3. Occupant sensor controls in corridors shall comply with Section C405.2.1.4. Occupant sensor controls for all other spaces specified in Section C405.2.1 shall comply with the following:

1. They shall automatically turn off lights within 20 minutes after all occupants have left the space.
2. They shall be manual on or controlled to automatically turn on the lighting to not more than 50-percent power.
3. They shall incorporate a manual control to allow occupants to turn off lights.

    Exception: Full automatic-on controls with no manual control shall be permitted in corridors, interior parking areas, stairways, restrooms, locker rooms, lobbies, library stacks and areas where manual operation would endanger occupant safety or security.

C405.2.1.2 Occupant sensor control function in warehouse storage areas. Lighting in warehouse storage areas shall be controlled as follows:

1. Lighting in each aisleway shall be controlled independently of lighting in all other aisleways and open areas.
2. Occupant sensors shall automatically reduce lighting power within each controlled area to an occupied setpoint of not more than 50 percent within 20 minutes after all occupants have left the controlled area.
3. Lights that are not turned off by occupant sensors shall be turned off by time-switch control complying with Section C405.2.2.1.
4. A manual control shall be provided to allow occupants to turn off lights in the space.

C405.2.1.3 Occupant sensor control function in open plan office areas. Occupant sensor controls in open plan office spaces less than 300 square feet (28 m^2) in area shall comply with Section C405.2.1.1.

Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 600 square feet (55 m^2) within the open plan office space.
2. General lighting in each control zone shall be permitted to automatically turn on upon occupancy within the control zone. General lighting in other unoccupied zones within the open plan office space shall be permitted to turn on to not more than 20 percent of full power or remain unaffected.
3. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.

   Exception: Where general lighting is turned off by time-switch control complying with Section C405.2.2.1.
4. General lighting in each control zone shall turn off or uniformly reduce lighting power to an unoccupied setpoint of not more than 20 percent of full power within 20 minutes after all occupants have left the control zone.

C405.2.1.4 Occupant sensor control function in corridors. Occupant sensor controls in corridors shall uniformly reduce lighting power to not more than 50 percent of full power within 20 minutes after all occupants have left the space.

Exception: Corridors provided with less than two footcandles of illumination on the floor at the darkest point with all lights on.

C405.2.2 Time-switch controls. Each area of the building that is not provided with *occupant sensor controls* complying with Section C405.2.1.1 shall be provided with *time-switch controls* complying with Section C405.2.2.1.

Exceptions:

1. Luminaires that are required to have specific application controls in accordance with Section C405.2.4.
2. Spaces where patient care is directly provided.
3. Spaces where an automatic shutoff would endanger occupant safety or security.
4. Lighting intended for continuous operation.
5. Shop and laboratory classrooms.

C405.2.2.1 Time-switch control function. Time-switch *controls* shall comply with all of the following:

1. Automatically turn off lights when the space is scheduled to be unoccupied.
2. Have a minimum 7-day clock.
3. Be capable of being set for seven different day types per week.
4. Incorporate an automatic holiday "shutoff" feature, which turns off all controlled lighting loads for not fewer than 24 hours and then resumes normally scheduled operations.
5. Have program backup capabilities, which prevent the loss of program and time settings for not fewer than 10 hours, if power is interrupted.
6. Include an override switch that complies with the following:

   6.1. The override switch shall be a manual control.

   6.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.

   6.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m^2).

Exceptions: Within mall concourses, auditoriums, sales areas, manufacturing facilities and sports arenas:

1. The time limit shall be permitted to be greater than 2 hours, provided that the switch is a captive key device.
2. The area controlled by the override switch shall not be limited to 5,000 square feet (465 m^2) provided that such area is less than 20,000 square feet (1860 m^2).

C405.2.3 Light-reduction controls. Where not provided with occupant sensor controls complying with Section C405.2.1.1, general lighting shall be provided with light-reduction controls complying with Section C405.2.3.1.

Exceptions:

1. Luminaires controlled by daylight responsive controls complying with Section C405.2.4.
2. Luminaires controlled by special application controls complying with Section C405.2.5.
3. Where provided with manual control, the following areas are not requirefd to have light-reduction control:

   3.1. Spaces that have only one luminaire with a rated power of less than 60 watts.

   3.2. Spaces that use less than 0.45 watts per square foot (4.9 W/m^2).

   3.3. Corridors, lobbies, electrical rooms and or mechanical rooms.

C405.2.3.1 Light-reduction control function. Spaces required to have light-reduction controls shall have a *manual control* that allows the occupant to reduce the connected lighting load by not less than 50 percent in a reasonably uniform illumination pattern with an intermediate step in addition to full on or off, or with contin-

uous dimming control, using one of the following or another *approved* method:

1. Continuous dimming of all luminaires from full output to less than 20 percent of full power.
2. Switching all luminaires to a reduced output of not less than 30 percent and not more than 70 percent of full power.
3. Switching alternate luminaires or alternate rows of luminaires to achieve a reduced output of not less than 30 percent and not more than 70 percent full power.

C405.2.4 Daylight responsive controls. *Daylight-responsive controls* complying with Section C405.2.4.1 shall be provided to control the general lighting within *daylight zones* in the following spaces:

1. Spaces with a total of more than 150 watts of gen*eral lighting* within primary sidelit zones complying with Section C405.2.4.2.
2. Spaces with a total of more than 300 watts of general lighting within sidelit daylight zones complying with Section C405.2.4.2.
3. Spaces with a total of more than 150 watts of *general lighting* within toplit daylight zones complying with Section C405.2.4.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Sidelit daylight zones on the first floor above grade in Group A-2 and Group M occupancies.
3. New buildings where the total connected lighting power calculated in accordance with Section C405.3.1 is not greater than the adjusted interior lighting power allowance (LPA_{adj}) calculated in accordance with Equation 4-8:

$$LPA_{adj} = [LPA_{norm} \times (1.0 - 0.4 \times UDZFA / TBFA)] \quad \textbf{(Equation 4-8)}$$

where:

LPA_{adj} = Adjusted building interior lighting power allowance in watts.

LPA_{norm} = Normal building lighting power allowance in watts calculated in accordance with section C405.3.2 and reduced in accordance with section C406.2.5.6 where used to comply with the requirements of section C406.

$UDZFA$ = Uncontrolled daylight zone floor area is the sum of all sidelit and toplit zones, calculated in accordance with sections C405.2.4.2 and C405.2.4.3, that do not have daylight responsive controls.

$TBFA$ = Total building floor area is the sum of all floor areas included in the lighting power allowance calculation in section C405.3.2.

C405.2.4.1 Daylight-responsive control function. Where required, *daylight-responsive controls* shall be provided within each space for control of lights in that space and shall comply with all of the following:

1. Lights in *toplit daylight* zones in accordance with Section C405.2.4.3 shall be controlled independently of lights in sidelit daylight zones in accordance with Section C405.2.4.2.
2. Lights in the primary sidelit daylight zone shall be controlled independently of lights in the secondary sidelit daylight zone.
3. *Daylight responsive controls* within each space shall be configured so that they can be calibrated from within that space by authorized personnel.
4. Calibration mechanisms shall be in a location with *ready access.*
5. Daylight responsive controls shall dim lights continuously from full light output to 15 percent of full light output or lower.
6. Daylight responsive controls shall be configured to completely shut off all controlled lights.
7. When occupant sensor controls have reduced the lighting power to an unoccupied setpoint in accordance with Sections C405.2.1.2 through C405.2.1.4, daylight responsive controls shall continue to adjust electric light levels in response to available daylight, but shall be configured to not increase the lighting power above the specified unoccupied setpoint.
8. Lights in sidelit zones in accordance with Section C405.2.4.2 facing different cardinal orientations [within 45 degrees (0.79 rad) of due north, east, south, west] shall be controlled independently of each other.

Exceptions:

1. Within each space, up to 150 watts of lighting within the primary sidelit daylight zone is permitted to be controlled together with lighting in a primary sidelit daylight zone facing a different cardinal orientation.
2. Within each space, up to 150 watts of lighting within the secondary sidelit daylight zone is permitted to be controlled together with lighting in a secondary sidelit daylight zone facing a different cardinal orientation.

C405.2.4.2 Sidelit daylight zone. The sidelit daylight zone is the floor area adjacent to vertical *fenestration* that complies with all of the following:

1. Where the fenestration is located in a wall, the sidelit daylight zone shall extend laterally to the nearest full-height wall, or up to 1.0 times the height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.4.2(1).
2. Where the fenestration is located in a rooftop monitor, the sidelit daylight zone shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less, as indicated in Figures C405.2.4.2(2) and C405.2.4.2(3).
3. The secondary sidelit daylight zone is directly adjacent to the primary sidelit daylight zone and shall extend laterally to 2.0 times the height from the floor to the top of the fenestration or to the nearest full height wall, whichever is less, and longitudinally from the edge of the fenestration to the nearest full height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.4.2(1). The area of secondary sidelit zones shall not be considered in the calculation of the daylight zones in Section C402.4.1.1.
4. The area of the fenestration is not less than 24 square feet (2.23 m^2).
5. The distance from the fenestration to any building or geological formation that would block access to daylight is greater than one-half of the height from the bottom of the fenestration to the top of the building or geologic formation.

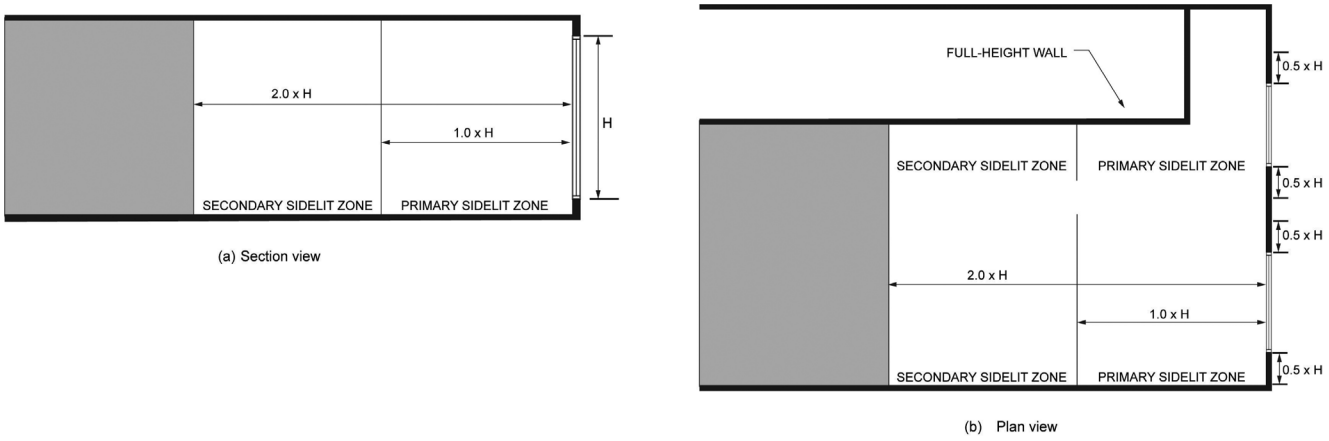


FIGURE C405.2.4.2(1)
PRIMARY AND SECONDARY SIDELIT DAYLIGHT ZONES

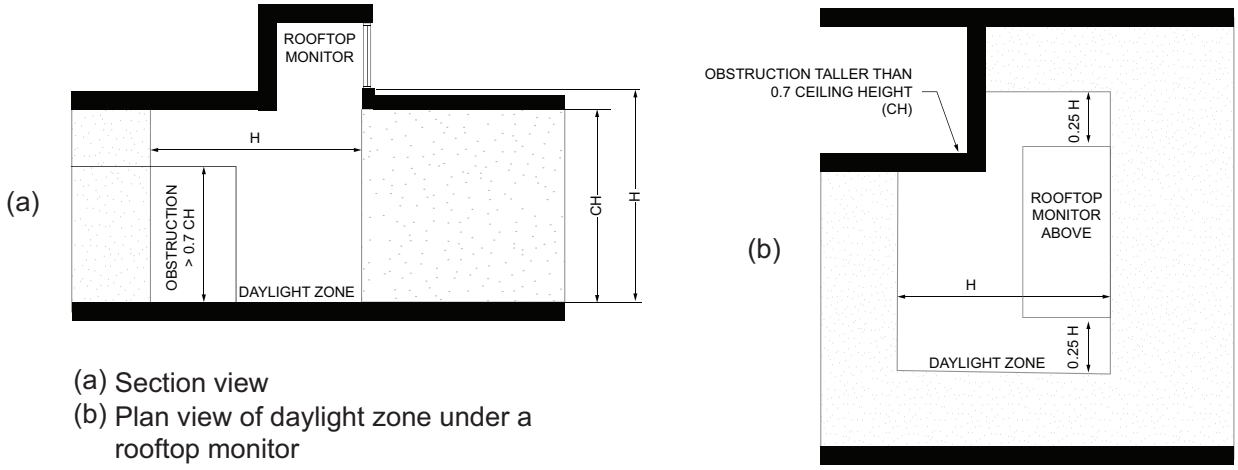
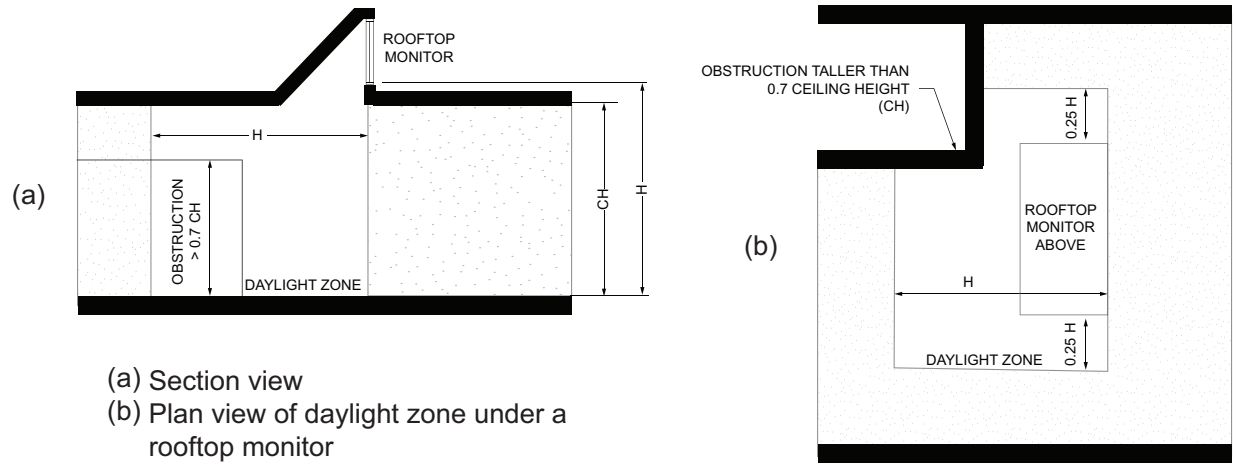


FIGURE C405.2.4.2(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

FIGURE C405.2.4.2(3)
DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR

6. The visible transmittance of the fenestration is not less than 0.20.
7. The projection factor (determined in accordance with Equation 4-5) for any overhanging projection that is shading the fenestration is not greater than 1.0 for fenestration oriented 45 degrees or less from true north and not greater than 1.5 for all other orientations.

C405.2.4.3 Toplit daylight zone. The *toplit daylight* zone is the floor area underneath a roof fenestration assembly that complies with all of the following:

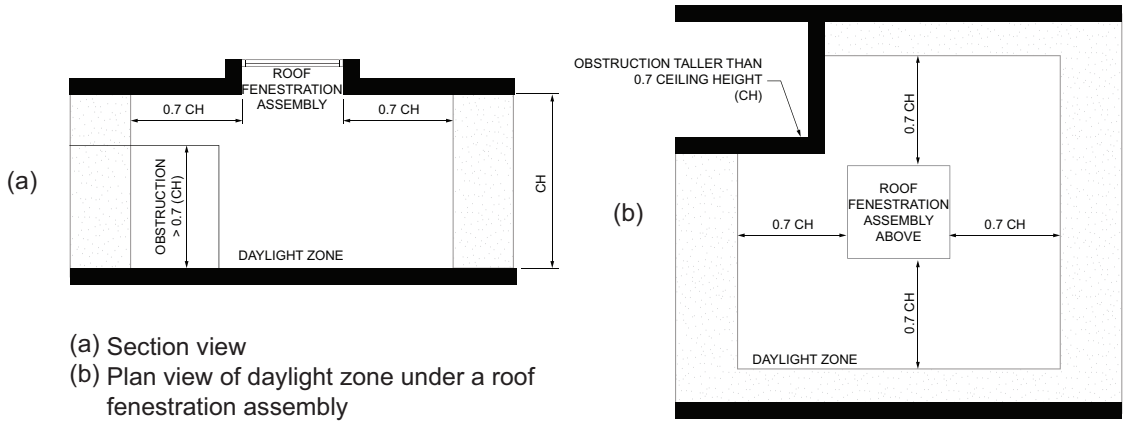
1. The *toplit daylight* zone shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.7 times the ceiling height, whichever is less, as indicated in Figure C405.2.4.3.
2. Direct sunlight is not blocked from hitting the roof fenestration assembly at the peak solar angle on the summer solstice by buildings or geological formations.
3. The product of the visible transmittance of the roof fenestration assembly and the area of the rough opening of the roof fenestration assembly divided by the area of the *toplit* zone is not less than 0.008.

C405.2.4.4 Atriums. Daylight zones at atrium spaces shall be established at the top floor surrounding the atrium and at the floor of the atrium space, and not on intermediate floors, as indicated in Figure C405.2.4.4.

C405.2.5 Specific application controls. Specific application controls shall be provided for the following:

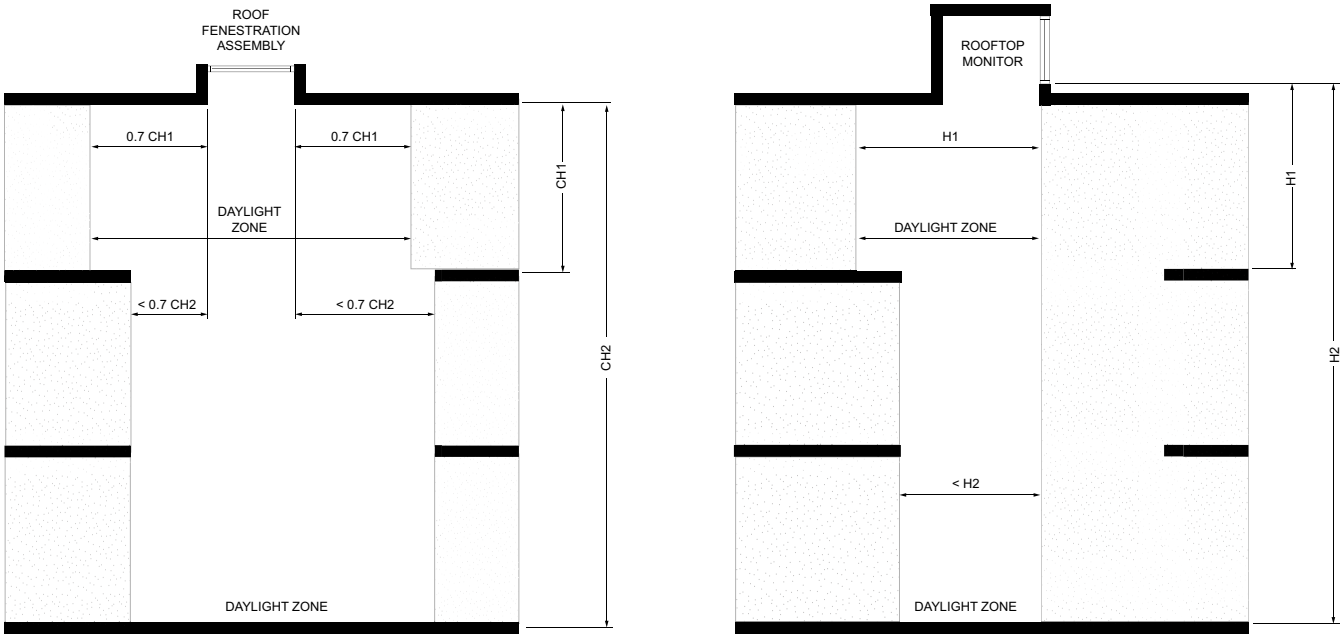
1. The following lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a time-switch control complying with Section C405.2.2.1. In addition, a manual control shall be provided to control such lighting separately from the general lighting in the space:
   1.1. Luminaires for which additional lighting power is claimed in accordance with Section C405.3.2.2.1.
   1.2. Display and accent.
   1.3. Lighting in display cases.
   1.4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.
   1.5. Lighting equipment that is for sale or demonstration in lighting education.
   1.6. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting.
2. *Sleeping units* shall have control devices or systems that are configured to automatically switch off all permanently installed luminaires and switched receptacles within 20 minutes after all occupants have left the unit.

   Exceptions:
   1. Lighting and switched receptacles controlled by card key controls.
   2. Spaces where patient care is directly provided.
   3. Permanently installed luminaires within *dwelling units* shall be provided with controls complying with Section C405.2.1.1 or C405.2.3.1.
3. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a time switch control complying with Section C405.2.2.1 that is independent of the controls for other lighting within the room or space.
4. Task lighting for medical and dental purposes that is in addition to *general lighting* shall be provided with a *manual control*.



(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

FIGURE C405.2.4.3
TOPLIT DAYLIGHT ZONE



(a) Section view of roof fenestration assembly at atrium

(b) Section view of roof monitor at atrium

C405.2.4.4
DAYLIGHT ZONES AT A MULTISTORY ATRIUM

C405.2.6 Manual controls. Where required by this code, manual controls for lights shall comply with the following:

1. They shall be in a location with *ready access* to occupants.
2. They shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

C405.2.7 Exterior lighting controls. Exterior lighting systems shall be provided with controls that comply with Sections C405.2.7.1 through C405.2.7.4.

Exceptions:

1. Lighting for covered vehicle entrances and exits from buildings and parking structures where required for eye adaptation.
2. Lighting controlled from within dwelling units.

C405.2.7.1 Daylight shutoff. Lights shall be automatically turned off when daylight is present and satisfies the lighting needs.

C405.2.7.2 Building facade and landscape lighting. Building façade and landscape lighting shall automatically shut off from not later than 1 hour after business closing to not earlier than 1 hour before business opening.

C405.2.7.3 Lighting setback. Lighting that is not controlled in accordance with Section C405.2.7.2 shall comply with the following:

1. Be controlled so that the total wattage of such lighting is automatically reduced by not less than

50 percent by selectively switching off or dimming luminaires at one of the following times:

1.1. From not later than midnight to not earlier than 6 a.m.

1.2. From not later than one hour after business closing to not earlier than one hour before business opening.

1.3. During any time where activity has not been detected for 15 minutes or more.

2. Luminaires serving outdoor parking areas and having a rated input wattage of greater than 78 watts and a mounting height of 24 feet (7315 mm) or less above the ground shall be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent during any time where activity has not been detected for 15 minutes or more. Not more than 1,500 watts of lighting power shall be controlled together.

C405.2.7.4 Exterior time-switch control function. Time-switch controls for exterior lighting shall comply with the following:

1. They shall have a clock capable of being programmed for not fewer than 7 days.
2. They shall be capable of being set for seven different day types per week.
3. They shall incorporate an automatic holiday setback feature.
4. They shall have program backup capabilities that prevent the loss of program and time settings for a period of not less than 10 hours in the event that power is interrupted.

C405.2.8 Parking garage lighting control. Parking garage lighting shall be controlled by an *occupant sensor* complying with Section C405.2.1.1 or a *time-switch control* complying with Section C405.2.2.1. Additional lighting controls shall be provided as follows:

1. Lighting power of each luminaire shall be automatically reduced by not less than 50 percent when there is no activity detected within a lighting zone for 20 minutes. Lighting zones for this requirement shall be not greater than 3,600 square feet.

   Exception: Lighting zones provided with less than 1.5 footcandles of illumination on the floor at the darkest point with all lights on are not required to have automatic light-reduction controls.

2. Where lighting for eye adaptation is provided at covered vehicle entrances and exits from buildings and parking structures, such lighting shall be separately controlled by a device that automatically reduces lighting power by at least 50 percent from sunset to sunrise.
3. The power to luminaires within 20 feet (6096 mm) of perimeter wall openings or fenestration shall automatically reduce in response to daylight by at least 50 percent.

   Exceptions:

   1. Where the opening-to-wall-ratio is less than 40 percent as viewed from the interior and encompasses the vertical distance from the driving surface to the lowest structural element.
   2. Where the distance from the opening to any exterior daylight blocking obstruction is less than one-half the height from the bottom of the opening or fenestration to the top of the obstruction.
   3. Where openings are obstructed by permanent screens or architectural elements restricting daylight entering the interior space.

C405.3 Interior lighting power requirements. A building complies with this section where its total connected interior lighting power calculated under Section C405.3.1 is not greater than the interior lighting power allowance calculated under Section C405.3.2.

C405.3.1 Total connected interior lighting power. The total connected interior lighting power shall be determined in accordance with Equation 4-9.

$$TCLP = [LVL + BLL + LED + TRK + \text{Other}] \quad \textbf{(Equation 4-9)}$$

where:

TCLP = Total connected lighting power (watts).

LVL = For luminaires with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp.

BLL = For luminaires incorporating a ballast or transformer, the rated input wattage of the ballast or transformer when operating that lamp.

LED = For light-emitting diode luminaires with either integral or remote drivers, the rated wattage of the luminaire.

TRK = For lighting track, cable conductor, rail conductor, and plug-in busway systems that allow the addition and relocation of luminaires without rewiring, the wattage shall be one of the following:

1. The specified wattage of the luminaires, but not less than 8 W per linear foot (25 W/lin m).
2. The wattage limit of the permanent current-limiting devices protecting the system.
3. The wattage limit of the transformer supplying the system.

Other = The wattage of all other luminaires and lighting sources not covered previously and associated with interior lighting verified by data supplied by the manufacturer or other *approved* sources.

The connected power associated with the following lighting equipment and applications is not included in calculating total connected lighting power.

1. Television broadcast lighting for playing areas in sports arenas.
2. Emergency lighting automatically off during normal building operation.
3. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
4. Casino gaming areas.
5. Mirror lighting in dressing rooms.
6. Task lighting for medical and dental purposes that is in addition to general lighting.
7. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting.
8. Lighting for theatrical purposes, including performance, stage, film production and video production.
9. Lighting for photographic processes.
10. Lighting integral to equipment or instrumentation and installed by the manufacturer.
11. Task lighting for plant growth or maintenance.
12. Advertising signage or directional signage.
13. Lighting for food warming.
14. Lighting equipment that is for sale.
15. Lighting demonstration equipment in lighting education facilities.
16. Lighting approved because of safety considerations.
17. Lighting in retail display windows, provided that the display area is enclosed by ceiling-height partitions.
18. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff.
19. Exit signs.
20. Antimicrobial lighting used for the sole purpose of disinfecting a space.

C405.3.2 Interior lighting power allowance. The total interior lighting power allowance (watts) for an entire building shall be determined according to Table C405.3.2(1) using the Building Area Method, or Table C405.3.2(2) using the Space-by-Space Method. The interior lighting power allowance for projects that involve only portions of a building shall be determined according to Table C405.3.2(2) using the Space-by-Space Method. Buildings with unfinished spaces shall use the Space-by-Space Method.

TABLE C405.3.2(1)
INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (w/ft^2)
Automotive facility	0.64
Convention center	0.64
Courthouse	0.74
Dining: bar lounge/leisure	0.69
Dining: cafeteria/fast food	0.66
Dining: family	0.61
Dormitory[a, b]	0.52
Exercise center	0.65
Fire station[a]	0.50
Gymnasium	0.65
Health care clinic	0.68
Hospital[a]	0.86
Hotel/Motel[a, b]	0.53
Library	0.70
Manufacturing facility	0.60
Motion picture theater	0.44
Multifamily[c]	0.45
Museum	0.55
Office	0.62
Parking garage	0.12
Penitentiary	0.65
Performing arts theater	0.82
Police station	0.64
Post office	0.62
Religious building	0.66
Retail	0.78
School/university	0.65
Sports arena	0.73
Town hall	0.67
Transportation	0.50
Warehouse	0.41
Workshop	0.83

For SI: 1 watt per square foot = 10.76 W/m^2.

a. Where sleeping units are excluded from lighting power calculations by application of Section C405.1.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

b. Where dwelling units are excluded from lighting power calculations by application of Section C405.1.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

c. Where dwelling units are excluded from lighting power calculations by application of Section C405.1.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units shall be counted. Where dwelling units are included in the lighting power calculations, only the area served by hardwired lighting shall be included.

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq ft)
Atrium	
Less than 40 feet in height	0.41
Greater than 40 feet in height	0.51
Audience seating area	
In an auditorium	0.57
In a convention center	0.65
In a gymnasium	0.23
In a motion picture theater	0.27
In a penitentiary	0.56
In a performing arts theater	1.10
In a religious building	0.72
In a sports arena	0.27
Otherwise	0.23
Banking activity area	0.56
Breakroom (See Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	0.74
Otherwise	0.71
Computer room	0.75
Conference/meeting/multipurpose room	0.88
Confinement cells	0.51
Copy/print room	0.31
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.71
In a hospital	0.61
In a manufacturing facility	0.28
In a primary or secondary school (and not used primarily by the staff)	0.71
Otherwise	0.41
Courtroom	1.06
Dining area	
In bar/lounge or leisure dining	0.62
In cafeteria or fast food dining	0.36
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.22
In family dining	0.52
In a penitentiary	0.35
Otherwise	0.42
Dwelling unit	0.43
Electrical/mechanical room	0.39
Emergency vehicle garage	0.41

(continued)

TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/sq ft)
Food preparation area	0.92
Guestroom[c, d]	0.41
Laboratory	
In or as a classroom	1.04
Otherwise	1.21
Laundry/washing area	0.43
Loading dock, interior	0.51
Lobby	
For an elevator	0.52
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.44
In a hotel	0.48
In a motion picture theater	0.20
In a performing arts theater	0.82
Otherwise	0.80
Locker room	0.43
Lounge/breakroom	
In a healthcare facility	0.42
Otherwise	0.44
Office	
Enclosed	0.73
Open plan	0.56
Parking area, interior	0.11
Pharmacy area	1.23
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	0.96
Otherwise	0.63
Sales area	0.85
Seating area, general	0.21
Stairway (see Space containing stairway)	
Stairwell	0.47
Storage room	0.38
Vehicular maintenance area	0.53
Workshop	1.09
BUILDING TYPE SPECIFIC SPACE TYPES[a]	**LPD (watts/sq ft)**
Automotive (see Vehicular maintenance area)	
Convention Center—exhibit space	0.50
Dormitory—living quarters[c, d]	0.43
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	0.58
In a recreation room (and not used primarily by the staff)	1.20
Fire Station—sleeping quarters[c]	0.19
Gymnasium/fitness center	
In an exercise area	0.50
In a playing area	0.75

TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/sq ft)
Healthcare facility	
In control room (MRI/CT/radiology/PET)	0.78
In an exam/treatment room	1.16
In an imaging room	0.94
In a medical supply room	0.54
In a nursery	0.87
In a nurse's station	0.75
In an operating room	1.87
In a patient room[c]	0.45
In a physical therapy room	0.82
In a recovery room	0.89
Library	
In a reading area	0.77
In the stacks	1.18
Manufacturing facility	
In a detailed manufacturing area	0.75
In an equipment room	0.61
In an extra-high-bay area (greater than 50′ floor-to-ceiling height)	0.73
In a high-bay area (25-50′ floor-to-ceiling height)	0.58
In a low-bay area (less than 25′ floor-to-ceiling height)	0.61
Museum	
In a general exhibition area	0.31
In a restoration room	0.77
Performing arts theater—dressing room	0.35
Post office—sorting area	0.66
Religious buildings	
In a fellowship hall	0.50
In a worship/pulpit/choir area	0.75
Retail facilities	
In a dressing/fitting room	0.45
In hair care salon	0.65
In nail care salon	0.75
In massage clinic	0.81
In a mall concourse	0.57
Sports arena—playing area	
For a Class I facility[e]	2.26
For a Class II facility[f]	1.45
For a Class III facility[g]	1.08
For a Class IV facility[h]	0.72

(continued)

TABLE C405.3.2(2)—continued
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/sq ft)
Transportation facility	
In a baggage/carousel area	0.28
In an airport concourse	0.25
At a terminal ticket counter	0.40
Warehouse—storage area	
For medium to bulky, palletized items	0.33
For smaller, hand-carried items	0.69

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 10.76 W/m^2.

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply
b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support, or people with special visual needs.
c. Where sleeping units are excluded from lighting power calculations by application of Section C405.1.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.
d. Where dwelling units are excluded from lighting power calculations by application of Section C405.1.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.
e. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.
f. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high-school facilities with seating for more than 2,000 spectators.
g. Class III facilities consist of club, amateur league, and high-school facilities with seating for 2,000 or fewer spectators.
h. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high-school facilities without provision for spectators.

C405.3.2.1 Building Area Method. For the Building Area Method, the interior lighting power allowance is calculated as follows:

1. For each building area type inside the building, determine the applicable building area type and the allowed lighting power density for that type from Table C405.3.2(1). For building area types not listed, select the building area type that most closely represents the use of that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type.
2. Determine the floor area for each building area type listed in Table C405.3.2(1) and multiply this area by the applicable value from Table C405.3.2(1) to determine the lighting power (watts) for each building area type.
3. The total interior lighting power allowance (watts) for the entire building is the sum of the lighting power from each building area type.

C405.3.2.2 Space-by-Space Method. Where a building has unfinished spaces, the lighting power allowance for the unfinished spaces shall be the total connected lighting power for those spaces, or 0.2 watts per square

Space Method, the interior lighting power allowance is calculated as follows:

1. For each space enclosed by partitions that are not less than 80 percent of the ceiling height, determine the applicable space type from Table C405.3.2(2). For space types not listed, select the space type that most closely represents the proposed use of the space. Where a space has multiple functions, that space may be divided into separate spaces.
2. Determine the total floor area of all the spaces of each space type and multiply by the value for the space type in Table C405.3.2(2) to determine the lighting power (watts) for each space type.
3. The total interior lighting power allowance (watts) shall be the sum of the lighting power allowances for all space types.

C405.3.2.2.1 Additional interior lighting power. Where using the Space-by-Space Method, an increase in the interior lighting power allowance is permitted for specific lighting functions. Additional power shall be permitted only where the specified lighting is installed and controlled in accordance with Section C405.2.5. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted in the following cases:

1. For lighting equipment to be installed in sales areas specifically to highlight merchandise, the additional lighting power shall be determined in accordance with Equation 4-10.

   Additional interior lighting power allowance = 1000 W + (Retail Area 1 × 0.45 W/ft^2) + (Retail Area 2 × 0.45W/ft^2) + (Retail Area 3 × 1.05 W/ft^2) + (Retail Area 4 × 1.87 W/ft^2)

   For SI units:

   Additional interior lighting power allowance = 1000 W + (Retail Area 1 × 4.8 W/m^2) + (Retail Area 2 × 4.84 W/m^2) + (Retail Area 3 × 11 W/m^2) + (Retail Area 4 × 20 W/m^2)

   (Equation 4-10)

   where:

   Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

   Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.

   Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.

   Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

   Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the *code official.*

2. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance or for highlighting art or exhibits, provided that the additional lighting power shall be not more than 0.9 W/ft^2 (9.7 W/m^2) in lobbies and not more than 0.75 W/ft^2 (8.1 W/m^2) in other spaces.

C405.4 Horticultural lighting. Not less than 95 percent of the permanently installed luminaires for *horticultural lighting* shall have a *photosynthetic photon* of not less than 1.7 µmol/J in *greenhouses* and not less than 1.9 umol/J for all other horticultural lighting. Luminaires for horticultural lighting shall be controlled by a device that that can be programmed to turn on at specific times and that can automatically turn off the luminaire when sufficient daylight is available.

C405.5 Exterior lighting power requirements. The total connected exterior lighting power calculated in accordance with Section C405.5.1 shall not be greater than the exterior lighting power allowance calculated in accordance with Section C405.5.2.

C405.5.1 Total connected exterior building exterior lighting power. The total exterior connected lighting power shall be the total maximum rated wattage of all lighting that is powered through the energy service for the building.

Exception: Lighting used for the following applications shall not be included.

1. Lighting *approved* because of safety considerations.
2. Emergency lighting automatically off during normal business operation.
3. Exit signs.
4. Specialized signal, directional and marker lighting associated with transportation.
5. Advertising signage or directional signage.
6. Integral to equipment or instrumentation and installed by its manufacturer.
7. Theatrical purposes, including performance, stage, film production and video production.
8. Athletic playing areas.
9. Temporary lighting.
10. Industrial production, material handling, transportation sites and associated storage areas.
11. Theme elements in theme/amusement parks.
12. Used to highlight features of art, public monuments, and the national flag.

13. Lighting for water features and swimming pools.
14. Lighting controlled from within dwelling units, where the lighting complies with Section C405.1.1.

C405.5.2 Exterior lighting power allowance. The exterior lighting power allowance (watts) is calculated as follows:

1. Determine the Lighting Zone (LZ) for the building according to Table C405.5.2(1), unless otherwise specified by the code official.
2. For each exterior area that is to be illuminated by lighting that is powered through the energy service for the building, determine the applicable area type from Table C405.5.2(2). For area types not listed, select the area type that most closely represents the proposed use of the area.
3. Determine the total area or length of each area type and multiply by the value for the area type in Table C405.5.2(2) to determine the lighting power (watts) allowed for each area type.
4. The total exterior lighting power allowance (watts) is the sum of the base site allowance determined according to Table C405.5.2(2), plus the watts from each area type.

TABLE C405.5.2(1)
EXTERIOR LIGHTING ZONES

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

C405.5.2.1 Additional exterior lighting power. Additional exterior lighting power allowances are available for the specific lighting applications listed in Table C405.5.2(3). These additional power allowances shall be used only for the luminaires serving these specific applications and shall not be used to increase any other lighting power allowance.

C405.5.3 Gas lighting. Gas-fired lighting is prohibited.

C405.6 Dwelling electrical meter. Each dwelling unit located in a *Group R*-2 building shall have a separate electrical meter.

C405.7 Electrical transformers. Low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.7 as tested and rated in accordance with the test procedure listed in DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

Exceptions: The following transformers are exempt:

1. Transformers that meet the *Energy Policy Act of 2005* exclusions based on the DOE 10 CFR 431 definition of special purpose applications.
2. Transformers that meet the *Energy Policy Act of 2005* exclusions that are not to be used in general purpose applications based on information provided in DOE 10 CFR 431.
3. Transformers that meet the *Energy Policy Act of 2005* exclusions with multiple voltage taps where the highest tap is not less than 20 percent more than the lowest tap.
4. Drive transformers.
5. Rectifier transformers.
6. Auto-transformers.
7. Uninterruptible power system transformers.
8. Impedance transformers.
9. Regulating transformers.
10. Sealed and nonventilating transformers.
11. Machine tool transformers.
12. Welding transformers.
13. Grounding transformers.
14. Testing transformers.

C405.8 Electric motors. Electric motors shall meet the minimum efficiency requirements of Tables C405.8(1) through C405.8(4) when tested and rated in accordance with the DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the motor manufacturer.

Exception: The standards in this section shall not apply to the following exempt electric motors:

1. Air-over electric motors.
2. Component sets of an electric motor.
3. Liquid-cooled electric motors.
4. Submersible electric motors.
5. Inverter-only electric motors.

C405.9 Vertical and horizontal transportation systems and equipment. Vertical and horizontal transportation systems and equipment shall comply with this section.

C405.9.1 Elevator cabs. For the luminaires in each elevator cab, not including signals and displays, the sum of the lumens divided by the sum of the watts shall be not less than 35 lumens per watt. Ventilation fans in elevators that do not have their own air-conditioning system shall not consume more than 0.33 watts/cfm at the maximum rated speed of the fan. Controls shall be provided that will de-energize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

TABLE C405.5.2(2)
LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

	LIGHTING ZONES			
	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance	160 W	280 W	400 W	560 W
Uncovered Parking Areas				
Parking areas and drives	0.015 W/ft^2	0.026 W/ft^2	0.037 W/ft^2	0.052 W/ft^2
Building Grounds				
Walkways and ramps less than 10 feet wide	0.50 W/linear foot	0.50 W/linear foot	0.55 W/linear foot	0.60 W/linear foot
Walkways and ramps 10 feet wide or greater, plaza areas, special feature areas	0.10 W/ft^2	0.10 W/ft^2	0.11 W/ft^2	0.14 W/ft^2
Plaza areas	0.028 W/ft^2	0.049 W/ft^2	0.070 W/ft^2	0.098 W/ft^2
Roof terraces and special features	0.04 W/ft^2	0.07 W/ft^2	0.10 W/ft^2	0.140 W/ft^2
Dinning areas	0.156 W/ft^2	0.273 W/ft^2	0.39 W/ft^2	0.546 W/ft^2
Stairways	0.60 W/ft^2	0.70 W/ft^2	0.70 W/ft^2	0.70 W/ft^2
Pedestrian tunnels	0.063 W/ft^2	0.11 W/ft^2	0.14 W/ft^2	0.21 W/ft^2
Landscaping	0.014 W/ft^2	0.025 W/ft^2	0.036 W/ft^2	0.04 W/ft^2
Building Entrances and Exits				
Pedestrian and vehicular entrances and exits	5.6 W/linear foot of opening	9.8 W/linear foot of opening	14 W/linear foot of opening	19.6 W/linear foot of opening
Entry canopies	0.072 W/ft^2	0.126 W/ft^2	0.18 W/ft^2	0.252 W/ft^2
Loading docks	0.104 W/ft^2	0.182 W/ft^2	0.260 W/ft^2	0.35 W/ft^2
Sales Canopies				
Free-standing and attached	0.20 W/ft^2	0.35 W/ft^2	0.50 W/ft^2	0.70 W/ft^2
Outdoor Sales				
Open areas (including vehicle sales lots)	0.072 W/ft^2	0.126 W/ft^2	0.180 W/ft^2	0.252 W/ft^2
Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	7 W/linear foot	7 W/linear foot	14.4 W/linear foot

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m^2.
W = watts.

TABLE C405.5.2(3)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

LIGHTING ZONES				
	Zone 1	Zone 2	Zone 3	Zone 4
Building façades	No allowance	0.075 W/ft^2 of gross above-grade wall area or 1.8 W/linear ft of façades length	0.113 W/ft^2 of gross above-grade wall area or 2.7 W/linear ft of façades length	0.15 W/ft^2 of gross above-grade wall area or 3.6 W/linear ft of façades length
Automated teller machines (ATM) and night depositories	90 W per location plus 35 W per additional ATM per location			
Uncovered entrances and gatehouse inspection stations at guarded facilities	0.144 W/ft^2	0.252 W/ft^2	0.36 W/ft^2	0.504 W/ft^2
Uncovered loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.104 W/ft^2	0.182 W/ft^2	0.260 W/ft^2	0.364 W/ft^2
Drive-through windows and doors	53 W per drive-through	92 W per drive-through	132 W per drive-through	185 W per drive-through
Parking near 24-hour retail entrances	80 W per main entry	140 W per main entry	200 W per main entry	280 W per main entry
For areas that are not listed in the table or are not comparable to areas listed in the table, use the comparable interior space type from Table C405.3.2(2) as modified by the factor in this row.	22% of the interior lighting power allowance value	39% of the interior lighting power allowance value	55% of the interior lighting power allowance value	77% of the interior lighting power allowance value
Uncovered entrances and gatehouse inspection stations at guarded facilities	0.50 W/ft^2 of area			
Uncovered loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	0.35 W/ft^2 of area			
Drive-up windows and doors	200 W per drive through			
Parking near 24-hour retail entrances.	400 W per main entry			

For SI: 1 watt per square foot = W/0.0929 m^2.
W = watts.

TABLE C405.7
MINIMUM NOMINAL EFFICIENCY LEVELS FOR 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

SINGLE-PHASE TRANSFORMERS		THREE-PHASE TRANSFORMERS	
kVA[a]	Efficiency (%)[b]	kVA[a]	Efficiency (%)[b]
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02
333	98.90	500	99.14
—	—	750	99.23
—	—	1000	99.28

a. kiloVolt-Amp rating.
b. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

TABLE C405.8(1)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN A, NEMA DESIGN B, AND *IEC DESIGN N MOTORS* (EXCLUDING FIRE PUMP) ELECTRIC MOTORS AT 60 HZ[a, b]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250 (186)	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300 (224)	95.8	95.4	96.2	95.8	95.8	95.8	—	—
350 (261)	95.8	95.4	96.2	95.8	95.8	95.8	—	—
400 (298)	95.8	95.8	96.2	95.8	—	—	—	—
450 (336)	95.8	96.2	96.2	96.2	—	—	—	—
500 (373)	95.8	96.2	96.2	96.2	—	—	—	—

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.8(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN C AND *IEC DESIGN H MOTORS* AT 60 HZ[a, b]

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	96.2	95.8	95.8	95.4	94.5	94.1

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.8(3)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25	—	65.6	69.5	67.5
0.33	—	69.5	73.4	71.4
0.50	—	73.4	78.2	75.3
0.75	—	76.8	81.1	81.7
1	—	77.0	83.5	82.5
1.5	—	84.0	86.5	83.8
2	—	85.5	86.5	N/A
3	—	85.5	86.9	N/A

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

TABLE C405.8(4)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR
CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS[a]

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25	—	66.6	68.5	62.2
0.33	—	70.5	72.4	66.6
0.50	—	72.4	76.2	76.2
0.75	—	76.2	81.8	80.2
1	—	80.4	82.6	81.1
1.5	—	81.5	83.8	N/A
2	—	82.9	84.5	N/A
3	—	84.1	N/A	N/A

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

C405.9.2 Escalators and moving walks. Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls that reduce speed as permitted in accordance with ASME A17.1/CSA B44 and applicable local code.

Exception: A variable voltage drive system that reduces operating voltage in response to light loading conditions is an alternative to the reduced speed function.

C405.9.2.1 Energy recovery. Escalators shall be designed to recover electrical energy when resisting overspeed in the down direction. The escalator shall be designed to recover, on average, more power than is consumed by the power recovery feature of its motor controller system.

C405.10 Voltage drop. The total *voltage drop* across the combination of customer-owned service conductors, feeder conductors and branch circuit conductors shall not exceed 5 percent.

C405.11 Automatic receptacle control. The following shall have automatic receptacle control complying with Section C405.11.1:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in enclosed offices, conference rooms, rooms used primarily for copy or print functions, breakrooms, classrooms, and individual workstations, including those installed in modular partitions and module office workstation systems.
2. At least 25 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

C405.11.1 Automatic receptacle control function. Automatic receptacle controls shall comply with the following:

1. Either split controlled receptacles shall be provided with the top receptacle controlled, or a controlled receptacle shall be located within 12 inches (304.8 mm) of each uncontrolled receptacle.
2. One of One of the following methods shall be used to provide control:
   2.1. A scheduled basis using a time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building of not more than 5,000 square feet (464.5 m2) and not more than one floor. The occupant shall be able to manually override an area for not more than 2 hours. Any individual override switch shall control the receptacles of not more than 5,000 feet (1524 m).
   2.2. An occupant sensor control that shall turn off receptacles within 20 minutes of all occupants leaving a space.
   2.3. An automated signal from another control or alarm system that shall turn off receptacles within 20 minutes after determining that the area is unoccupied.
3. All controlled receptacles shall be permanently marked in accordance with NFPA 70 and be uniformly distributed throughout the space.
4. Plug-in devices shall not comply.

Exceptions: Automatic receptacle controls are not required for the following:

1. Receptacles specifically designated for equipment requiring continuous operation (24 hours per day, 365 days per year).
2. Spaces where an automatic control would endanger the safety or security of the room or building occupants.
3. Within a single modular office workstation, noncontrolled receptacles are permitted to be located more than 12 inches (304.8 mm), but not more than 72 inches (1828 mm) from the controlled receptacles serving that workstation.

C405.12 Energy Monitoring. New buildings with a gross *conditioned floor area* of 25,000 square feet (2322 m2) or larger shall be equipped to measure, monitor, record, and report energy consumption data in compliance with Sections C405.12.1 through C405.12.5.

Exception: R-2 occupancies and individual tenant spaces are not required to comply with this section provided that the space has its own utility services and meters and has less than 5,000 square feet (464.5 m2) of *conditioned floor area*.

C405.12.1 Electrical energy metering. For all electrical energy supplied to the building and its associated site, including but not limited to site lighting, parking, recreational facilities, and other areas that serve the building and its occupants, meters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C405.12.2.

C405.12.2 End-use metering categories. Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category indicated in Table C405.12.2. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the measured load for each of the end-use categories indicated in Table C405.12.2 shall be permitted to be from a load that is not within that category.

Exceptions:

1. HVAC and water heating equipment serving only an individual dwelling unit shall not require end-use metering.
2. End-use metering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.
3. End-use metering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 m^2) where a dedicated source meter complying with Section C405.12.3 is provided.

C405.12.3 Meters. Meters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section C405.12.4. Source meters shall be allowed to be any digital-type meter. Lighting, HVAC, or other building systems that can monitor their energy consumption shall be permitted instead of meters. Current sensors shall be permitted, provided that they have a tested accuracy of ±2 percent. Required metering systems and equipment shall have the capability to provide at least hourly data that is fully integrated into the data acquisition system and graphical energy report in accordance with Sections C405.12.4 and C405.12.5.

C405.12.4 Data acquisition system. A data acquisition system shall have the capability to store the data from the required meters and other sensing devices for a minimum of 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly, and yearly logged data for each end-use category required by Section C405.12.2.

TABLE C405.12.2
ENERGY USE CATEGORIES

LOAD CATGEROGY	DESCRIPTION OF ENERGY USE
Total HVAC system	Heating, cooling, and ventilation, including but not limited to fans, pumps, boilers, chillers, and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use.
Interior lighting	Lighting systems located within the building.
Exterior lighting	Lighting systems located on the building site but not within the building.
Plug loads	Devices, appliances, and equipment connected to convenience receptacle outlets.
Process load	Any single load that is not included in an HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including, but not limited to data centers, manufacturing equipment and commercial kitchens.
Building operations and other miscellaneous loads	The remaining loads not included elsewhere in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, ornamental fireplaces, swimming pools, in-ground spas, and snow-melt systems.
Electric Vehicle Charging	Loads associated with charging an electric vehicle.
Solar Production	Energy produced from on-site renewable energy system

C405.12.5 Graphical energy report. A permanent and readily accessible reporting mechanism shall be provided in the building that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the energy consumption for each end-use category required by Section C405.12.2 at least every hour, day, month, and year for the previous 36 months.

C405.13 Electric vehicle (EV) charging for new construction. The building shall be provided with electric vehicle (EV) charging in accordance with this section and the *National Electrical Code* (NFPA 70). Where parking spaces are added or modified without an increase in building size, only the new parking spaces are subject to this requirement. The number of required *EVSE installed spaces*, *EV ready spaces*, *EV capable spaces*, and *EV capable light spaces* shall be determined based on the total number of provided vehicle parking spaces or the number of vehicle parking spaces required under Section 9-9-6, "Parking Standards," B.R.C. 1981 prior to any approved parking reductions.

C405.13.1 Group R occupancies. Group R occupancies with three or more *dwelling units* and/or *sleeping units*

shall be provided with EV charging in accordance with Table C405.13.1. Calculations for the number of spaces shall be rounded up to the nearest whole number. The following substitutions shall be applicable:

1. R-2 Occupancies shall be permitted to substitute a *DCFC EVSE* for up to 5 spaces.
2. All attached garages with direct connection to a dwelling unit shall have one *EV ready* space.
3. When spaces exceed the minimum required for a specified space in Table C405.12.1, additional:
    a. *EVSE* installed spaces are permitted to be used to meet the minimum requirements for *EV ready spaces*, *EV capable spaces*, and *EV capable light spaces*.
    b. *EV ready* spaces are permitted to be used to meet the minimum requirements for *EV capable spaces* and *EV capable light spaces*.
    c. *EV-capable* spaces are permitted to be used to meet the minimum requirements for *EV-capable light spaces*.

TABLE C405.13.1
GROUP R OCCUPANCIES

# OF SPACES	NUMBER OF EVSE INSTALLED SPACES	NUMBER OF EV READY SPACES	NUMBER OF EV CAPABLE SPACES	NUMBER OF EV CAPABLE LIGHT SPACES
1–10	0	100%	0	0
> 10	5% of spaces (min. 1 dual port charging station)	15% of spaces	40% of spaces	40% of spaces

C405.13.2 Group A, B, E, I, M and S-2 occupancies. Group A, B, E, I, M and open or enclosed parking garages under an S-2 occupancy shall be provided with electric vehicle charging in accordance with Table C405.13.2. Calculations for the number of spaces shall be rounded up to the nearest whole number. The following substitutions shall be applicable:

1. Commercial buildings other than R-2 Occupancies shall be permitted to substitute a *DCFC EVSE* for up to 10 spaces.
2. When spaces exceed the minimum required for a specified space in Table C405.12.1, additional:
    a. *EVSE* installed spaces are permitted to be used to meet the minimum requirements for *EV ready spaces*, *EV capable spaces*, and *EV capable light spaces*.
    b. *EV ready* spaces are permitted to be used to meet the minimum requirements for *EV capable spaces* and *EV capable light spaces*.
    c. *EV-capable* spaces are permitted to be used to meet the minimum requirements for *EV-capable light spaces*.

TABLE C405.13.2
GROUP A, B, E, I, M AND S-2 OCCUPANCIES

# OF SPACES	NUMBER OF EVSE INSTALLED SPACES	NUMBER OF EV READY SPACES	NUMBER OF EV CAPABLE SPACES	NUMBER OF EV CAPABLE LIGHT SPACES
1–10	2 spaces	2 spaces	0	remaining spaces
> 10 including parking garages	5% of spaces (min. 1 dual port charging station)	10% of spaces	10% of spaces	20% of spaces*

*For parking garage, once spaces have been allocated, any remaining spaces in a parking garage shall, at a minimum, be *EV capable light spaces.*

C405.13.3 Identification. Construction documents shall designate all *EV capable light*, *EV capable spaces*, *EV ready spaces* and *EVSE installed spaces* and indicate the locations of conduit and termination points serving them. The circuits or spaces reserved for the circuits for *EV capable spaces*, *EV ready spaces*, and *EVSE installed spaces* shall be clearly identified in the panel or subpanel directory. The raceway and/or conduit for *EV capable light*, *EV capable* and *EV ready spaces* shall be clearly identified at both the panel or subpanel and the termination point at the parking space.

C405.13.4 EVSE installation. EVSE shall be installed in accordance with NFPA 70 and shall be listed and labeled in accordance with UL 2202 or UL 2594. When serving an accessible parking space, EVSE shall be accessible in accordance with City of Boulder Building Code, Chapter 11, Accessibility, and Section C405.13.5. EVSE shall meet all of the following requirements:

1. A power capacity of at least 8.3 kVa (or 40A at 208/240V) and has the ability to connect to the internet OR an inductive charging system for battery-powered electric vehicles that is ENERGY STAR certified and has the ability to connect to the internet.
2. An electric vehicle charging system shall be wall-mounted or pedestal style and may provide multiple cords to connect with *electric vehicles*.
3. An electric vehicle charging system shall be listed and labeled for EV charging and must comply with the current version of Article 625 of the National Electrical Code.

C405.13.4.1 EVSE minimum charging rate. Each installed EVSE shall comply with one of the following:

1. Be capable of charging at a minimum rate of 6.2 kVA (or 30A at 208/240V).
2. When serving multiple EVSE installed spaces and controlled by an energy management system providing load management, be capable of simultaneously sharing each EVSE installed space at a minimum charging rate of no less than 3.3 kVA.

C405.13.5 EV parking space requirements. Spaces designated for EVSE installed, EV ready, EV capable and EV

capable light shall meet the applicable requirements of Sections C405.13.5.1 through C405.13.5.4

C405.13.5.1 EVSE installed spaces. An installed EVSE with multiple output connections shall be permitted to serve multiple EVSE installed spaces. Each EVSE installed serving either a single EVSE installed space or multiple EVSE installed spaces, shall comply with all of the following:

1. Be installed in accordance with Section C405.13.4.
2. Be located within 3 feet of each EVSE installed space it serves.
3. Have a minimum circuit capacity of 8.3 kVA (40A 2 208/240V).

C405.13.5.2 EV Ready Spaces. Each EV ready space shall have a branch circuit that complies with all of the following:

1. Terminates at a receptacle or junction box located within 3 feet of each EV ready space it serves. EV ready includes two adjacent parking spaces if the receptacle is installed adjacent to and between both parking spaces.
2. Has a minimum circuit capacity of 8.3 kVA (40A 208/240V).
3. The electrical panel, electrical distribution equipment directory, and all outlets or enclosures shall be marked "For future electric vehicle supply equipment (EVSE)."

C405.13.5.3 EV Capable Spaces. Each EV capable space shall comply with all of the following:

1. A continuous raceway and/or conduit shall be installed between a suitable electrical panel or other electrical distribution equipment and terminate within 3 feet of the EV capable space and shall be capped. EV capable includes two adjacent parking spaces if the raceway and/or conduit terminates adjacent to and between both parking spaces.
2. The installed raceway and/or conduit shall be sized and rated to supply a minimum of 208 volts and a minimum of 40-ampere rated circuits.
3. The electrical panel or other electrical distribution equipment to which the raceway and/or conduit connects shall have sufficient dedicated space and spare electrical capacity to supply a minimum of 208 volts and a minimum of 40-ampere rated circuits.
4. The termination point of the conduit and/or raceway and the electrical distribution equipment directory shall be marked: "For future electric vehicle supply equipment (EVSE)."
5. Reserved capacity shall be no less than 8.3 kVA (40A 208/240V) for each EV capable space.

C405.13.5.4 EV Capable Light Spaces. Each EV capable light space shall comply with all of the following:

1. A continuous raceway and/or conduit shall be installed between a suitable electrical panel or other electrical distribution equipment and terminate within 3 feet of the EV capable light space and shall be capped. EV capable light includes two adjacent parking spaces if the raceway and/or conduit terminates adjacent to and between both parking spaces.
2. Installed raceway and/or conduit shall be sized and rated to supply a minimum of 208 volts and a minimum of 40-ampere rated circuits.
3. Dedicated physical space to accommodate all equipment necessary for electrical service to future EVSE.
4. The routing of the raceway and/or conduit must be noted on the construction documents and the raceway shall be permanently and visibly marked "EV CAPABLE" at the load center and termination point locations.

C405.13.6 Accessible parking. Where new *EVSE installed spaces* and/or new *EV ready spaces* and new accessible parking, as defined by the *City of Boulder Building Code*, Chapter 11, "Accessibility," are both provided, parking facilities shall be designed so that at least one accessible parking space shall be an *EV ready space* or *EVSE installed space*.

C405.13.7 Number and features of *universal vehicle charging spaces*. Where electric vehicle charging stations are provided for public use, the number of universal vehicle charging stations shall be provided in accordance with Table C405.13.5. Vehicle space size shall be 132 inches (3350 mm) minimum in width with an adjoining access aisle that is 60 inches (1525 mm) minimum in width. Additionally, the features of universal vehicle spaces and equipment shall comply with ICC A117.1 Sections 502.3 through 502.5, and Section 502.11, except that an *EVSE installed space* is permitted to be located at the end of the access aisle opposite the drive aisle.

Exception: For parking facilities of more than 100 total parking spaces, or 200 total parking spaces for Group I occupancies, the number of required universal vehicle charging stations may be reduced to 10 plus 5% of all required *EVSE installed spaces*. The total number of universal vehicle charging stations need not exceed 40.

TABLE C405.13.5
ELECTRIC VEHICLE CHARGING STATION FOR PUBLIC USE

NUMBER OF ELECTRIC VEHICLE CHARGING STATIONS REQUIRED	MINIMUM NUMBER OF UNIVERSAL VEHICLE CHARGING STATIONS
1	1
2 to 25	2
26 to 50	4
51 to 100	6
Over 100	8, plus 4 for each additional 200

C405.14 Solar Readiness. All newly constructed commercial buildings shall comply with the requirements of Sections C405.15 through C405.18.

C405.15 *Solar-ready zone*. Solar zones shall be clearly indicated on the construction documents.

C405.15.1 Location and size of solar zone. The *solar-ready zone* shall have a minimum total area described as follows. The *solar-ready zone* shall comply with access, pathway, smoke ventilation, and spacing requirements as specified in the Boulder Revised Code. The *solar-ready zone* total area shall be comprised of one or more rectangular areas. For sloped roofs each area must be not less than 200 square feet and no side of any rectangular area shall be less than 11 feet in length. For low-sloped or flat roofs, each area must be not less than 330 square feet, with a minimum length running generally north to south of 15' and a minimum length running generally east to west of 22' and no side of any rectangular area shall be less than 11 feet in length. The *solar-ready zone* shall be located on one or more of the following areas:

1. The roof or overhang of the building.
2. The roof or overhang of another structure located within 250 feet of the building on the same parcel or lot.
3. Covered parking installed with the building project.
4. A façade of the building that is within 15 degrees of true south.

The total *solar-ready zone* area shall not be less in size than an area that equals 40 percent of the total roof area, calculated as the horizontally projected gross roof area less the area covered by skylights, occupied roof decks, vegetative roof areas, and mandatory access or set back areas as required by the Boulder Revised Code. The following roof areas will be excluded when calculating the total roof area of the building:

1. Areas with a permanently installed on-site renewable energy systems that meets the following criteria:
    a. The system produces the energy output equivalent to covering 40 percent of the net roof area with solar photovoltaic calculated as the horizontally projected gross roof area less the area covered by skylights, occupied roof decks, vegetative roof areas, and mandatory access or set back areas as required by the Boulder Revised Code.
    b. The system is located on the roof or overhang of the building or on the roof or overhang of another structure located within 250 feet of the building, on the building premises, on covered parking, or another approved location installed with the building project and under the same property ownership
2. Roof areas where the annual solar access is less than 70 percent. For the purposes of this code, solar access means the ratio of solar insolation including shade to the solar insolation without shade. Shading from obstructions located on the roof or any other part of the building shall not be included in the determination of annual solar access.

    Exception: Solar zones are not required in buildings where the roof is designed and approved to be used for vehicular traffic or parking or for a heliport.

C405.15.2 Orientation. All sections of the solar zone located on steep sloped roofs shall be oriented between 110 degrees and 270 degrees of true north.

C405.15.3 Obstructions. No obstructions, including, but not limited to, vents, chimneys, architectural features, and roof-mounted equipment, shall be located in the solar zone. Any obstruction located on the roof or any other part of the building that projects above a solar zone shall be located at least twice the distance, measured in the horizontal plane, of the height difference between the highest point of the obstruction and the horizontal projection of the nearest point of the solar zone, measured in the vertical plane.

Exception: Any roof obstruction, located on the roof or any other part of the building, that is oriented north of all points on the solar zone.

C405.15.4 Roof loads and documentation. The structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

C405.16 Interconnection pathways. The construction documents shall indicate at least one potential pathway for routing of conduit and/or raceway from the solar-ready zone to the point of interconnection with the electrical service panel and electrical storage system area.

C405.17 Documentation. A copy of the construction documents or a comparable document indicating the information from Sections C405.15 and C405.16 shall be provided to and maintained by the building owner. The building owner shall provide a copy of the construction documents or a comparable document indicating the information from Sections C405.15 and C405.16 to any purchasers and subsequent owners of the building or any part thereof.

C405.18 Electrical services reserved space. The main electrical service panel shall have a minimum bus bar rating of not less than 200 amps. The main electrical service panel shall have reserved spaces to allow for the installation of double pole circuit breakers for a future solar electric installation and a double pole circuit breaker for future electrical storage system installation. The reserved spaces shall be positioned at the opposite (load) end from the input feeder location or main circuit location. The reserved spaces shall be permanently marked as “For Future Solar Electric and Storage.”. The minimum reserved amperage shall be determined from Table C405.18.

TABLE C405.18
MINIMUM RESERVED AMPERAGE
PER SQUARE FOOT OF PLANNED SOLAR AREA

INVERTER SYSTEM VOLTAGE	AMPERAGE PER SQUARE FOOT
120	0.125
240	0.063
208	0.042
277	0.054
480	0.018

C405.19 Electrical energy storage system-ready area. The building shall have an area allocated of not less than 2 feet (610 mm) in one dimension and 4 feet (1219 mm) in another dimension and located in accordance with Section 1207 of the *International Fire Code* for future installation of an energy storage system. The location and layout diagram of the electrical energy storage system-ready area shall be indicated on the construction documents.

C405.20 Electric ready. These provisions shall be applicable for all new buildings, additions and *first tenant finish* permits that utilize combustion equipment. In the event of a *first tenant finish* to a commercial *core* and *shell* building or unfinished space is credited towards meeting the requirements of this chapter, the *code official* shall not issue a certificate of occupancy to the tenant until the requirements of Section C405.20.1 or C405.20.2 have met as applicable.

C405.20.1 Commercial building less than 10,000 sq.ft. and all R-occupancies. Commercial buildings that have a gross floor area of less than 10,000 sq.ft., and all R-occupancies of any size, shall comply with Sections C405.20.1.1 through C405.20.1.5.

C405.20.1.1 Combustion equipment. Combustion equipment shall be provided with all of the following:

1. A dedicated, appropriately phased branch circuit sized to accommodate future electric equipment or appliances to serve a comparable capacity to meet the heating load.
2. An electric receptacle or junction box that meets the requirements of Section C405.20.1.1.5, and is connected to the electrical panel through the branch circuit. Each electrical receptacle or junction box shall have reasonable access to the combustion equipment or dedicated physical space for future electric equipment with no obstructions other than the current combustion equipment.
3. Where combustion equipment is used for space or water heating, dedicated space shall be provided for all future electric equipment including an electric resistance backup coil for ducted systems if applicable.

Exception: Buildings with installed air conditioning systems are not required to provide additional dedicated physical space for an outdoor heat pump.

C405.20.1.2 Electrical panel space. The electrical panel shall have reserved physical space for a minimum two-pole or three-pole circuit breaker for each branch circuit provided for future electric equipment or appliances. The physical space in the electrical panel for each circuit breaker shall be sized with sufficient breaker capacity to meet the electrical demand of the future electric equipment or appliance that is sized to serve a comparable capacity to meet the heating load.

C405.20.1.3 Labeling. The junction box or receptacle and the dedicated circuit breaker space serving future electric equipment or appliances in the electrical panel shall be labeled for their intended use.

C405.20.1.4 Adjacency. The electrical receptacle or junction box must be provided within 3 feet of the combustion equipment or appliances or within 3 feet of the dedicated physical space for future electric equipment or appliances.

Exception: For combustion equipment dedicated to space or water heating, the electrical receptacle or junction box shall be located not more than 6 feet from the combustion equipment or the dedicated physical space for future electric equipment.

C405.20.1.5 Condensate drain. Where combustion equipment dedicated to space heating and water heating is installed, a location shall be provided for condensate drainage.

C405.20.2 Commercial building 10,000 sq.ft. and greater excluding R-occupancies. Commercial buildings excluding R-occupancies that have a gross floor area greater than or equal to 10,000 sq.ft., shall comply with Sections C405.20.2.1 through C405.20.2.4.

C405.20.2.1 Combustion equipment and appliances. Combustion equipment shall be provided with all of the following:

1. A junction box that is located in the same physical space as the combustion equipment and is reasonably accessible, and that is connected to the electrical panel by continuous conduit and/or raceways.
2. Dedicated electrical panel space for an appropriately phased branch circuit sized to accommodate future electric equipment or appliances to serve a comparable capacity to meet the heating load.
3. Where *combustion equipment* is used for space and water heating, dedicated physical space shall be provided for all future electric equipment.

C405.20.2.2 Electrical panel space. The electrical panel shall have reserved physical space for a minimum two-pole or three-pole circuit breaker for each branch circuit provided for future electric equipment or appliances. The physical space in the electrical panel for each circuit breaker shall be sized with sufficient breaker capacity to meet the electrical demand of the future electric equipment or appliance that is sized to serve a comparable capacity to meet the heating load.

C405.20.2.3 Labeling. The dedicated circuit breaker space serving future electric equipment or appliances in

the electrical panel shall be labeled "For future electric equipment".

C405.20.2.4 Physical space. Dedicated physical space shall be provided for additional electric equipment, including but not limited to transformers and cabinets, necessary for electrical service to future electric equipment or appliances.

SECTION C406
ADDITIONAL CONSERVATION REQUIREMENTS

C406.1 Compliance. Section C406 establishes additional conservation requirements for buildings. Buildings shall comply as follows with the conservation requirements of this Section C406:

1. Buildings with greater than 2,000 square feet (186 m^2) shall comply with Section C406.1.1. Buildings over 25,000 square feet is required to choose a minimum of one measure from C406.3.
2. Build-out construction with greater than 1,000 square feet (93 m^2) conditioned floor area that does not have final lighting or final HVAC systems installed under a prior building permit shall comply with Section C406.1.1.1

Exceptions: Core and shell buildings where no less than 20 percent of the net floor area is without final lighting or final HVAC and that comply with all of the following:

1. Buildings with greater than 5,000 square feet (465 m^2) of conditioned floor area that comply with Section C406.1.1.
2. Portions of the building where the net floor area is without final lighting or final HVAC that comply with Section C406.1.1.1.
3. Portions of the building where the net floor area has final lighting and final HVAC systems that comply with Section C406.1.1.

C406.1.1 Additional conservation credit requirements. Buildings shall achieve the minimum building conservation credit requirements established in Table C406.1.1 for their occupancy type with measures from Section C406.2 or C406.3 or both sections. Where a building contains multiple occupancies, credits under Table C406.1.1 from each building occupancy type shall be weighted by the gross floor area of each type to determine the weighted average project energy credits required. Associated supporting occupancies shall be included with the primary occupancy group for purposes of Section C406.

Exceptions:

1. Unconditioned parking garages that achieve 50% of the credits required for occupancy types S-1 and S-2 in Table C406.1.1.
2. Portions of buildings devoted to manufacturing or industrial uses.

TABLE C406.1.1
BUILDING CONSERVATION CREDIT REQUIREMENTS BY OCCUPANCY TYPE

OCCUPANCY TYPE	MIXED FUEL BUILDING	ALL-ELECTRIC BUILDING*
R-2	105	65
I-2	58	18
B	98	58
A-2	87	47
M	87	62
E	92	42
S-1, S-2	97	57
All other	40	n/a

C406.1.1.1 New construction less than 5,000 square feet & building core/shell and initial build-out construction. Where separate permits are issued for new construction, core and shell buildings and build-out construction, compliance shall be in accordance with the following requirements:

1. New construction less than 5,000 square feet, core and shell buildings or portions of buildings initially built-out shall comply with one of the following:
   1.1. Where the scope of work includes a new or previously installed central HVAC system or service water heating system with chillers, heat pumps, boilers, or loop pumping systems with heat rejection, the project shall achieve at least 50 percent of the energy credits required in Table C406.1.1.
   1.2. Where the scope of work does not include those systems listed in 1.1 above, the project shall achieve at least 33 percent of the energy credits required in Table C406.1.1.
2. 5,0000 square feet, core and shell buildings or portions of buildings initially built-out, the energy credits achieved shall be subject to the following:
   2.1. Lighting measure credits shall be determined only for areas with final lighting installed.
   2.2. Where HVAC or service water heating systems are designed to serve the entire building, full HVAC or service water heating measure credits shall be achieved.
   2.3. Where HVAC or service water heating systems are designed to service individual areas, HVAC or service water heating measure credits achieved shall be reduced in proportion to the floor area

with final HVAC systems or final service water heating systems installed.

Exception: Buildings less than 2,000 square feet are exempt from these requirements.

C406.1.2 Conservation credits determination. Overall conservation credits achieved for the project shall be the sum of the conservation credits for individual measures included in the building. Credits are available for the measures listed in Section C406.2 and C406.3. Base energy credits are shown in Tables C406.2 and C406.3 based on building occupancy type. Conservation credits achieved shall be determined in one of three ways, depending on the measure:

1. The conservation credit shall be the base energy credit for the measure where no adjustment factor or formula is shown in the measure description in Section C406.2.
2. The conservation credit shall be the base energy credit for the measure adjusted by a factor or formula where an adjustment factor or formula is stated in the measure description in Section C406.2. Where adjustments are applied, each conservation credit shall be rounded to the nearest whole number.
3. The conservation credit shall be determined by direct formula as stated in the measure description in Section C406.2. Where the direct formula is applied, each individual measure credit shall be rounded to the nearest whole number.

C406.2 Additional conservation credit measures. Credits are available for the measures listed in this Section C406.2. Each conservation measure used to meet credit requirements for the project shall meet or exceed the requirements in Sections C402 through C405. Credit for measures installed in the project shall be determined by one of three approaches defined in C406.1.2.

Conservation credits required for the project shall be the sum of the individual conservation credit measures. Credits are available for the measures listed in section C406.2. Where a project contains multiple building occupancy types:

1. Credits achieved for each occupancy type shall be summed and then weighted by the floor area of each occupancy type to determine the weighted average project conservation credits achieved.
2. Credits for improved envelope efficiency and lighting reduction (L06) shall be determined for the building or permitted floor area as a whole. Credits for other measures shall be taken from applicable tables or calculations weighted by the building occupancy type floor area.

C406.2.1 More efficient building envelope. A project will achieve credits for improved envelope performance by complying with one or several of following measures:

1. Section C406.2.1.2, E02
2. Section C406.2.1.3, E03
3. Section C406.2.1.6, E06

C406.2.1.1 E01 Reserved.

C406.2.1.2 E02 Total UA envelope reduction. Credit will be achieved if the total UA of the building thermal envelope as designed is at least15 percent below the total UA of the building thermal envelope in accordance with Section C402.1.5.

C406.2.1.3 E03 Reduced air leakage. Credit will be achieved if the tested building air leakage is at least 15 percent lower than the maximum leakage permitted by Section C402.5 provided the building is tested in accordance with the applicable methods in Section C402.5.

C406.2.1.4 E04 Reserved.

C406.2.1.5 E05 Reserved.

C406.2.1.6 E06 Improved fenestration. Credit will be achieved if the energy performance characteristics of all vertical fenestration in the project meet the requirements in Table C406.2.1.6 and Section C406.2.1.3.

TABLE C406.2.1.6
IMPROVED FENESTRATION EFFICIENCY REQUIREMENTS

FENESTRATION METRIC	WINDOWS		ENTRANCE DOORS
	Fixed	Operable	
Maximum U-factor	0.31	0.38	0.54
Maximum SHGC[a]	0.34	0.28	0.33
Minimum VT[b]	0.41	0.41	0.41

a. *Solar Heat Gain Coefficient.*
b. *Visible Transmittance*.

C406.2.2 More efficient HVAC performance. To achieve credits for more efficient HVAC performance, all heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in tables referenced by Section C403.3.3. Where multiple efficiency requirements are listed, equipment shall meet the seasonal or part-load efficiencies, including SEER/ SEER2, EER/integrated energy efficiency ratio (IEER), integrated part load value (IPLV), or AFUE. Equipment that is larger than the maximum capacity range indicated in tables referenced by Section C403.3.3shall meet the efficiencies listed for the largest capacity for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve a project, the HVAC performance improvement of the project shall be the weighted average improvement based on individual system capacity. Projects will achieve HVAC efficiency credits for one or several of the following measures:

1. C406.2.2.2 H02
2. C406.2.2.3 H03
3. C406.2.2.4 H04
4. C406.2.2.5 H05

C406.2.2.1 H01. Reserved.

C406.2.2.2 H02 More efficient HVAC equipment heating performance. Credit for more efficient HVAC equipment heating performance will be achieved if at least 90 percent of the total HVAC capacity serving the total conditioned floor area of the entire building, or

TABLE C406.2
BASE CREDIT FOR ADDITIONAL CONSERVATION MEASURES

ID	ENERGY CREDIT MEASURE	SECTION	OCCUPANCY TYPE							
			R-2, R-4, and I-1	I-2	B	A-2	M	E	S-1, S-2	Other
E01	Reserved	—								
E02	UA reduction (15%)	C406.2.1.2	15	3	6	7	11	6	21	10
E03	Envelope Leak reduction	C406.2.1.3	16	3	4	9	13	1	25	9
E04	Reserved	—								
E05	Reserved	—								
E06	Improved Fenestration	C406.2.1.6	18	1	5	2	5	18	1	7
H01	Reserved	—								
H02	Heating efficiency	C406.2.2.2	5	8	4	11	17	11	31	11
H03	Cooling efficiency	C406.2.2.3	2	1	1	1	1	1	1	X
H04	Residential HVAC Control	C406.2.2.4	27	X	X	X	X	X	X	X
H05	DOAS Fan Control	C406.2.2.5	36	56	38	53	91	65	132	61
H06	Reserved	—								
H07	Central space heating heat pump	C406.2.2.7	30	30	30	30	30	30	30	30
W01	SHW preheat recovery	C406.2.3.1	111	6	13	40	19	14	6	8
W02	Heat pump water heater	C406.2.3	96	3	5	28	5	10	2	20
W03	Reserved	—								
W04	SHW pipe insulation	C406.2.3.4	8	1	4	3	4	5	2	23
W05	Point of use water heaters	C406.2.3.5	X	X	20	X	X	5	X	
W06	Thermostatic balancing valves	C406.2.3.6	3	1	1	1	1	2	1	4
W07	SHW heat trace system	C406.2.3.7	14	2	5	4	5	6	2	13
W08	SHW submeters	C406.2.3.8	20	X	X	X	X	X	X	1
W09	Reserved	—								
W10	Shower heat recovery	C406.2.3.1	29	1	3	X	X	3	X	20
P01	Energy monitoring	C406.2.4.1	2	3	X	2	5	3	5	54
L01	Reserved	—								
L02	Lighting dimming & tuning	C406.2.5.2	1	5	6	2	7	5	6	3
L03	Increase occ sensor	C406.2.5.3	2	5	6	1	7	4	7	X
L04	Increase daylight area	C406.2.5.4	3	6	7	2	9	5	8	4
L05	Res light control	C406.2.5.5	7	X	X	X	X	X	X	5
L06	Light Power reduction	C406.2.5.6	1	6	8	2	6	7	8	6
Q01	Reserved	—								
Q02	Commercial kitchen equipment	C406.2.6.2	X	15	X	40	X	X	X	5
Q03	Reserved	—								

tenant space in accordance with Section C406.1.1, complies with the following requirements:

1. Equipment installed shall be types that are listed in tables referenced by Section C 403.3.3. Electric resistance heating capacity shall be limited to 20% of system capacity with the exception of heat pump supplemental heating.
2. Equipment shall exceed the minimum heating efficiency requirements listed in tables referenced by section C403.3.3 by at least 5 percent. Where equipment exceeds the minimum annual heating efficiency requirements by 5 percent or more, credit for heating performance shall be determined using Equation 4-11 rounded to the nearest whole number.

$ACC_{HE} = ACC_{H5} \times (HEI / 0.05)$ **(Equation 4-11)**

Where:

ACC_{HE} = additional conservation credit for heating efficiency improvement

ACC_{H5} = base credits from Table C406.2 for applicable occupancy type

HEI = the efficiency improvement (percent) of the system as designed

C406.2.2.3 H03 More efficient HVAC equipment cooling and fan performance. Credit for more efficient HVAC equipment cooling and fan performance will be achieved if at least 90 percent of the total HVAC capacity serving the total conditioned floor area of the entire building, or tenant space in accordance with Section C406.1.1, complies with the following requirements:

1. Equipment installed shall be types that are listed in tables referenced by Section C 403.3.3.
2. Equipment shall exceed the minimum cooling efficiency requirements listed in tables referenced by Section C403.3.3 by 5 percent or more. For water-cooled chiller plants, heat rejection equipment efficacy shall also be increased by at least the chiller efficiency improvement. Where equipment exceeds the minimum annual cooling efficiency requirements by more than 5 percent, energy efficiency credits for cooling shall be determined using Equation 4-12 rounded to the nearest whole number.

   Where fan energy is not included in packaged equipment rating or it is and the fan size has been increased from the as-rated equipment condition, fan power or horsepower shall be no more than 5 percent of the allowed fan power in Section C403.8.1.

$ACC_{CE} = ACC_{C5} \times (CEI / 0.05)$ **(Equation 4-12)**

Where:

ACC_{CE} = additional conservation credits for cooling efficiency improvement

ACC_{C5} = base cooling efficiency credits from Table C406.2 for applicable occupancy type. Where multiple types of HVAC equipment is installed with different cooling efficiencies, the capacity-weighted average efficiency improvement shall be used. Where multiple equipment performance requirements apply, the equipment shall exceed the annualized energy or part-load requirement. Meeting both part-load and full-load efficiency percentage improvements is not required.

CEI = cooling efficiency improvement, the incremental improvement in efficiency over the minimum efficiency for the class of equipment, expressed as a fraction. For HVAC equipment classes with both full-load and part-load (seasonal) metrics, the part-load metric should be used.

(Equation 4-13)

For metrics that increase as efficiency increases, CEI shall be calculated as follows:

CEI = (CMdes/CMmin) – 1

For metrics that decrease as efficiency increases, CEI shall be calculated as follows:

CEI = (CMmin/CMdes) - 1

Where:

CMdes = design cooling efficiency, part-load, or annualized metric where available

CMmin = minimum required cooling efficiency, part-load, or annualized rating where available from Section C403.3.3

For Data Centers using ASHRAE Standard 90.4, CEI shall be calculated as follows:

CEI = (AMLCmax/AMLCdes) – 1

Where:

AMLCdes = as-designed Annualized Mechanical Load Component calculated in accordance with ASHRAE Standard 90.4, Section 6.5

AMLCmax = maximum annualized mechanical load component from ASHRAE Standard 90.4, Table 6.5

C406.2.2.4 H04 Residential HVAC Control. Credit for residential HVAC controls will be achieved if HVAC systems serving dwelling units or sleeping units are controlled to automatically activate a setback of at least 5°F (3°C) for both heating and cooling modes during occupied sleep periods and during unoccupied periods. The temperature controller shall be configured to provide setback during occupied sleep periods. The unoccupied setback mode shall be configured to operate in conjunction with one of the following:

1. Occupancy sensors in each room of the dwelling unit contained with a door switch to initiate setback and non-ventilation mode for all HVAC units in the dwelling within 20 minutes of all spaces being vacant immediately after a door switch operation. Where separate room HVAC units are used, an individual occupancy sensor on each HVAC unit that is configured to provide setback shall meet this requirement.
2. An advanced learning thermostat or controller that recognizes occupant presence and automatically creates a schedule for occupancy and provides a dynamic setback schedule based on when the spaces are generally unoccupied.
3. An automated control and sensing system that uses geo fencing connected to the dwelling unit occupants' cell phones and initiates the setback condition when all occupants are away from the building.

C406.2.2.5 H05 Dedicated outdoor Air System. Credit for dedicated outdoor air systems (DOAS) can be achieved only for single zone HVAC units that are not required to have multi-speed or variable speed fan control in accordance with Section C403.8.6.1. To achieve this credit, HVAC controls and ventilation systems shall include all the following:

1. Zone controls that cycle the heating/cooling unit fans off when not providing required heating/ cooling or limit fan power to 0.12 Watts per cfm of zone outdoor air.
2. Outdoor air supplied by an independent ventilation system designed to provide no more than 110 percent of the minimum outdoor air to each individual occupied zone, as specified by the *International Mechanical Code*.
3. Ventilation systems have energy recovery with an enthalpy recovery ratio of 65 percent or more at heating design conditions.
4. For ventilation system serving multiple zones and the system is not in a latent recovery outside air dehumidification mode, partial economizer cooling through an outdoor air bypass or wheel speed control automatically does one of the following:
    a. Sets the energy recovery leaving air temperature 55°F or 100% outdoor air bypass when the majority of zones require cooling and outdoor air temperature is below 70°F.
    b. The HVAC ventilation system includes supply air temperature controls that automatically reset the supply air temperature in response to outdoor air temperatures.
5. Ventilation systems providing mechanical dehumidification use recovered energy for reheat within the limits of item 4, above. This shall not limit the use of latent energy recovery for dehumidification.

The energy credit achieved for this measure is determined by multiplying the base energy credit from Table C406.2 by the fraction of system cooling capacity (nominal tons) that includes variable speed fan control.

C402.2.2.6. H06 Reserved.

C402.2.2.7. H07 Central space heating heat pump. Credit for this measure may be achieved only when the building uses all-electric systems for central space heating. Credits for this measure will be achieved if systems serve multiple spaces and use only electricity for space heating and reheat. Supplemental electric resistance heating capacity shall be limited to a maximum of 50% of rated capacity. Systems that qualify for this requirement include, but are not limited to, variable refrigerant flow (VRF) systems, air-to-water heat pumps, water-to-water heat pumps, and ground-source heat pump systems.

C406.2.3 Reduced Energy Use for Service Water Heating. Projects with service water-heating equipment that serves the whole building, a building addition or a tenant space shall achieve credits for reduced energy use for service water heating through compliance with the requirements of this section. Systems achieve credit by meeting one of the following requirements, combinations of measures achieve credit only if expressly listed:

1. By selecting one of the following measures: C406.2.3.1 W01, C406.2.3.2 W02 or C406.2.3.4 W04
2. By selecting one following measures: C406.2.3.5 W05, C406.2.3.6 W06, or C406.2.3.7 W07,
3. C406.2.3.8 W08,
4. C406.2.3.9 W09,
5. C406.2.3.10 W10,
6. Any combination of measures in C406.2.3.1 through C406.2.3.10 as long no more than one measure from Section C406.2.3.1 through C406.2.3.4 and no more than one measure from C406.2.3.5 through C406.2.3.7 are selected.

C406.2.3.1 W01 Recovered or renewable water-heating. Credits for recovered or renewable water heating will be achieved if the building complies with the requirements of this section. The building service water-heating system shall have one or more of the following that are sized to provide not less than 30 percent of the building's annual hot water requirements, or sized to provide 70 percent of the building's annual hot water requirements if the building is required to comply with Section C403.10.5:

1.1. Waste heat recovery from service hot water, recovery chillers, building equipment, or process equipment.

1.2. A water-to-water heat pump that precools chilled water return for building cooling.

1.3. On-site renewable energy water-heating systems.

C406.2.3.2. W02 Heat pump water heater. Credits for heat pump water heaters will be achieved if air-source heat pump water heaters do not draw conditioned air from within the building, except exhaust air that would otherwise be exhausted to the exterior. Any recirculating system and final heating shall be met with a separate non-heat pump heating source. The design shall also comply with the following as applicable:

2.1. For multi-family, dormitories, and healthcare occupancies with a recirculating system, at least 30% of design end use service water heating requirements shall be met using heat pump preheat with a COP of not less than 4.0 tested at 50°F (10°C) entering air and 70°F (21°C) entering water in accordance with AHRI standard 1300. A preheat storage tank equal to 25% of peak demand shall be included in the design.

2.2. For office, restaurant, and school occupancies with piping temperature maintenance, at least 30% of design end use service water heating requirements shall be met using heat pump preheat with a combined input-capacity-weighted-average UEF of 3.0 with a medium draw pattern for unitary equipment with either a heat trace system or a separate water heater in series for recirculating system and final heating.

2.3. For retail, small office, and warehouse occupancies with no recirculating system, at least 30% of design end use service water heating requirements shall be met using the heat pump portion of a hybrid water heater with a combined input-capacity-weighted-average UEF of 3.0 with a medium draw pattern for unitary equipment, including electric resistance heating to meet peak loading.

Where the heat pump capacity at 50°F (10°C) entering air and 70°F (21°C) entering water exceeds 50% of the design end use load excluding recirculating system losses, the base credits from Table C406.2 shall be prorated based on Equation 4-16.

W02 credit = base W02 table credit × HP*LLLL* 50% **(Equation 4-16)**

Where:

HPLF = Heat pump capacity as a fraction of the design end use service hot water requirements excluding recirculating system losses, not to exceed 80%.

C406.2.3.3. W03 Reserved.

C406.2.3.4 W04 Water-heating pipe insulation. Credits for water-heating pipe insulation will be achieved if service hot water is provided by a central water-heating system and the hot water pipe insulation thickness is at least 1.5 times the thickness required in Table C403.12.3. All service hot water piping shall be insulated from the hot water source to the fixture shutoff. For Group S (warehouse and storage) and Group M (retail) buildings, this measure is only available where a recirculation or heat trace system is used and piping length exceeds 80 lineal feet.

C406.2.3.5 W05 Point of use water heaters. Credits for point of use water heaters are available only for office or school buildings larger than 10,000 ft2 (930 m2). Credits are achieved if fixtures requiring hot water are supplied from a localized source of hot water with no recirculating system or heat trace piping. Supply piping from the water heater to the termination of the fixture supply pipe shall be insulated to the levels shown in Table C403.12.3 without exception. The volume from the water heater to the termination of the fixture supply pipe shall be limited as follows:

5.1. Nonresidential lavatories: not more than 2 oz (60 mL)

5.2. All other plumbing fixtures or appliances: not more than 0.25 gallons (0.95 L)

Exception: Where all remotely located hot water uses meet the requirements for measure W05, separate water heaters serving commercial kitchens or showers in locker rooms shall be permitted to have a local recirculating system or heat trace piping.

C406.2.3.6 W06 Thermostatic balancing valves. Credits for thermostatic balancing valves are available only where service water heating is provided centrally and distributed throughout the building. Credits will be achieved if each recirculating system branch return connection to the main service hot water supply piping has an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 115°F (46°C).

C406.2.3.7 W07 Heat trace system. Credits for heat trace systems are only available for projects with gross floor area greater than 10,000 square feet and a central water heating system. Credits will be achieved if the system includes self-regulating electric heat cables, connection kits, and electronic controls. The cable shall be installed directly on the hot water supply pipes underneath the insulation to replace standby losses.

C406.2.3.8 W08 Water heating system submeters. Credits for water heating system submeters are available only to Group R-2 occupancies where each individual dwelling unit is served by a central service water heating system has a service hot water meter connected to a reporting system that reports actual domestic hot water use of the individual dwelling unit. Preheated water serving the cold-water inlet to showers need not be metered. Credits cannot be achieved for this measure where other codes or regulations require individual dwelling unit hot water metering use of the individual dwelling unit. Preheated water serving the cold-water inlet to showers need not be metered. Credits cannot be achieved for this measure where other codes or regulations require individual dwelling unit hot water metering.

C406.2.3.9 W09 Reserved.

C406.2.3.10 W10 Shower drain heat recovery. Credits for shower drain heat recovery will be achieved if cold water serving building showers are be preheated by shower drain heat recovery units that comply with Section C404.7. The efficiency of drain water heat recovery units shall be 54 percent or greater, measured in accordance with CSA B55.1. Full credits are available only for the following occupancy types: I-2, I-4, R-1, R-2, and group E. Credits are only available only where there are more than eight showers. Credit is achieved only for buildings that utilize drain water heat recovery on at least 75% of shower drains in the building.

C406.2.4 P01 Energy monitoring. Credit may be achieved for this measure only if the project is not required to comply with Section C405.12. If eligible, credits will be achieved for installation of an energy

monitoring system that complies with all the requirements of Sections C405.12.1 through C405.12.5.

C406.2.5 Energy savings in lighting systems. Credits will be achieved for increased lighting system performance if the building complies with one or several of the following measures:

1. C406.2.5.2 L02
2. C406.2.5.3 L03
3. C406.2.5.4 L04
4. C406.2.5.5 L05
5. C406.2.5.6 L06

C406.2.5.1 L01 Reserved.

C406.2.5.2 L02 Enhanced digital lighting controls. Credit will be achieved if at least 50 percent of the gross floor area within the project complies with the following requirements:

1. Interior general lighting shall be located, scheduled, and operated in accordance with the lighting control standards in Section C405.2 and shall be configured with the following enhanced control functions:
    1.1. Luminaires shall be configured for continuous dimming.
    1.2. Each luminaire shall have luminaire level lighting controls.
    1.3. No more than eight luminaires within a *daylight zone* shall be controlled by a single *daylighting responsive control*.
2. Luminaires shall be controlled by a digital control system configured with the following capabilities:
    2.1. Reconfiguration of scheduling and illumination levels of individual and groups of luminaires.
    2.2. Load shedding.
    2.3. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.
3. Construction documents shall include submittal of a sequence of operations, including a specification outlining each of the functions required by this section.
4. Luminaires shall be initially configured consistent with the following:
    4.1. *High-end trim*, setting the maximum light output of individual luminaires or groups of luminaires to support visual needs of a space or area, shall be implemented such that maximum light output or power of controlled lighting is initially reduced by rate of at least 15 percent from full output. The average maximum light output or power of the controlled lighting shall be documented without high end trim and with high end trim to verify reduction of light output or power by at least 15 percent when tuned.
    4.2. Where lumen maintenance control is used, controls shall be configured to limit the initial maximum lumen output or maximum lighting power to 85 percent or less of full light output or full power draw aluminum maintenance controls shall be limited to increasing lighting power by 1% per year.
    4.3. High-end trim and lumen maintenance controls shall be accessible only to authorized personnel.

C406.2.5.3 L03 Increase occupancy sensor. Credit will be achieved for this measure if the project complies with the lighting control requirements of Sections C406.2.5.3.1, C406.2.5.3.2, and C406.2.5.3.3.

C406.2.5.3.1 Occupant sensor controls. Occupant sensor controls shall be installed to control lights in the following space types:

1. Courtroom
2. Electrical/mechanical room
3. Food preparation area
4. Laboratory
5. Elevator lobby
6. Pharmacy area
7. Vehicular maintenance area
8. Workshop
9. Chapel in a facility for the visually impaired
10. Recreation room in a facility for the visually impaired
11. Exercise area in a fitness center
12. Playing area in a fitness center
13. Exam/treatment room in a health care facility
14. Imaging room in a health care facility
15. Physical therapy room in a healthcare facility
16. Library reading area
17. Library stacks
18. Detailed manufacturing area
19. Equipment room in a manufacturing facility
20. Low-bay Area in a manufacturing facility
21. Post office sorting area
22. Religious fellowship hall
23. Religious worship area
24. Hair salon
25. Nail salon
26. Banking activity area

27. Computer room, data center
28. Laundry washing area
29. Medical supply room in a healthcare facility
30. Telemedicine room in a healthcare facility
31. Museum restoration room

C406.2.5.3.2 Occupant sensor control function. Occupant sensor controls shall automatically turn lights off within 10 minutes after all occupants have left the space. If a manual control complying with Section C405.2.6 allows occupants to turn off lights, time-switch controls are not required.

Exception: In spaces where an automatic shutoff could endanger occupant safety or security, occupant sensor controls shall uniformly reduce lighting power to not more than 20 percent of full power within 10 minutes after all occupants have left the space. Time-switch controls complying with Section C405.2.2.1 shall only automatically turn lights off.

C406.2.5.3.3 Occupant sensor time function. Occupant sensor controls installed in accordance with Sections C405.2.1.1, C405.2.1.2 C405.2.1.3, and C405.2.1.4 shall automatically turn lights off or reduce lighting power within 10 minutes after all occupants have left the space. When the space is unoccupied, the lighting power shall be reduced by a minimum of 20 percent below the full lighting power. In egress areas the lighting power shall be reduced to the power level required to meet egress light levels.

C406.2.5.4 L04 Increase daylight area. Credit will be achieved for this measure if the total daylit area of the project (DLAbldg) has continuous daylight dimming meeting the requirements of Section C405.2.4 and is at least 5 percent greater than the typical daylit area (DLAtyp). Credit for measure L04 shall be determined based Equation 4-14:

$$ACCDL = ACC_{L04} \times 20 \times [(DLAbldg/GLFA) - DLAtyp] \quad \textbf{(Equation 4-14)}$$

Where:

ACCDL = additional conservation credit daylighting

ACC_{L04} = Section C406.2.5.4 base credits from Table C406.2

GLFA = project gross lighted floor area, ft^2 or m^2

DLAtyp = typical % of building area with daylight control (as a fraction) from Table C406.2.5.4

DLAbldg = the % building area with daylight control, but limited to no greater than DLAmax in Table C406.2.5.4

TABLE C406.2.5.4
DLAtyp AND DLAmax VALUES BY BUILDING USE TYPE

BUILDING USE TYPE	DLAtyp	DLAmax
Group B: Office ≤ 5000 ft^2	10%	20%
Group B: Office > 5000 ft^2	21%	31%
Group M: Retail, ≤ 1,000 ft^2 of roof area	0%	20%
Group M: Retail, >1,000 ft^2 of roof area	60%	80%
Group E: Education	42%	52%
Groups S-1 and S-2: Warehouse	50%	70%
Group I-2, R, and other	NA	NA

C406.2.5.5 L05 Residential light control. Credit for this measure is only available in buildings containing group R-2 occupancy spaces. Credit will be achieved for this measure if interior lighting systems comply with the following:

1. Common area restrooms, laundry rooms, storage rooms, and utility rooms shall have automatic hold off occupancy sensor controls that comply with the requirements for Section C405.2.1.1. Each additional device shall control no more than 5,000 square feet of floor area.
2. Each dwelling unit shall have a main control by the main entrance that turns off all the lights and all switched receptacles in the dwelling unit. Two switched receptacles shall be provided in living and keeping rooms or areas and shall be clearly identified. All switched receptacles shall be located within 12 inches of an unswitched receptacle. The main controls may have two controls, one for permanently wired lighting and one for receptacles. The main controls shall be identified as “lights master off” and “switched outlets master off.

C406.2.5.6 L06 Reserved.

C406.2.6 Efficient Equipment Credits.

C406.2.6.1 Q01 Reserved.

C406.2.6.2 Q02 Efficient commercial kitchen equipment. Credit for this measure is only available for buildings and spaces designated as occupancy type A-2, or facilities whose primary business type involves the use of a commercial kitchen. Credits will be achieved for this measure if at least one electric fryer is installed before the issuance of the certificate of occupancy and all fryers, dishwashers, steam cookers, and ovens installed before the issuance of the certificate of occupancy shall comply with all of the following:

1. Achieve performance levels in accordance with the equipment specifications listed in Tables C406.2.6.2(1) through C406.2.6.2(3) when rated in accordance with the applicable test procedure.
2. Have associated performance levels listed on the construction documents submitted for permitting.

TABLE C406.2.6.2(1)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL FRYERS

TYPE	HEAVY-LOAD COOKING ENERGY EFFICIENCY	IDLE ENERGY RATE (watts)	TEST PROCEDURE
Standard Open Deep-Fat Electric Fryers	> 83%	≤ 800	ASTM F1361
Large Vat Open Deep-Fat Electric Fryers	> 80%	≤ 1,100	ASTM F2144

TABLE C406.2.6.2(2)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL STEAM COOKERS

TYPE	PAN CAPACITY	COOKING ENERGY EFF	IDLE ENERGY RATE	TEST PROCEDURE
Electric	3 pan	50%	400 W	ASTM F1484
	4 pan	50%	530 W	
	5 pan	50%	670 W	
	6 pan +	50%	800 W	

TABLE C406.2.6.2(3)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL DISHWAHERS (HIGH TEMPERATURE)[1]

MACHINE TYPE	IDLE ENERGY RATE	WASHING ENERGY	WATER CONSUMPTION
Under Counter	< 0.30 kW	< 0.35 kWh/rack	< 0.86 GPR
Stationary Single Tank Door	< 0.55 kW	< 0.35 kWh/rack	< 0.89 GPR
Pot, Pan, and Utensil	< 0.90 kW	< 0.55 + 0.05 × SFrack	< 0.58 GPSF
Single Tank Conveyor	< 1.20 kW	< 0.36 kWh/rack	< 0.70 GPR
Multiple Tank Conveyor	< 1.85 kW	< 0.36 kWh/rack	< 0.54 GPR
Single Tank Flight Type	Reported	Reported	GPH < 2.975c + 55.0
Multiple Tank Flight Type	Reported	Reported	GPH < 4.96c + 17.0

1 Ratings shall follow test procedures ASTM F1696 and ASTM F1920 as applicable.

C406.3 Additional load management and carbon credit requirements. Credits achieved through the measures in Sections C406.3.1 through C406.3.9.12 count towards the total credit requirements for the specified occupancy in Table C406.1.1. Credits amounts for measures in Sections C406.3.1 through C406.3.9.12 shall be determined by Table C406.3.

C406.3.1 G01 Lighting load management. Credits for lighting load management will be achieved if luminaires have dimming control capability and automatic motion controllers that gradually reduce generating power during peak periods. The load management controls shall reduce lighting power in 75% of the building area with at least 20% of the luminaires being capable of continuous dimming over a period longer than 15 minutes.

C406.3.2 G02 HVAC load management. Credit for this measure will be achieved if automatic load management controls are configured as follows:

1. Where electric cooling is used to gradually increase the cooling setpoint by at least three degrees Fahrenheit over a minimum of three hours or reduce effective cooling capacity to 60% of installed capacity during the peak period.
2. Where electric heating is used to gradually decrease the heating setpoint by at least three degrees Fahrenheit over a minimum or reduce effective heating capacity to 60% of its installed capacity during the peak period.
3. Where HVAC systems are serving multiple zones and have less than 70 percent outdoor air required, include controls that provide excess outdoor air preceding the peak period and reduce outdoor air by at least 30% during the peak period in accordance with ASHRAE Standard 62.1, section 6.2.5.2 short term conditions, or provisions for approved engineering analysis per the International Mechanical Code Section C403.3.1.1, Outdoor Air Flowrates.

C406.3.3 G03 Automated shading load management. Credit for this measure will be achieved where fenestration on east, south, and west exposures exceeds 20% of the wall area and meets all of the following:

1. Automatic exterior shading devices or dynamic glazing that are capable of reducing solar gain (SHGC) through sunlit fenestration by at least 50 percent when fully closed shall receive the full credits in Table C406.3. The exterior shades shall have

TABLE TABLE C406.3
LOAD MANAGEMENT AND CARBON CREDITS

ID	Energy Credit Measure	Section	R-2, R-4, and I-1	I-2	B	A-2	M	E	S-1, S-2
G01	Lighting Load Management	C406.3.1	11	14	18	4	21	14	23
G02	HVAC Load Management	C406.3.2	22	14	11	14	19	31	13
G03	Automated Shading	C406.3.3	13	2	10	n/a	10	15	n/a
G04	Electric Energy Storage	C406.3.4	13	15	30	15	40	15	24
G05	Cooling Energy Storage	C406.3.5	17	18	15	10	19	28	1
G06	Reserved								
G07	Building Thermal Mass	C403.3.7	58	53	9	18	24	60	20
G08	Embodied Carbon Credits	C403.3.8	30	30	30	30	30	30	30

fully open and fully closed SHGC determined in accordance with AERC1.

2. Automatic interior shading devices with a minimum solar reflectance of 0.50 for the surface facing the fenestration shall receive 40 percent of the credits in Table C406.3.
3. All shading devices, dynamic glazing, or shading attachments shall:
    3.1. Provide at least 90 percent coverage of the total fenestration on east, south, and west exposures in the building.
    3.2. Be automatically controlled and shall modulate in multiple steps or continuously the amount of solar gain and light transmitted into the space in response to peak period and either daylight levels or solar intensity.

C406.3.3 G03 Automated shading load management. Credits for automated shading load management are available only where fenestration on the east, west and south elevations exceeds 20% of the wall area. Credits will be achieved for this measure as follows:

1. Automatic exterior shading devices or dynamic glazing capable of reducing solar gain (SHGC) through sunlit fenestration by at least 50 percent when fully closed will receive the full credits shown for this measure in Table C406.3. The exterior shades shall have fully open and fully closed SHGC determined in accordance with AERC1.
2. Automatic interior shading devices with a minimum solar reflectance of 0.50 for the surface facing the fenestration receive 40 percent of the credits shown for this measure in Table C406.3.
3. All shading devices, dynamic glazing, or shading attachments shall:
    3.1 Provide at least 90 percent coverage of the total fenestration on east, south, and west exposures in the building.
    3.2 Be automatically controlled and modulate in multiple steps or continuously the amount of solar gain and light transmitted into the space in response to peak period and either daylight levels or solar intensity.
    3.3 Include a manual override located in the same enclosed space as the shaded vertical fenestration. The manual override shall be configured so that override operation of automatics controls last no longer than an hour. The manual override shall be locked out during peak periods.

C406.3.4 G04 Electric energy storage. Credit for electric energy storage will be achieved if the electric storage devices meet the requirements of this section. Electric energy storage devices shall be charged and discharged by automatic load management controls to store energy during non-peak periods and use stored energy during peak periods to reduce building demand. To achieve credits for this measure, electric storage devices shall have a minimum capacity of 1.5 Wh/ft^2 of gross building area. The credits shown in Table C406.3 for this measure are achieved for installed electric storage of 5 Wh/ft^2. Credits achieved for this measure is determined by prorating the credits shown in Table C406.3 for actual installed storage capacity. Prorated credits are limited to a storage capacity of 15 Wh/ft^2, although larger capacity systems may be installed.

C406.3.5 G05 Cooling energy storage. Credits for cooling energy storage will be achieved if automatic load management controls are capable of activating ice or chilled water storage equipment to reduce demand during summer peak periods. Storage tank standby loss shall be demonstrated through analysis to be no more than two percent of storage capacity over a 24-hour period for the cooling design day. The base credits shown in Table C406.3 are achieved for storage capacity of the design peak hour cooling mode with a 1.15 sizing factor. Credits achieved for this measure are determined by prorating the credits shown in Table C406.3 for installed storage system sizes between 0.5 and 4.0 times the design day peak hour cooling load, rounded to the nearest whole credit. Prorated credits are limited to this range, although larger storage systems may be installed. Credit shall be determined from Equation 4-15.

$$ACC_{cs} = EC1.0 \times (1.44 \times SR + 0.71) / 2.15 \quad \textbf{(Equation 4-15)}$$

Where:

ACC_{cs} = cooling storage credits achieved for the project

EC1.0 = G05 base energy credit, based on 1.0 ton-hours storage per design-day ton of cooling load

SR = storage ratio in ton-hours storage per design day ton (kWh/kW) of cooling load, limited to $0.5 \leq SR \leq 4.0$

C406.3.6 G06 Reserved.

C406.3.7 G07 Building thermal mass. Credit for building thermal mass is available only to projects where at least 80 percent of the gross floor area is unoccupied between midnight and 6:00 a.m.. Credit for building thermal mass is achieved if the project has additional passive interior mass and a night flush control of the HVAC system. To achieve this credit the project shall meet the following requirements:

1. Interior to the building envelope insulation, provide 10 lb per square foot of passive thermal mass. Thermal mass construction shall have mass surfaces directly contacting the air in the conditioned spaces; directly attached gypsum panels area allowed. Mass with carpet or furred gypsum panels for exterior wall mass that is on the exterior of the insulation layer may not be counted toward the required building mass.
2. HVAC units for 80 percent of the supply air flow in the project shall (a) be equipped with outdoor air

economizers and fans that have variable or are capable of operating at 66% or lower air flow and (b) be included in the night flush control sequence

3. Night flush controls shall be configured with the following sequence flush strategy:
    3.1. Summer mode shall be activated when outdoor air temperature exceeds 70°F and shall continue uninterrupted until deactivated when outdoor air temperature falls below 45°F. During summer mode, the occupied cooling setpoint shall be set at least 2°F higher than normal and the occupied heating set point shall be reset at least 2°F lower than normal.
    3.2. When all the following conditions exist, night flush shall be activated:
        3.2.1. Summer mode is active in accordance with item 3.1.
        3.2.2. Outdoor air temperature is 5°F or more below indoor average zone temperature.
        3.2.3. Indoor average zone temperature is greater than morning occupied heating setpoint.
        3.2.4. Local time is between 10:00 pm and 6:00 am.

C406.3.8 G08 Embodied carbon (CO2e) credits. To achieve credits for reduction of embodied carbon, all materials or products of the type chosen to meet this credit option used in the construction of the building shall meet the requirements of this section. The construction documents shall identify the products proposed for the construction of the building and demonstrate compliance of the proposed products with the requirements of this section. A minimum of three materials or products selected from the options in Sections C406.3.8.1 through C406.2.8.11 must be chosen to achieve the credit set forth in Table C406.3; alternatively, one selection from the options in Sections C406.3.8.1 through C406.3.8.11 and compliance with Section C406.3.9.12 will also achieve the credit.

C406.3.8.1 Embodied CO2e of insulation products. 75 percent of mineral wool (heavy density, light, and loose-fill), and cellulose insulation products used in the building, based on product cost or area, do not exceed 125 percent of *IW-EPD's* kgCO2e/m2-RSI. Products shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/m2-RSI and *product specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and its associated kgCO2e/m2-RSI, per the *product-specific Type III EPD*.

C406.3.8.2 Embodied CO2e of interior finishes. CO_2e of interior finishes shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/unit and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/unit, per the *product-specific Type III EPD*.

C406.3.8.2.1 Embodied CO2e of interior floor covering products. 80 percent of solid and engineered flooring, ceramic tile, natural stone floor, and resilient flooring (homogeneous and heterogeneous vinyl, and rigid core) used in the building, based on cost or area, shall not exceed 125% of *IW-EPD's* kgCO2e/m2.

C406.3.8.2.2 Embodied CO2e of acoustical ceiling systems. 80 percent of all acoustical ceiling products used in the building, based on cost or weight, shall not exceed 125 percent of *IW-EPD's* kgCO2e/kg.

C406.3.8.3 Embodied CO2e of insulated metal panels products. 80 percent of all insulated metal panel siding used in the building, based on cost or area, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m2, and products shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/unit and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/m2, per the *product-specific Type III EPD*.

C406.3.8.4 Embodied CO2e of roof assemblies and rooftop structures products. CO2e of roofing assemblies and rooftop structures products shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/m2 and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/m2, per the *product-specific Type III EPD*.

C406.3.8.4.1 Embodied CO2e of roofing products. 80 percent of all built-up, PVC, and asphalt roofing products used in the building, based on product cost or area, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m2.

C406.3.8.4.2 Embodied CO2e of insulated metal panels products. 80 percent of insulated metal panel products used in the building, based on product cost or area, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m2.

C406.3.8.5 Embodied CO2e in concrete products. CO2e of ready-mix and precast concrete shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/unit and *prod-*

uct-specific Type III EPDs shall be verified by a registered design professional on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/unit, per the *product-specific Type III EPD*.

C406.3.8.5.1 Embodied CO2e in ready-mix concrete products. 90 percent of all ready-mix concrete mixes used in the building's primary structural frame, secondary members, seismic force-resisting system, and foundations shall not exceed the project limit (CO2emax, see Equation 4-16) determined by 125 percent of *IW-EPD's* kgCO2e/y3.

Exceptions: Precast, shotcrete, or auger cast concrete.

CO2eproj < CO2emax **(Equation 4-16)**

where:

CO2eproj = Σ(CO2en) (vn)|CO2emax = Σ(CO2elim) (vn)

n = the total number of concrete mixtures for the project

CO2en = the global warming potential for mixture n per mixture *product-specific Type III EPD*, kgCO2e/y3

CO2elim = the global warming potential limit for mixture n per 125% of *IW-EPD's* kgCO2e/y3

vn = the volume of mixture n concrete to be placed in the project, in cubic yards (y3)

C406.3.8.5.2 Embodied CO2e in precast concrete products. 75 percent of all precast concrete products used as ordinary precast structural walls and foundations, based on cost or weight, shall not exceed 125 percent of *IW-EPD's* kg-CO2e/metric ton.

C406.3.8.6 Embodied CO2e in masonry construction products. CO_2e of clay bricks and cement products shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/unit and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/unit, per the *product-specific Type III EPD*.

C406.3.8.6.1 Embodied CO2e of clay bricks. 50 percent of all clay brick products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m3.

C406.3.8.6.2 Embodied CO2e of masonry cement. 50 percent of all masonry cement used in the building, based on cost or weight, shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton.

C406.3.8.7 Embodied CO2e in steel products. CO2e of primary and secondary steel products shall meet the requirements in this section, and products shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/metric ton and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary thereof by the registered design professional shall be submitted with the building permit application and shall include a list of each product and associated kgCO2e/metric ton, per the *product-specific Type III EPD*.

Exceptions: When a minimum of 90 percent of steel products listed in this section, based on cost or weight, are produced in a facility or facilities that complies with one of the following and independent, third-party documentation is submitted with the building permit application demonstrating such compliances:

1. On the date of procurement, the facility is independently, or as part of an aggregation of facilities, a Green Power Partner in the United States Environmental Protection Agency (U.S. EPA) Green Power Partnership program or listed in an equivalent renewable power procurement registry, as approved by the *chief building official*.
2. Not less than 50 percent of the energy sourced for production at the facility is a renewable energy resource provided through one or more of the following:
   2.1. On-site renewable energy system
   2.2. Off-site renewable energy system owned by the production facility owner
   2.3. Community renewable energy facility
   2.4. Power Purchase Agreement (PPA)

C406.3.8.7.1 Embodied CO2e of structural steel products. 90 percent of all hollow structural steel sections, hot rolled structural steel sections and steel plate products used in the building's primary structural frame, secondary members, seismic force-resisting system, and foundations, steel decking, and roll-formed cladding shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton.

C406.3.8.7.2 Embodied CO2e of steel reinforcing bar Products. 90 percent of all concrete reinforcing bars used in the building shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton.

C406.3.8.7.3 Embodied CO2e of steel joist products. 50 percent of all open web steel joists and joist girder products used in the building shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton.

C406.3.8.7.4 Embodied CO2e of cold formed steel products. 50 percent of all cold formed steel construction decking, secondary structural steel frame components, and nonstructural framing components for walls, floors, ceilings, and roofs used in

the building shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton.

C406.3.8.8 Embodied CO2e of wood products. CO_2e of wood products shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/unit and *product-specific Type III EPDs* shall be verified by a registered design professional on the project, and a shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/unit, per the *product-specific Type III EPD*.

Exceptions:

1. Fire-retardant-treated wood
2. Preservative-treated wood
3. Furniture and cabinetry

C406.3.8.8.1 Embodied CO2e of grade lumber products. 10 percent of all softwood and redwood lumber products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kg-CO2e/m3.

C406.3.8.8.2 Embodied CO2e of prefabricated joist products. 50 percent of all prefabricated wood I-joist products used in the building, based on cost or length, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m.

C406.3.8.8.3 Embodied CO2e of glued cross-laminated timber products. 90 percent of all glued laminated timber products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m3.

C406.3.8.8.4 Embodied CO2e of wood structural panel products. 50 percent of all soft plywood, oriented strand board products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m3.

C406.3.8.8.5 Embodied CO2e of structural composite lumber products. 50 percent of all laminated veneer lumber and laminated strand lumber products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m3.

C406.3.8.8.6 Embodied CO2e of particleboard and fiberboard products. 50 percent of all medium density fiberboard, cellulosic fiberboard, and particleboard products used in the building, based on cost or volume, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m3.

C406.3.8.9 Embodied CO2e of glazing products. 50 percent of all flat glass used in window products installed in the building, based on cost or weight, shall not exceed 125 percent of *IW-EPD's* kgCO2e/metric ton. Products shall meet the requirements in this section, and products used for compliance shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/metric ton and *product-specific Type III EPDs* shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/metric ton, per the *product-specific Type III EPD*.

Exceptions:

1. Plastic glazing
2. Fire-rated glazing
3. Interior partition walls
4. Skylights
5. Guards and railings
6. Glazing in athletic facilities
7. Floor/ceiling walking surfaces
8. Elevator hoist way glazing

C406.3.8.10 Embodied CO2e of gypsum products. 80 percent of all gypsum board, gypsum sheathing, and glass-mat gypsum board products used in the building, based on cost or area, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m2. Products shall have a product-specific Type III EPD. Confirmation of the product's kgCO2e/m2 and EPDs shall be verified by a *registered design professional* on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/m2, per the *product-specific Type III EPD*.

C406.3.8.11 Embodied CO2e of foam plastic insulation products. 50 percent of all insulation products, including expanded polystyrene (EPS) and polyurethane foam insulation (HFC or HFO) used in the building, based on cost and area, shall not exceed 125 percent of *IW-EPD's* kgCO2e/m2-RSI. Products shall have a *product-specific Type III EPD*. Documentation of the product's kgCO2e/m2-RSI and *product-specific Type III EPDs* shall be verified by a registered design professional on the project, and a summary shall be submitted upon application for building permit and shall include a list of each product and associated kgCO2e/m2-RSI., per the *product-specific Type III EPD*.

C406.3.8.12 Whole building lifecycle analysis (WB LCA). Conduct a whole building life-cycle assessment, including operating energy, against a baseline building that demonstrates a minimum of 10% reduction for at least three of the six impact categories listed below, one of which must be global warming potential. The building envelope, structural elements including footings and foundations, interior ceilings, walls, and floors; and exterior finishes shall be studied for the assessment. The baseline and proposed buildings must be of comparable size, function, complexity, orientation, and operating energy performance. The service life of the baseline and proposed buildings must be the same and at least 60 years. The same life-cycle assessment software tools and data sets shall be used to evaluate both the baseline building and the proposed building. The construction documents shall report all listed impact

categories. Data sets must comply with the standards of ISO 14044.

Impact Categories:

1. Global warming potential (greenhouse gases), in kg CO2e.
2. Depletion of the stratospheric ozone layer, in kg CFC-11e.
3. Acidification of land and water sources, in moles H+ or kg SO2e.
4. Eutrophication, in kg nitrogen eq or kg phosphate eq.
5. Formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
6. Depletion of nonrenewable energy resources, in MJ using CML/depletion of fossil fuels in TRACI.

SECTION C407
TOTAL BUILDING PERFORMANCE

C407.1 Scope. This section establishes criteria for compliance using total building performance. Compliance with this section requires the use of ASHRAE Standard 90.1-2022 Appendix G, as modified by this code. Required modifications to this standard are included in this section and in Appendix CA, "Boulder Modified Appendix G Protocol" to this code. All end use load components within and associated with the building shall be modeled.

Exception: Energy used to recharge or refuel vehicles that are used for on-road and off-site transportation purposes shall be excluded from end use load compliance modeling. Energy supplied to vehicle charging equipment shall be submetered per section C407.6.

C407.2 Mandatory requirements. Compliance under the total building performance path of Section C407 requires compliance with the section of this code identified in Table C407.2.

C407.3 Performance-based compliance. Compliance based on building performance shall be determined in accordance with Section C407.3.1, C407.3.2 or C407.3.3. Energy use for the *proposed design* shall be reported to the *code official* as energy use intensity (EUI) in kBtu/sf/yr.

C407.3.1 Modeled baseline. Projects shall comply with Section 4.2.1.1 of ASHRAE Standard 90.1-2022, as modified in Section C407.4. Projects complying using this Section C407.3.1 to demonstrate compliance shall use a site energy index as defined in Appendix I of ASHRAE 90.1-2022 and as defined in Section C407.4.

C407.3.2 Fixed performance target. Only project types listed in Table C407.3.2 may use this section for compliance with Section C407.3. Eligible projects may demonstrate compliance by meeting the EUI targets identified in the Table C407.3.2. The *proposed building model* predicted performance shall be demonstrated using the energy modeling procedures for the proposed building performance in Appendix G of ASHRAE 90.1-2022, as modified in Section C407.4. Buildings with multiple occupancy types listed in Table C407.3.2 shall develop a performance target based on area weighted-average EUI calculated by floor area of each occupancy type.

TABLE C407.2
MANDATORY REQUIREMENTS

SECTION	TITLE
C401	General
C402.5	Air leakage—thermal envelope
C403.1	General
C403.2	System design
C403.3	Mechanical system energy source
C403.4	Heating and cooling system controls
C403.5.5	Economizer fault detection and diagnostics
C403.7 (except C403.7.5.1)	Ventilation and exhaust systems
C403.8 (except C403.8.6)	Fans and fan controls
C403.9	Large-diameter ceiling fans
C403.11 (except C403.11.3)	Refrigeration equipment performance
C403.12	Construction of HVAC system elements
C403.13	Mechanical systems located outside of the building thermal envelope
C404	Service Water Heating
C405 (except C405.3)	Electrical Power and Lighting Systems
Reserved	
C408	Maintenance information and system commissioning

a. Reference to a code section includes all the relative subsections except as indicated in the table.

C407.3.3 Measured performance outcome. With approval of the *chief building official*, projects may demonstrate compliance with this code by documenting that the building has achieved the EUI target calculated per C407.3.1 or C407.3.2 within 10 percent based on metered energy use after occupancy.

C407.3.3.1 Excluded energy use. Energy used for data centers and EV charging equipment may be excluded from the total EUI of the building, provided that this energy use is separately metered per the requirements of Section C407.6.

C407.3.3.2 Demonstration of operating energy use. Metered energy data shall be reported to the *code official* using Energy Star Portfolio Manager and adjusted for the percentage of occupied floor area. The applicant shall demonstrate that, while at least 75 percent occupied, the building operates at or below its assigned EUI target established in Section C407.3.2 for any recording period of 12 consecutive months that is completed within three years of the date of the Certificate of Occupancy. The owner shall notify the *code official* when this 12-month period has been successfully completed.

TABLE C407.3.2
FIXED EUI TARGETS

BUILDING TYPE	PERFORMANCE TARGETS (kBtu/ft²)
Medium office (5,000–50,000 sf)	23
Mid-rise apartment (Type R2)	32
Primary school	34
Large Office (> 50,000 sf)	40
Small office (< 5000 sf)	19
Secondary school	31
Warehouse	11
Retail Store	40
Small Hotel	35
Hospital	76
Restaurant	200
Strip Mall	40

C407.3.3.3 Adjustments to EUI targets. The *chief building official* may approve an adjustment to a building's EUI target based on unanticipated changes to building operation and conditions as set forth in Items 1 through 3 below. The applicant shall demonstrate the need for adjustment based on the standards set forth Items 1 through 3 with specific documentation of the need:

1. **Adjustment for change in occupancy.** When the occupancy of the building or a portion of the building changes from that assumed in the permit submittal, the *code official* will adjust the assigned EUI target to reflect the new occupancy. If the new occupancy is not listed in Section C407.3.2, either the *code official* shall assign it an EUI target based on the best-performing local examples of that occupancy type, or a metering system shall be provided that excludes the energy loads for the additional occupancy.
2. **Adjustment for unusually cold years.** If the heating degree days (HDD) recorded by the National Weather Service for the Denver International Airport exceeds the average HDD value identified in local TMY3 data for the 12-month demonstration period, the *code official* will adjust the assigned EUI target by 1 percent for each 4-percent increase of HDD from average HDD for that period.
3. **Adjustment for other factors.** The *chief building official* may approve adjustments to the assigned EUI target for conditions other than those identified in this section if the *chief building official* finds that the conditions represent reasonable changes impacting the building use characteristics that were not anticipated when the EUI target was assigned.

C407.3.3.4 Financial security. The applicant shall provide a financial security to be used if the building fails to achieve an operating EUI at or lower than the building's EUI target according to Section C407.3.2. The financial security shall be submitted to and approved by the *chief code official* prior to issuance of the building permit. The financial security requirement shall be fulfilled by an escrow of funds with the city for an amount equal to $2.00 per square foot of gross floor area. If the owner provides evidence that the building has operated at or below its target energy performance level, as provided in Section C407.3.3.2, the financial security provided by the applicant shall be returned to the applicant and the applicant will have no further obligations under this section.

C407.3.3.5 Procedure for noncompliance. If the owner fails to provide evidence that the building has operated as required under Section C407.3.3.2, the *chief building official* shall require the applicant to draw down on the financial security of Section C407.3.3.4 to lower the operating energy use of the building, including recommissioning, repairs, and improvements to the existing energy-consuming systems, or provision of additional energy efficiency measures to reduce the building's energy use. Such expenditures shall be approved in advance by the *chief building official*, and the work shall be fully completed within one year of the date when a financial security has been drawn down.

C407.4 Modifications to Appendix G. Compliance with this section requires the use of ASHRAE Standard 90.1-2022 Appendix G, as modified by Appendix I to that standard, where references to "energy cost" are replaced with "site energy", and as modified here-in Section C407.4 and by Appendix CA "Boulder Modified Appendix G Protocol" of this code. Modifications to the Appendix G protocol include the following:

C407.4.1 Building performance requirement. The Site Energy Index target shall be calculated in accordance with Appendix I and Section 4.2.1.1(c) of ASHRAE 90.1-2022 with the following modifications:

1. The required Performance Index (Site Energy) shall be reduced by 15 percent for mixed-fuel buildings and 10 percent for all-electric buildings.
2. The building performance factors in Table 4.2.1.1 of Standard 90.1 shall be replaced by those listed in Table C407.4.1.

C407.4.2 Performance backstop. All elements of the building envelope and HVAC system must meet the mandatory requirements of ASHRAE Standard 90.1-2016, Sections 5.5 and 6.8. No individual component tradeoffs below these prescriptive requirements will be allowed in the proposed building performance model. Exceptions to the 40 percent window-to-wall area may be approved by the *code official* provided that the project can still meet the required building energy performance requirements of Section C401.

C407.4.3 Fixed schedules. All projects using the performance pathway must use the mandatory building schedules and equipment power density schedules

TABLE C407.4.1
BUILDING PERFORMANCE FACTORS (BPF) SITE ENERGY

BUILDING AREA TYPE	BUI8LDING PERFORMANCE FACTOR (BPF)
Office	0.52
Retail	0.47
School	0.50
Healthcare	0.63
Restaurant	0.69
Hotel	0.66
Warehouse	0.45
Apartment	0.67
All others	0.50

provided in Appendix CA, "Boulder Modified Appendix G Protocol" of this code for both the baseline and proposed building model.

Exceptions:

1. The *code official* may approve alternate schedules prior to submittal to account for special use conditions.
2. The *code official* may approve alternate schedules for unregulated loads in the proposed building design that reflect plug and process load management strategies.

C407.4.4 Appendix G mandatory requirements. The mandatory sections of ASHRAE Standard 90.1-2022 are superseded by the mandatory requirements listed in Section C407.2: Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4.

C407.5 Solar requirements. The project must meet the following solar requirements:

C407.5.1 Minimum installed solar capacity. The project must install an on-site renewable energy system sized to meet at least 5 percent of annual proposed design energy consumption. Projects pursuing C407.3.2 for compliance are exempt from this requirement.

C407.5.2 Solar readiness. The project must also meet the requirements of Section C405.14, Solar Readiness.

C407.6 Performance feedback. Applicants using the performance path to show compliance are required to submit an analysis comparing the modeled design to actual energy use of the building for a consecutive 12-month period within two years of project occupancy. This analysis shall use billing data and submetered data from the building meters to identify the accuracy of the energy model and any areas of performance divergence from predicted energy use. The applicant shall provide a narrative summary describing areas of alignment and misalignment of predictive modeling and compliance modeling following ASHRAE 90.1 with actual energy use patterns, including modeled EUI and actual EUI from metered use. This analysis shall be designed to support the ongoing commissioning or retro-commissioning process required in Section C408.

SECTION C408
MAINTENANCE INFORMATION AND SYSTEM COMMISSIONING

C408.1 General. This section covers the provision of maintenance information and the commissioning of, and the functional testing requirements for, building systems.

C408.1.1 Building operations and maintenance information. The building operations and maintenance documents shall be provided to the owner and shall consist of manufacturers' information, specifications and recommendations; programming procedures and data points; narratives; and other means of illustrating to the owner how the building, equipment and systems are intended to be installed, maintained and operated. Required regular maintenance actions for equipment and systems shall be clearly stated on a readily visible label on the equipment or appliance. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

C408.1.2 Energy use monitoring plan. As part of the operations manual, the project must provide a written description of what metered data is collected, how metering data is collected and stored, and how the data can be accessed for project analysis by the building operator.

C408.2 Mechanical systems and service water-heating systems commissioning and completion requirements. Prior to the final mechanical and plumbing inspections, the *registered design professional or approved agency* shall provide evidence of mechanical systems *commissioning* and completion in accordance with the provisions of this section.

Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements. Copies of all documentation shall be given to the owner or owner's authorized agent and made available to the *code official* upon request in accordance with Sections C408.2.4 and C408.2.5.

Exceptions: The following systems are exempt:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3.1 that serve individual *dwelling units* and *sleeping units*.

C408.2.1 *Commissioning* plan. A *commissioning plan* shall be developed by a *registered design professiona*l or *approved agency* and shall include the following items:

1. A narrative description of the activities that will be accomplished during each phase of *commissioning,* including the personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances, or systems to be tested and a description of the tests to be performed.

3. Functions to be tested including, but not limited to, calibrations and economizer controls.
4. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
5. Measurable criteria for performance.

C408.2.2 Systems adjusting and balancing. HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.

C408.2.2.1 Air systems balancing. Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable- volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.746 kW), fan speed shall be adjusted to meet design flow conditions.

Exception: Fans with fan motors of 1 hp (0.74 kW) or less are not required to be provided with a means for air balancing.

C408.2.2.2 Hydronic systems balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

Exception: The following equipment is not required to be equipped with a means for balancing or measuring flow:

1. Pumps with pump motors of 5 hp (3.7 kW) or less.
2. Where throttling results in not greater than 5 percent of the nameplate horsepower draw above that required if the impeller were trimmed.

C408.2.3 Functional performance testing. Functional performance testing specified in Sections C408.2.3.1 through C408.2.3.3 shall be conducted.

C408.2.3.1 Equipment. Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specification such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and *sequence of operation*, including under full-load, part-load, and the following emergency conditions.

1. All modes as described in the *sequence* of *operation*.
2. All modes as described in the *sequence* of *operation*.
3. Redundant or *automatic* back-up mode.
4. Performance of alarms.
5. Mode of operation upon a loss of power and restoration of power.

Exception: Unitary or packaged HVAC equipment listed in the tables in Section C403.3.3 that do not require supply air economizers.

C408.2.3.2 Controls. HVAC and service water-heating control systems shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with *approved* plans and specifications.

C408.2.3.3 Economizers. Air economizers shall undergo a functional test to determine that they operate in accordance with the manufacturer's specifications.

C408.2.4 Preliminary commissioning report. A preliminary report of *commissioning* test procedures and results shall be completed and certified by the r*egistered design professional* or *approved agency* and provided to the building owner or owner's authorized agent. The report shall be organized with mechanical and service hot water findings in separate sections to allow independent review. The report shall be identified as "Preliminary Commissioning Report," shall include the completed Commissioning Compliance Checklist, Figure C408.2.4, and shall identify:

1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
3. Climatic conditions required for performance of the deferred tests.
4. Results of functional performance tests.
5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

C408.2.4.1 Acceptance of report. Buildings, or portions thereof, shall not be considered as acceptable for a final inspection pursuant to Section C105.2.6 until the *code official* has received the Preliminary Commissioning Report from the building owner or owner's authorized agent.

C408.2.4.2 Copy of report. The *code official* shall be permitted to require that a copy of the Preliminary

Commissioning Report be made available for review by the *code official*.

C408.2.5 Documentation requirements. The construction *documents* shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the *certificate of occupancy*.

C408.2.5.1 System balancing report. A written report describing the activities and measurements completed in accordance with Section C408.2.2.

C408.2.5.2 Final commissioning report. A report of test procedures and results identified as "Final Commissioning Report" shall be delivered to the building owner or owner's authorized agent. The report shall be organized with mechanical system and service hot water system findings in separate sections to allow independent review. The report shall include the following:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

C408.3 Functional testing of lighting controls. Automatic lighting controls required by this code shall comply with this section.

C408.3.1 Functional testing. Prior to passing final inspection, the *registered design professional* or *approved agency* shall provide evidence that the lighting control systems have been tested to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the *construction documents* and manufacturer's instructions. Functional testing shall be in accordance with Sections C408.3.1.1 through C408.3.1.3 for the applicable control type.

C408.3.1.1 Occupant sensor controls. Where *occupant sensor controls* are provided, the following procedures shall be performed:

1. Certify that the *occupant sensor* has been located and aimed in accordance with manufacturer recommendations.
2. For projects with seven or fewer *occupant sensors*, each sensor shall be tested. For projects with more than seven *occupant sensors,* testing shall be done for each unique combination of sensor type and space geometry. Where multiples of each unique combination of sensor type and space geometry are provided, not less than 10 percent and in no case fewer than one, of each combination shall be tested unless the *code official* or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.
3. For *occupant sensor controls* to be tested, verify the following:
   - 3.1. Where *occupant sensor controls* include status indicators, verify correct operation.
   - 3.2. The controlled lights turn off or down to the permitted level within the required time.
   - 3.3. For auto-on *occupant sensor controls*, the lights turn on to the permitted level when an occupant enters the space.
   - 3.4. For manual-on *occupant sensor controls*, the lights turn on only when manually activated.
   - 3.5. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

C408.3.1.2 Time-switch controls. Where *time-switch controls* are provided, the following procedures shall be performed:

1. Confirm that the *time-switch control* is programmed with accurate weekday, weekend and holiday schedules.
2. Provide documentation to the owner of *time-switch controls* programming including weekday, weekend, holiday schedules, and set-up and preference program settings.
3. Verify the correct time and date in the time switch.
4. Verify that any battery back-up is installed and energized.
5. Verify that the override time limit is set to not more than 2 hours.
6. Simulate occupied condition. Verify and document the following:
   - 6.1. All lights can be turned on and off by their respective area control switch.
   - 6.2. The switch only operates lighting in the enclosed space in which the switch is located.
7. Simulate unoccupied condition. Verify and document the following:
   - 7.1. Nonexempt lighting turns off.
   - 7.2. Manual override switch allows only the lights in the enclosed space where the override switch is located to turn on or remain on until the next scheduled shutoff occurs.
8. Additional testing as specified by the *registered design professional.*

C408.3.1.3 Daylight responsive controls. Where *daylight responsive controls* are provided, the following shall be verified:

1. Control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.
2. Daylight controlled lighting loads adjust to light level setpoints in response to available daylight.
3. The calibration adjustment equipment is located for *ready access* only by authorized personnel.

C408.3.2 Documentation requirements. The construction documents shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the *certificate of occupancy*.

C408.3.2.1 Drawings. Construction documents shall include the location and catalogue number of each piece of equipment.

C408.3.2.2 Manuals. An operating and maintenance manual shall be provided and include the following:

1. Name and address of not less than one service agency for installed equipment.
2. A narrative of how each system is intended to operate, including recommended setpoints.
3. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
4. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended relamping shall be clearly identified.
5. A schedule for inspecting and recalibrating all lighting controls.

C408.3.2.3 Report. A report of test results shall be provided and include the following:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.

Project Information: _____ Project Name:_____

Project Address:_____

Commissioning Authority:_____

Commissioning Plan (Section C408.2.1)

☐ Commissioning Plan was used during construction and includes all items required by Section C408.2.1

☐ Systems Adjusting and Balancing has been completed.

☐ HVAC Equipment Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ HVAC Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Economizer Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Lighting Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Service Water-Heating System Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Manual, record documents and training have been completed or scheduled

☐ Preliminary Commissioning Report submitted to owner and included all items required by Section C408.2.4

I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2018 IECC.

Signature of Building Owner or Owner's Representative _____ Date_____

FIGURE C408.2.4
COMMISSIONING COMPLIANCE CHECKLIST

CHAPTER 5 [CE]
EXISTING BUILDINGS

User note:

About this chapter: *Many buildings are renovated or altered in numerous ways that could affect the energy use of the building as a whole. Chapter 5 requires the application of certain parts of Chapter 4 in order to maintain, if not improve, the conservation of energy by the renovated or altered building.*

SECTION C501
GENERAL

C501.1 Scope. The provisions of this chapter shall control the *alteration*, *repair*, *addition* and *change of occupancy* of existing buildings and structures.

C501.1.1 Existing buildings. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing *building* or *building* system lawfully in existence at the time of adoption of this code.

C501.2 Compliance. *Additions*, *alterations*, *repairs*, and changes of occupancy to, or relocation of, existing *buildings* and structures shall comply with Sections C502, C503, C504 and C505 of this code, as applicable, and with the provisions for *alterations*, *repairs*, *additions* and changes of occupancy or relocation, respectively, in the *International Building Code*, *International Existing Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code*, *International Property Maintenance Code*, *International Private Sewage Disposal Code* and NFPA 70. Changes where unconditioned space is changed to conditioned space shall comply with Section C502. Where both additions and alterations are included in the scope of work, the larger portion of work shall govern the compliance method.

Exception: *Additions*, *alterations*, *repairs*, or changes of occupancy complying with ANSI/ASHRAE/IESNA 90.1.

C501.3 Maintenance. *Buildings* and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems required by this code shall be maintained in conformance to the code edition under which they were installed. The owner or the owner's authorized agent shall be responsible for the maintenance of buildings and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protection and safety systems and devices in existing structures.

C501.4 New and replacement materials. Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided that hazards to life, health or property are not created. Hazardous materials shall not be used where the code for new construction would not allow use of these materials in buildings of similar occupancy, purpose and location.

C501.5 *Designated Historic buildings*. The provisions of this code relating to the construction, *repair, alteration*, restoration and movement of structures, and *change of occupancy* shall apply to *designated historic buildings*. The *code official* shall have the authority to waive certain requirements for a *designated historic building* if the *code official* finds that compliance with a requirement would have an adverse impact upon the historic character of the individual landmark or, if the building is contributing to a historic district, upon the historic character of the contributing building or historic district.

SECTION C502
ADDITIONS

C502.1 General. *Additions* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction subject to the following:

1. *Additions* with a construction valuation of $500,000 or more shall comply with Section C407.
2. *Additions* with a construction valuation less than $500,00 shall comply with Section C502.2 or C407.

Additions shall not create unsafe or hazardous conditions or overload existing *building* systems. An *addition* shall be deemed to comply with this code if the *addition* alone complies or if the existing building and *addition* comply with this code as a single building.

C502.2 Prescriptive compliance. *Additions* with a construction valuation less than $500,000 shall comply with Sections C502.2.1 through C502.2.6.3. *Additions* complying with Section C407 are exempt from the requirements of Section C502.2.

C502.2.1 Vertical fenestration area. Additions shall comply with the following:

1. Where an addition has a new *vertical fenestration* area that results in a total building *fenestration* area less than or equal to that permitted by Section C402.4.1, the addition shall comply with Section C402.1.5, C402.4.3 or C407.
2. Where an addition with new *vertical fenestration* that results in a total building *fenestration* area greater than permitted by Section C402.4.1 or an *addition* that, itself, exceeds the fenestration area permitted by Section C402.4.1, the fenestration shall

comply with Section C402.4.1.1 for the *addition* only.

3. Where an addition has new *vertical fenestration* that results in a total building vertical fenestration area exceeding that permitted by Section C402.4.1.1, the addition shall comply with Section C402.1.5 or C407.

C502.2.2 Skylight area. Skylights shall comply with the following:

1. Where an addition has new *skylight* area that results in a total building *fenestration* area less than or equal to that permitted by Section C402.4.1, the addition shall comply with Section C402.1.5 or C407.
2. Where an addition has new *skylight* area that results in a total building *skylight* area greater than permitted by C402.4.1 or where additions have skylight area greater than that permitted by Section C402.4.1, the *skylight* area shall comply with Section C402.4.1.2 for the *addition* only.
3. Where an addition has new skylight area that results in a total building *skylight* area exceeding that permitted by Section C402.4.1.2, the addition shall comply with Section C402.1.5 or C407.

C502.2.3 Building mechanical systems. New mechanical systems and equipment that are part of the *addition* and serve the building heating, cooling and ventilation needs shall comply with Section C403.

C502.2.3.1 Mechanical systems acceptance testing. New mechanical systems that serve *additions* shall comply with Sections C408.2.2, C408.2.3 and C408.2.5.

Exceptions:

1. Mechanical systems and service water-heating systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3.1 that serve individual *dwelling units* and *sleeping units*.

C502.2.4 Service water-heating systems. New service water-heating equipment, controls and service water heating piping shall comply with Section C404.

C502.2.4.1 Service hot water systems acceptance testing. New service hot water systems that serve *additions* shall comply with Sections C408.2.3 and C408.2.5.

Exceptions:

1. Service water-heating systems in buildings where the total mechanical equipment capacity is less than 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3.1 that serve individual *dwelling units* and *sleeping units*.

C502.2.5 Pools and inground permanently installed spas. New pools and inground permanently installed spas shall comply with Section C404.10.

C502.2.6 Lighting power and systems. New lighting systems that are installed as part of the addition shall comply with Section C405.

C502.2.6.1 Interior lighting power. The total interior lighting power for the *addition* shall comply with Section C405.3.2 for the *addition* alone, or the existing building and the *addition* shall comply as a single building.

C502.2.6.2 Exterior lighting power. The total exterior lighting power for the *addition* shall comply with Section C405.5.2 for the *addition* alone, or the existing building and the *addition* shall comply as a single building.

C502.2.6.3 Lighting acceptance testing. New lighting systems that serve *additions* shall comply with Section C408.3.

SECTION C503
ALTERATIONS

C503.1 General. *Alterations* to any *building* or structure shall comply with the requirements of Section C503. *Alterations* shall be such that the existing *building* or structure is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration*. *Alterations* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction. When calculating alteration level, only previously conditioned floor area shall count as existing building floor area. *Alterations* shall not create an unsafe or hazardous condition or overload existing *building* systems. *Level 3 alterations* shall also comply with Section C503.8.

Exception: The following *alterations* need not comply with the requirements for new construction, provided that the energy use of the building is not increased:

1. Storm windows installed over existing *fenestration*.
2. Surface-applied window film installed on existing single-pane *fenestration* assemblies reducing solar heat gain, provided that the code does not require the glazing or *fenestration* to be replaced.
3. Existing ceiling, wall or floor cavities exposed during construction, provided that these cavities are filled with insulation.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. *Roof recover*.

5.1. *Air barriers* shall not be required for *roof recover* and roof replacement where the *alterations* or renovations to the building do

not include *alterations*, renovations or *repairs* to the remainder of the building envelope.

C503.2 Change in space conditioning. Any nonconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code as if new construction.

Exceptions:

1. Where the component performance alternative in Section C402.1.5 is used to comply with this section, the proposed total UA of the existing building, the addition, and any alterations shall be less than or equal to the total UA of the existing building.
2. Where the total building performance option in Section C407 is used to show compliance with this section, the annual energy cost of the proposed design shall be not greater than 110 percent of the annual energy cost otherwise permitted by Section C407.3.

C503.3 Building envelope. New building envelope assemblies that are part of the *alteration* shall comply with Sections C402.1 through C402.5. Level 1 and 2 *alterations* are exempt from the requirement of Sections C402.5.1.2, C402.5.1.3 and C402.5.1.4.

Exception: Where the existing building exceeds the fenestration area limitations of Section C402.4.1 prior to alteration, the building is exempt from Section C402.4.1 provided that there is not an increase in fenestration area.

C503.3.1 Roof replacement. *Roof replacements* shall comply with Section C402.1.3, C402.1.4, C402.1.5 or C407 where the existing roof assembly is part of the *building thermal envelope* and contains insulation entirely above the roof deck. In no case shall the R-value of the roof insulation be reduced or the U-factor of the roof assembly be increased as part of the *roof replacement*.

C503.3.2 Vertical fenestration. The addition of *vertical fenestration* that results in a total building *fenestration* area less than or equal to that specified in Section C402.4.1 shall comply with Section C402.1.5, C402.4.3 or C407. The addition of *vertical fenestration* that results in a total building *fenestration* area greater than Section C402.4.1 shall comply with Section C402.4.1.1 for the space adjacent to the new fenestration only. *Alterations* that result in a total building *vertical fenestration* area exceeding that specified in Section C402.4.1.1 shall comply with Section C402.1.5 or C407. Provided that the vertical fenestration area is not changed, using the same vertical fenestration area in the *standard reference design* as the building prior to alteration shall be an alternative to using the vertical fenestration area specified in Table G3.1 of Appendix G of ASHRAE 90.1-2022.

C503.3.3 Skylight area. New *skylight* area that results in a total building *skylight* area less than or equal to that specified in Section C402.4.1 shall comply with Section C402.1.5, C402.4 or C407. The addition of *skylight* area that results in a total building skylight area greater than Section C402.4.1 shall comply with Section C402.4.1.2 for the space adjacent to the new skylights. *Alterations* that result in a total building skylight area exceeding that specified in Section C402.4.1.2 shall comply with Section C402.1.5 or C407. Provided that the skylight area is not changed, using the same skylight area in the *standard reference design* as the building prior to alteration shall be an alternative to using the skylight area specified in Table G3.1 of Appendix G of ASHRAE 90.1-2022.

C503.4 Heating and cooling systems. New heating, cooling and duct systems that are part of the *alteration* shall comply with Sections C403. *Level 1*, *2* and *3 alterations* are exempt from the requirements of Section C403.3. New combustion equipment shall not be installed where there was not one previously installed.

C503.4.1 Economizers. New cooling systems that are part of *alteration* shall comply with Section C403.5.

C503.4.2 Mechanical system acceptance testing. New mechanical systems that serve *alterations* shall comply with Sections C408.2.2, C408.2.3 and C408.2.5.

Exceptions:

1. Mechanical systems and service water-heating systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3.1 that serve individual *dwelling units* and *sleeping units*.

C503.5 Service hot water systems. New service hot water systems that are part of the *alteration* shall comply with Section C404. *Level 1*, *2* and *3 alterations* are exempt from the requirements of Section C404.2.

C503.5.1 Service hot water system acceptance testing. New service hot water systems that serve *alterations* shall comply with Sections C408.2.3 and C408.2.5.

Exceptions:

1. Service water-heating systems in buildings where the total mechanical equipment capacity is less than 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3.1 that serve individual *dwelling units* and *sleeping units*.

C503.6 Lighting systems. New lighting systems that are part of the *alteration* shall comply with Section C405.

Exception. *Alterations* that replace less than 10 percent of the luminaires in a space, provided that such *alterations* do not increase the installed interior lighting power.

C503.6.1 Lighting acceptance testing. New lighting systems that serve *alterations* shall comply with Section C408.3.

C503.7 Electric Ready (Level 3 alterations only). In the case of a *level 3 alteration* that is a first tenant finish, the requirements of Section C405.20 shall also be met.

C503.8 Level 3 alterations. In addition to the other requirements of this section, *Level 3 alterations* shall also comply with Section C407.3 except that EUI target shall be not greater than 125 percent of the EUI otherwise permitted by Section C407.3. For *Level 3 alterations* that also include both *substantial mechanical alteration* and *substantial thermal envelope alteration*, the principle/primary space conditioning equipment shall be all-electric or fueled by an energy source other than fossil fuels.

SECTION C504
REPAIRS

C504.1 General. *Buildings*, and structures, and parts thereof shall be repaired in compliance with Section C501.3 and this section. Work on nondamaged components that is necessary for the required *repair* of damaged components shall be considered to be part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section C501.3, ordinary *repairs* exempt from *permit* and abatement of wear due to normal service conditions shall not be subject to the requirements for *repairs* in this section.

Where a building was constructed to comply with ANSI/ASHRAE/IESNA 90.1, repairs shall comply with the standard and need not comply with Sections C402, C403, C404 and C405.

C504.2 Application. For the purposes of this code, the following shall be considered to be repairs:

1. Glass-only replacements in an existing sash and frame.
2. *Roof repairs*.
    2.1. Air barriers shall not be required for *roof repair* where the repairs to the building do not include *alterations*, renovations or *repairs* to the remainder of the building envelope.
3. Replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided that an existing vestibule that separates a conditioned space from the exterior shall not be removed.
4. *Repairs* where only the bulb, the ballast or both within the existing luminaires in a space are replaced, provided that the replacement does not increase the installed interior lighting power.

SECTION C505
CHANGE OF OCCUPANCY OR USE

C505.1 General. Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Where the use in a space changes from one use in Table C405.3.2(1) or C405.3.2(2) to another use in Table C405.3.2(1) or C405.3.2(2), the installed lighting wattage shall comply with Section C405.3. Where the space undergoing a change in occupancy or use is in a building with a fenestration area that exceeds the limitations of Section C402.4.1, the space is exempt from Section C402.4.1 provided that there is not an increase in fenestration area.

Exceptions:

1. Where the component performance alternative in Section C402.1.5 is used to comply with this section, the proposed UA shall be not greater than 110 percent of the target UA.
2. Where performance-based compliance in Section C407 is required to comply with this section, the proposed design EUI or Performance Index (Site Energy) shall be not greater than 110 percent of the EUI or PI (Site Energy) otherwise permitted by Section C407.3.

CHAPTER 6 [CE]
REFERENCED STANDARDS

User note:

About this chapter: *Chapter 6 lists the full title, edition year and address of the promulgator for all standards that are referenced in the code. The section numbers in which the standards are referenced are also listed.*

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 107.

AAMA

American Architectural Manufacturers Association
1827 Walden Office Square
Suite 550
Schaumburg, IL 60173-4268

AAMA/WDMA/CSA 101/I.S.2/A C440—17: North American Fenestration Standard/Specifications for Windows, Doors and Unit Skylights
Table C402.5.2

AHAM

Association of Home Appliance Manufacturers
1111 19th Street NW, Suite 402
Washington, DC 20036

ANSI/AHAM RAC-1—2015: Room Air Conditioners
Table C403.3.2(4)

AHAM HRF-1—2016: Energy, Performance and Capacity of Household Refrigerators, Refrigerator-Freezers and Freezers
Table C403.11.1

AHRI

Air-Conditioning, Heating, & Refrigeration Institute
2111 Wilson Blvd, Suite 500
Arlington, VA 22201

ISO/AHRI/ASHRAE 13256-1 (1998 RA2014): Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014): Water-to-Water and Brine-to-Water Heat Pumps —Testing and Rating for Performance
Table C403.3.2(2)

210/240—2017 and 2023: Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment
Table C403.3.2(1), Table C403.3.2(2)

310/380—2017 (CSA-C744-17): Standard for Packaged Terminal Air Conditioners and Heat Pumps
Table C403.3.2(4)

340/360—2019: Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment
Table C403.3.2(1), Table C403.3.2(2)

365(I-P)—2009: Commercial and Industrial Unitary Air-conditioning Condensing Units
Table C403.3.2(1)

390 (I-P)—2003: Performance Rating of Single Package Vertical Air-conditioners and Heat Pumps
Table C403.3.2(4)

400 (I-P)—2015: Performance Rating of Liquid-to-Liquid Heat Exchangers

440—2008: Performance Rating of Room Fan Coils—with Addendum 1
C403.12.3

460—2005: Performance Rating of Remote Mechanical-draft Air-cooled Refrigerant Condensers
Table C403.3.2(7)

AHRI—continued

550/590 (I-P)—2018: Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle
C403.3.2.1, Table C403.3.2(3)

560—2018: Absorption Water Chilling and Water Heating Packages
Table C403.3.2(3)

910—2014: Performance Rating of Indoor Pool Dehumidifiers
Table C403.3.2(11)

920—2015: Performance Rating of DX-Dedicated Outdoor Air System Units
Table C403.3.2(12), Table C403.3.2(13)

1160 (I-P) —2014: Performance Rating of Heat Pump Pool Heaters (with Addendum 1)
Table C404.2

1200 (I-P)—2013: Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets
C403.11, Table C403.11.1(1), Table C403.11.1(2)

1230—2014: Performance Rating of Variable Refrigerant Flow (VRF) Multi-split Air-Conditioning and Heat Pump Equipment (with Addendum 1)
Table C403.3.2(9)

1250 (I-P)—2014: Standard for Performance Rating in Walk-in Coolers and Freezers
Table C403.11.2.1(3)

1360—2017: Performance Rating of Computer and Data Processing Room Air Conditioners
Table C403.3.2(10), Table C403.3.2(16)

AMCA

Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1806

208—18: Calculation of the Fan Energy Index
C403.8.3

220—19 (R2012): Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating
C402.5.6

230—15: Laboratory Methods of Testing Air Circulating Fans for Rating and Certification
C403.9

500D—18: Laboratory Methods for Testing Dampers for Rating
C403.7.7

ANSI

American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

Z21.10.3/CSA 4.3—17: Gas Water Heaters, Volume III—Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous
Table C404.2

Z21.47/CSA 2.3—16: Gas-fired Central Furnaces
Table C403.3.2(5)

Z83.8/CSA 2.6—16: Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct Furnaces
Table C403.3.2(5)

APSP

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue, Suite 580
Alexandria, VA 22314

14—2019: American National Standard for Portable Electric Spa Energy Efficiency
C404.9

ASABE

American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI 49085

S640—2017: Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)
C405.4

ASHRAE

ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329

ANSI/ASHRAE/ACCA Standard 183—(RA2017): Peak Cooling and Heating Load Calculations in Buildings, Except Low-rise Residential Buildings
C403.1.1

ASHRAE—2020: ASHRAE HVAC Systems and Equipment Handbook—2020
C403.1.1

ISO/AHRI/ASHRAE 13256-1 (1998 RA2014): Water-to-Air and Brine-to-Air Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2 (1998 RA2014): Water-to-Water and Brine-to-Water Heat Pumps—Testing and Rating for Performance
Table C403.3.2(2)

55—2017: Thermal Environmental Conditions for Human Occupancy
Table C407.5.1

90.1—2022: Energy Standard for Buildings Except Low-rise Residential Buildings
C401.2, Table C402.1.3, Table C402.1.4, Table C407.6.1, C502.1, C503.1, C504.1

90.4—2016: Energy Standard for Data Centers
C403.1.2, C405.2.4

140—2014: Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs
C407.6.1

146—2011: Testing and Rating Pool Heaters
Table C404.2

ASME

American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

ASME A17.1—2019/CSA B44—19: Safety Code for Elevators and Escalators
C405.8.2

ASTM

ASTM International
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959

C90—2016A: Specification for Load-bearing Concrete Masonry Units
Table C401.3

C1363—11: Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
C303.1.4.1, Table C402.1.4, 402.2.7

C1371—15: Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
Table C402.3

C1549—2016: Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
Table C402.3

D1003—13: Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
C402.4.2.2

ASTM—continued

D8052/D8052M—2017: Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies
C402.5.1.4

E283—2004(2012): Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen
Table C402.5.2, C402.5.7

E408—13: Test Methods for Total Normal Emittance of Surfaces Using Inspection-meter Techniques
Table C402.3

E779—10(2018): Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
C402.5

E903—2012: Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)
Table C402.3

E1827—2011(2017): Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
C402.5, C606.4

E1918—06(2016): Standard Test Method for Measuring Solar Reflectance of Horizontal or Low-sloped Surfaces in the Field
Table C402.3

E1980—11: Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-sloped Opaque Surfaces
Table C402.3, C402.3.2

E2357—2018: Standard Test Method for Determining Air Leakage of Air Barriers Assemblies
C402.5.1.4

E3158—2018: Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building
C402.5.3

F1281—2017: Specification for Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Pressure Pipe
Table C404.5.2.1

F1361—2017: Standard Test Method for Performance of Open Deep Fat Fryers
Table C406.12(1)

F1484—2018: Standard Test Method for Performance of Steam Cookers
Table C406.12(2)

F1495—2014a: Standard Specification for Combination Oven Electric or Gas Fired
Table C406.12(4)

F1496—2013: Standard Test Method for Performance of Convection Ovens
Table C406.12(4)

F1696—2018: Standard Test Method for Energy Performance of Stationary-Rack, Door-Type Commercial Dishwashing Machines
Table C406.12(3)

F1920—2015: Standard Test Method for Performance of Rack Conveyor Commercial Dishwashing Machines
Table C406.12(3)

F2093—2018: Standard Test Method for Performance of Rack Ovens
Table C406.12(4)

F2144—2017: Standard Test Method for Performance of Large Open Vat Fryers
Table C406.12(1)

F2861—2017: Standard Test Method for Enhanced Performance of Combination Oven in Various Modes
Table C406.12(4)

CRRC

Cool Roof Rating Council
2435 North Lombard Street
Portland, OR 97217

ANSI/CRRC-S100—2020: Standard Test Methods for Determining Radiative Properties of Materials
Table C402.3, C402.3.1

CSA

CSA Group
8501 East Pleasant Valley Road
Cleveland, OH 44131-5516

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors, and Unit Skylights
Table C402.5.2

CSA B55.1—2015: Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units
C404.7

CSA B55.2—2015: Drain Water Heat Recovery Units
C404.7

CTI

Cooling Technology Institute
P. O. Box 681807
Houston, TX 77268

ATC 105—2019: Acceptance Test Code for Water Cooling Tower
Table C403.3.2(7)

ATC 105DS—2018: Acceptance Test Code for Dry Fluid Coolers
Table C403.3.2(7)

ATC 105S—11: Acceptance Test Code for Closed Circuit Cooling Towers
Table C403.3.2(7)

ATC 106—11: Acceptance Test for Mechanical Draft Evaporative Vapor Condensers
Table C403.3.2(7)

STD 201—11: Standard for Certification of Water Cooling Towers Thermal Performances
Table C403.3.2(7)

CTI STD 201 RS(17): Performance Rating of Evaporative Heat Rejection Equipment
Table C403.3.2(7)

DASMA

Door & Access Systems Manufacturers Association, International
1300 Sumner Avenue
Cleveland, OH 44115-2851

105—2017: Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors
C303.1.3, Table C402.5.2

DOE

U.S. Department of Energy
c/o Superintendent of Documents
1000 Independence Avenue SW
Washington, DC 20585

10 CFR, Part 430—2015: Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule
Table C403.3.2(5), Table C403.3.2(6), Table C404.2

10 CFR, Part 430, Subpart B, Appendix N—(2015): Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers
C202

10 CFR, Part 431—2015: Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules
Table C403.3.2(6), C405.6, Table C405.6, C405.7

10 CFR 431 Subpart B App B: Uniform Test Method for Measuring Nominal Full Load Efficiency of Electric Motors
C403.8.4, Table C405.7(1), Table C405.7(2), Table C405.7(3), C405.7(4)

NAECA 87—(88): National Appliance Energy Conservation Act 1987 [Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]
Table C403.3.2(1), Table C403.3.2(2), Table C403.3.2(5)

HVI

Home Ventilating Institute
1740 Dell Range Blvd. Ste H PMB 45
Cheyenne, WY 82009

916—18: Airflow Test Procedure
C403.8.5

ICC

International Code Council, Inc.
500 New Jersey Avenue NW
6th Floor
Washington, DC 20001

ANSI/RESNET/ICC 380—19: Standard for Testing Airtightness of Buildings, Dwelling Unit and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems
C402.5.2, C402.5.3

IBC—21: International Building Code®
C201.3, C303.2, C402.5.3, C501.2

ICC 500—2020: Standard for the Design and Construction of Storm Shelters
C402.4.2

IFC—21: International Fire Code®
C201.3, C501.2

IFGC—21: International Fuel Gas Code®
C201.3, C501.2

IMC—21: International Mechanical Code®
C201.3, C402.5.3, C403.2.2, C403.7.1, C403.7.2, C403.7.4, C403.7.5, C403.7.7, C403.12.1, C403.12.2.1, C403.12.2.2, C403.6, C403.6.6, C501.2

IPC—21: International Plumbing Code®
C201.3, C501.2

IPMC—21: International Property Maintenance Code®
C501.2

IPSDC—21: International Private Sewage Disposal Code®
C501.2

IEEE

Institute of Electrical and Electronic Engineers
3 Park Avenue, 17th Floor
New York, NY 10016

IEEE 515.1—2012: IEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
C404.6.2

IES

Illuminating Engineering Society
120 Wall Street, 17th Floor
New York, NY 10005-4001

ANSI/ASHRAE/IESNA 90.1—2022: Energy Standard for Buildings, Except Low-rise Residential Buildings
C401.2, Table C402.1.3, Table C402.1.4, C502.1, C503.1, C504.1

ISO

International Organization for Standardization
Chemin de Blandonnet 8, CP 401, 1214 Vernier
Geneva, Switzerland

ISO/AHRI/ASHRAE 13256-1(2017): Water-to-Air and Brine-to-Air Heat Pumps -Testing and Rating for Performance
Table C403.3.2(2)

ISO/AHRI/ASHRAE 13256-2(2017): Water-to-Water and Brine-to-Water Heat Pumps -Testing and Rating for Performance
C403.3.2(2)

NBI

New Buildings Institute
151 SW 1st Ave, Suite 300
Portland, OR 97204

Embodied Carbon Building Code (2023): An overlay o model code language for limiting the climate impact of building products
C406.3.8

NEMA

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209

MG1—2016: Motors and Generators
C202

NFPA

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

70—20: National Electrical Code
C501.2

NFRC

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

100—2020: Procedure for Determining Fenestration Products *U-factors*
C303.1.3, C402.2.1.1

200—2020: Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
C303.1.3, C402.4.1.1

203—2017: Procedure for Determining Translucent Fenestration Product Visible Transmittance at Normal Incidence
C303.1.3

400—2020: Procedure for Determining Fenestration Product Air Leakage
Table C402.5.2

SMACNA

Sheet Metal and Air Conditioning Contractors' National Association, Inc.
4021 Lafayette Center Drive
Chantilly, VA 20151-1219

SMACNA—2012: HVAC Air Duct Leakage Test Manual Second Edition
C403.2.11.2.3

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062-2096

710—12: Exhaust Hoods for Commercial Cooking Equipment—with Revisions through November 2013
C403.7.5

727—06: Oil-fired Central Furnaces—with Revisions through October
Table C403.3.2(5)

731—95: Oil-fired Unit Heaters
Table C403.3.2(5)

1784—151: Air Leakage Tests of Door Assemblies—with Revisions through February 2015
C402.5.3

US-FTC

United States-Federal Trade Commission
600 Pennsylvania Avenue NW
Washington, DC 20580

CFR Title 16 (2015): *R*-value Rule
C303.1.4

WDMA

Window and Door Manufacturers Association
2025 M Street NW, Suite 800
Washington, DC 20036-3309

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
Table C402.5.2

APPENDIX CA
BOULDER MODIFIED APPENDIX G PROTOCOL

User note:

About this appendix: *This appendix contains sections of ASHRAE 90.1-2022 Normative Appendix G that have been modified to reflect specific requirements of the 2024 City of Boulder Energy Conservation Code (CoBECC). Only sections of Appendix G that have been modified from the original language are included in this document.*

Section G1
GENERAL

Section G1.2. Performance Rating

G1.2.1 Mandatory Provisions

This *performance rating method* requires conformance with the following provisions:

a. All mandatory requirements of Chapter 4 of the *2024 City of Boulder Energy Conservation Code* (*COBECC*) must be met. These supersede the mandatory requirements in Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ASHRAE Standard 90.1-2022.

b. The interior lighting power shall not exceed the *interior lighting power allowance* determined using either:

   1. Tables G3.7-1 and G3.7-2 and the methodology described in Section 9.5.2, or
   2. Table G3.8 and the methodology described in Section 9.5.1.

c. Energy *efficiency* levels of installed components and *systems* shall meet or exceed the efficiency levels used to calculate the *proposed building performance*.

d. The proposed envelope U factors shall not exceed the performance requirements of ASHRAE 90.1-2016 listed in Table 5.5-5. No tradeoffs of envelope performance below these levels are allowed.

e. Verification, testing and *commissioning* requirements of Section C408 of the 2024 City of Boulder Energy Conservation Code shall supersede the requirements of Section 4.2.5.

f. The proposed HVAC equipment efficiencies at a minimum shall meet the performance requirements determined in Tables 6.8.1-1 through Table 6.8.1-21.

G1.2.2 Performance Rating Calculation

All new construction in Boulder with a construction value of $500,000 or more must comply with Section G1.2.2.1, G1.2.2.2 or G1.2.2.3, below.

G1.2.2.1 Modeled Baseline

Compliance with Section C407.3.1 of the 2024 CoBECC, Modeled Baseline path requires that the Performance Index target (PI_t) (site energy) for the *proposed design* be reduced by 15 percent for mixed-fuel buildings and 10 percent for all-electric buildings from a PI_t (site energy) target that complies with the ASHRAE 90.1-2022 as modified by Appendix I for "site energy".

The performance of the *proposed design* is calculated in accordance with the provisions of this protocol using the equation G1.2.2.1.1 or G1.2.2.1.2 below as applicable. Both the proposed building performance and baseline building performance shall include all end-use load components within and associated with the building when calculation the Performance EUI for Site Energy.

Mixed Fuel Buildings:

$$PIt_{site} = 0.85 \times (BBUE + (BPF_{site} \times BBRE) \quad BBP$$

(Eq. G1.2.2.1.1)

All Electric Buildings:

$$PIt_{site} = 0.90 \times (BBUE + (BPF_{site} \times BBRE) \quad BBP$$

(Eq. G1.2.2.1.2)

where:

PIt_{site} = The maximum Performance Index (Site Energy) for the *proposed design* to comply with the Boulder Energy Code

BBUE = Baseline Building Unregulated *Site Energy*, the portion of the annual site energy of a *baseline building design* that is due to *unregulated energy use*.

BBRE = Baseline *Building* Regulated *Site Energy*. The portion of the annual *site energy* of a *baseline building design* that is due to *regulated energy use*.

BPF_{site} = *Building* Performance Factor (BPF) from Table G1.2 below. For *building* area types not listed in the table, use "All Others." Where a *building* includes multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types. (Table G1.1 replaces Table 4.2.1.1 in 90.1- 2022)

BBP = *Baseline Building Performance*. The annual *site energy* of the *baseline building design*

including both *regulated* and *unregulated energy use*.

TABLE G1.1
BUILDING PERFORMANCE FACTORS FOR SITE ENERGY USE (BPF_{SITE})

USE TYPE	BPF
Office	0.52
Retail	0.47
School	0.50
Healthcare	0.63
Restaurant	0.69
Hotel	0.66
Warehouse	0.45
Apartment	0.67
All Others	0.50

G1.2.2.2 Fixed Performance Target

Projects of the types listed in Table G1.2 may use the site EUI targets identified in the Table G1.2 in lieu of baseline modeling of performance index (PI) (site energy). The *proposed building model* predicted performance will be demonstrated not to exceed the values in this table, using the energy modeling procedures described in this appendix. *Buildings* with multiple occupancy types listed in Table G1.2 (only) may develop a performance target based on an area weighted average EUI calculated by floor area of each occupancy type.

TABLE G1.2
FIXED PERFORMANCE TARGETS FOR PERFORMANCE PATHWAY

TABLE G1.2
SITE EUI TARGETS

BUILDING TYPE	PERFORMANCE TARGETS ($kBtu/ft^2/year$)
Medium Office (5,000-50,000 sf)	23
Mid-rise Apartment	32
Primary School	34
Large Office (> 50,000 sf)	40
Small Office (< 5,000 sf)	19
Secondary School	31
Warehouse	11
Retail Store	40
Small Hotel	35
Hospital	76
Restaurant	200
Strip Mall	40

G1.2.2.3 Measured Performance Outcome

With approval of the *chief building official*, projects may demonstrate compliance with the 2024 CoBECC by proving that the building has achieved the modeled performance calculated in accordance with Section G1.2.2.1 or G1.2.2.2, based on metered energy use after occupancy. Section C407.3.3 of the 2024 CoBECC outlines how projects comply with this path.

Section G1.3 Documentation Submittal Requirements

The building permit application for performance rating shall include all *building* and mechanical drawings and information necessary to verify that the building envelope and mechanical design for the project corresponds with the annual energy analysis. This includes, but is not limited to, equipment and material cut sheets, specifications, and sequences of operations. If credit for lighting energy savings is proposed to be taken, then electrical drawings and proposed lighting power density calculation shall be submitted. If credit is proposed to be taken for energy savings from plug-in equipment or control measures, then such measures should be pre-approved by the *code official*. Measures of the project that are not approved as part of the building permit application shall be modeled the same way in both the *proposed building* and *baseline design* and shall comply with the requirements of the 2024 CoBECC.

Simulated performance shall be documented, and documentation shall be submitted to the building official. The information shall be submitted in a report and shall include the following:

a. The performance path chosen per Section C407.3 of the 2024 CoBECC, the *simulation program* used, the version of the *simulation program*, and the results of the *energy* analysis, including the calculated values for the baseline *building* unregulated site energy (BBUE), baseline building regulated site *energy* (BBRE), *building* performance factor (BPF_{site}), *baseline building performance*, the *proposed building* performance, proposed Performance Index for site *energy* (PI_{site}), and target Performance Index for site *energy* (PIt_{site}) and the percentage improvement. A brief description of the project, the key *energy efficiency* improvements compared with the requirements in Sections 5 through 10, the *simulation program* used, the version of the *simulation program*, the performance pathway used (per 2024 CoBECC, Section C407.3), and the results of the *energy* analysis. This summary shall contain the calculated values for the *baseline building performance (or EUI target)*, the *proposed building performance*, and the percentage improvement.

b. An overview of the project that includes the number of stories (above and below *grade*), the typical *floor* size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is *conditioned space*.

c. A list of the *energy*-related features that are included in the design and on which the performance rating is based. This list shall document all *energy* features that differ between the models used in the *baseline building performance* and *proposed building performance* calculations.

d. A list showing compliance for the *proposed design* with all the mandatory provisions in Table C407.2 of the 2024 CoBECC.

e. Documentation of compliance with the backstop values found in of Table 5.5-5 and Tables 6.8.1 to 6.8.1.7 of the ASHRAE 90.1-2016 (Identified in Section C407.4.2 of the 2024 CoBECC)

f. A table with a summary by end use of the *proposed building performance energy use intensity* (EUI) and the baseline building performance EUI, with each end-use separated into regulated and unregulated components.

A site plan showing all adjacent *buildings* and topography that may shade the proposed *building* (with estimated height or number of *stories*).

g. *Building* elevations and *floor* plans (schematic is acceptable).

h. A diagram showing the *thermal blocks* used in the computer simulation.

i. An explanation of any significant modeling assumptions.

j. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table G3.1(1)(a) of ASHRAE 90.1-2022.

k. *Building* elevations and *floor* plans (schematic is acceptable).

l. A diagram showing the *thermal blocks* used in the computer simulation.

m. An explanation of any significant modeling assumptions.

n. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table G3.1(1)(a) of ASHRAE 90.1-2022.

o. Input and output reports from the *simulation program* or compliance software, including a breakdown of *energy* use by at least the following components: lights, internal *equipment* loads, *service water- heating equipment*, *space*-heating *equipment*, *space*-cooling and heat rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of *unmet load hours* for both the *proposed design* and *baseline building design*.

p. *Purchased energy rates* used in the simulations.

q. An explanation of any error messages noted in the *simulation program* output.

r. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* use intensity savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

s. The reduction in *proposed building performance* associated with *on-site renewable energy*.

t. The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section G2.2.4 of ASHRAE 90.1-2022.

The Commercial Energy Modeling Summary Report template can be found at www.BoulderEnergyCode.com.

Section G2
SIMULATION GENERAL REQUIREMENTS

Section G2.1 Performance Calculations

The *proposed building* performance and *baseline building* performance shall be calculated using the following:

a. The same *simulation program*.

b. The same weather data.

c. The same *energy* rates.

d. The same required *building* schedules (unless changes are pre-approved by the building official).

e. The same required *equipment* power densities (unless changes are pre-approved by the building official).

Section G2.4
Renewable, Recovered, and Purchased Energy

G2.4.1 On-site Renewable Energy and Site-Recovered Energy

Site-recovered energy shall not be considered *purchased energy* and shall be subtracted from the *proposed design energy* consumption prior to calculating the *proposed building performance*. *On-site renewable energy* generated by *systems* included on the *building* permit that is used by the *building* shall be subtracted from the *proposed design energy* consumption prior to calculating the *proposed building performance*. The reduction in *proposed building site energy performance (EUI)* associated with *on-site renewable energy* systems shall be at least 5 percent of the calculated *proposed building performance* when following Section C407.3.1 of the 2024 CoBECC and Section G1.2.2.1 of this protocol. Where the proposed design includes electricity generated from sources other than *on-site renewable energy*, the baseline design shall include the same generation system.

Section G3
CALCULATION OF THE PROPOSED DESIGN AND BASELINE BUILDING PERFORMANCE

TABLE G3.1
MODELING REQUIREMENTS FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*

NO. 4 SCHEDULES		
No.	**Proposed Building Performance**	**Baseline Building Performance**
4. Schedule		
	Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous *equipment* power, *thermostat set points*, infiltration, service hot water usage and *HVAC system* operation shall be used. Projects are required to use the schedules provided in Table G.4. **Exception:** For buildings where non-standard operations are anticipated, projects may propose specific schedule modifications for pre-approval by the *chief building official.* ~~The schedules shall be typical of the proposed building type as determined by the designer and approved by the *rating authority.*~~ **Temperature and Humidity Schedules.** Temperature and humidity *control set points* and schedules as well as *temperature control throttling range* shall be the same for *proposed design* and *baseline building design*. **HVAC Fan Schedules.** Schedules for HVAC fans that provide *outdoor air* for *ventilation* shall run continuously whenever *spaces* are occupied and shall be cycled ON and OFF to meet heating and cooling loads during unoccupied hours. **Exceptions:** 1. Where no heating and/or cooling *system* is to be installed, and a heating or cooling *system* is being simulated only to meet the requirements described in this table, heating and/or cooling *system* fans shall not be simulated as running continuously during occupied hours but shall be cycled ON and OFF to meet heating and cooling loads during all hours. 2. HVAC fans shall remain on during occupied and unoccupied hours in *spaces* that have health- and safety-mandated minimum *ventilation* requirements during unoccupied hours. 3. HVAC fans shall remain on during occupied and unoccupied hours in *systems* primarily serving *computer rooms*. 4. Dedicated *outdoor air* supply fans shall stay off during unoccupied hours.	Same as *proposed design*. **Exceptions:** 1. *Set points* and schedules for *HVAC systems* that automatically provide occupant thermal comfort via means other than directly controlling the air dry-bulb and wet-bulb temperature may be allowed to differ, provided that equivalent levels of occupant thermal comfort are demonstrated via the methodology in ASHRAE Standard 55, Section 5.3.3, "Elevated Air Speed," or Standard 55, Appendix B, "Computer Program for Calculation of PMV-PPD." 2. Schedules may be allowed to differ between *proposed design* and *baseline building design* when necessary to model nonstandard *efficiency* measures, provided that the revised schedules have been approved by the *chief building official* ~~rating authority~~. Measures that may warrant use of different schedules include but are not limited to *automatic* lighting *controls*, *automatic* natural *ventilation controls*, *automatic demand control ventilation controls*, and *automatic controls* that reduce *service water-heating* loads or process loads. In no case shall schedules differ where the *controls* are *manual* (e.g., *manual* operation of light switches or *manual* operation of windows). 3. *HVAC* system fan schedules may be allowed to differ when Section G3.2.1.2(a) of ASHARE 90.1-2022 applies. 4. For *systems* 6 and 8, only *terminal*-unit fan and *reheat* coil shall be energized to meet heating *set point* during unoccupied hours.

(continued)

TABLE G3.1
MODELING REQUIREMENTS FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

NO. 12 RECEPTACLE AND OTHER LOADS		
No.	**Proposed Building Performance**	**Baseline Building Performance**
12. Receptacle and Other Loads		
Receptacle and *process loads*, such as those for office and other *equipment*, ~~shall be estimated based on the *building area type* or *space* type category and~~ shall be assumed to be identical in the *proposed design* and *baseline building design*, except as specifically approved by the *building official*. ~~only when quantifying performance that exceeds the requirements of Standard 90.1 but not when the *Performance Rating Method* is used as an alternative path for minimum standard compliance in accordance with Section 4.2.1.1. These loads~~ Receptacle and process loads shall always be included in simulations of the *building*. These loads shall be included when calculating the *proposed building performance* and the *baseline building performance* as required by Section G1.2.1. **Exception:** When receptacle controls installed in *spaces* where not required by Section C405.11 of the 2024 CoBECC, are included in the *proposed building design*, the hourly receptacle shall be reduced as follows: RPC = RC x 10% Where: RPC = receptacle power credit EPS_{pro} = EPS_{bas} x (1 - RPC) RC = percentage of all controlled receptacles EPS_{bas} = *baseline equipment* power hourly schedule (fraction) EPS_{pro} = Proposed equipment power hourly schedule (fraction) a. Where power and other *systems* covered by Sections 8 and 10 of ASHRAE 90.1-2022 have been designed and submitted with design documents, those *systems* shall be determined in accordance with Sections 8 and 10. b. Where power and other *systems* covered by Sections 8 and 10 of ASHRAE 90.1-2022 have not been submitted with design documents, those *systems* shall comply with but not exceed the requirements of those sections. *c.* *Equipment controls (e.g. Computer Power Management, Advanced Power Strips etc.)* designed to improve energy performance shall be modeled in the *proposed design* using equipment schedule adjustments approved by the *rating authority.*	Equipment power density in the baseline building design shall be determined using the whole building or space-by-space values in Table G.5.1 and Table G.5.2 of this protocol. The default values cover energy used for equipment that is normally plugged into convenience outlets and does not include process equipment such as commercial refrigeration cases, walk-in freezers and refrigerators, cooking equipment, elevators, and other devices. Standardized receptacle hourly schedules shall be used with the specified power densities. Motors shall have minimum *efficiency* ratings found in Table G3.9.1. Other *systems* covered by Section 10 of ASHRAE 90.1-2022 and miscellaneous loads shall be modeled as identical to those in the *proposed design* ~~including schedules of operation and *control* of the *equipment*. *Energy* used for cooking *equipment*, receptacle loads, computers, medical or laboratory *equipment*, and manufacturing and industrial process *equipment* not specifically identified in the standard power and *energy* rating or capacity of the *equipment* shall be identical between the *proposed building performance* and the *baseline building performance*.~~ **Exceptions:** When quantifying performance that exceeds the requirements of Standard 90.1, variations of the power requirements, schedules, or *control* sequences of the *equipment* modeled in the *baseline building design* from those in the *proposed design* shall be approved by the *building official* based on documentation that the *equipment* installed in the proposed design represents a significant verifiable departure from documented current conventional practice. The burden of this documentation is to demonstrate that accepted conventional practice would result in baseline building equipment different from that installed in the proposed design. Occupancy and occupancy schedules shall not be changed.

Section G4
REQUIRED SCHEDULES (New Section)

All projects using the performance pathway shall use the mandatory *building* schedules and *equipment* power density schedules provided Table G4 below.

Exceptions:

1) The *chief building official* may approve alternate schedules prior to submittal to account for special use conditions. The same values must be used in the *baseline* and *proposed building* model.

2) The code official may approve alternate schedules for unregulated loads in the *proposed building design* that reflect plug and process load management strategies.

ADDITION TO APPENDIX G: TABLE G.5.1
PLUG LOAD MODELING REQUIREMENTS
WHOLE BUILDING

WHOLE BUILDING CATEGORIES	DEFAULT EQUIPMENT POWER DENSITY (W/ft²)
Automotive Facility	0.5
Convention Center	0.75
Courthouse	1.67
Dining: Bar Lounge/Leisure	1.32
Dining: Cafeteria/Fast Food	1.37
Dining: Family	1.26
Dormitory	1.96
Exercise Center	0.67
Fire Station	1.54
Gymnasium	0.67
Healthcare Clinic	1.22
Hospital	1.25
Hotel	1.56
Library	0.94
Manufacturing Facility	0.34
Motel	1.56
Motion Picture Theater	0.74
Multifamily	1.42
Museum	0.74
Office	0.75
Parking Garage	n.a.
Penitentiary	1.49
Performing Arts Theater	0.74
Police Station	1.54
Post Office	0.91
Religious Building	0.3
Retail	0.7
School/University	0.69
Sports Arena	0.75

(continued)

ADDITION TO APPENDIX G: TABLE G.5.1
PLUG LOAD MODELING REQUIREMENTS
WHOLE BUILDING—continued

WHOLE BUILDING CATEGORIES	DEFAULT EQUIPMENT POWER DENSITY (W/ft²)
Town Hall	0.75
Transportation	0.52
Warehouse	0.3
Workshop	0.43

ADDITION TO APPENDIX G: TABLE G.5.2
PLUG LOAD MODELING REQUIREMENTS
SPACE-BY-SPACE

SPACE-BY-SPACE CLASSIFICATIONS	DEFAULT EQUIPMENT POWER DENSITY (W/ft²)
Audience Seating Area, Auditorium	0.75
Audience Seating Area, Religious Building	0.73
Audience Seating Area, Sports Arena	0.74
Audience Seating Area, Transportation Facility	0.75
Audience Seating Area, Other	0.75
Atrium, Less than or equal to 40 ft	n.a.
Atrium, More than 40 ft	n.a.
Banking Activity Area	1.72
Classroom/Lecture/Training, Penitentiary	0.59
Classroom/Lecture/Training, K-12, laboratory, and shops	0.59
Classroom/Lecture/Training, Other	0.59
Conference/Meeting/Multipurpose	0.73
Confinement Cells	1.49
Copy/Print Room,*	UWBD[a]
Corridor, Assisted Living	1.4
Corridor, Hospital	1.25
Corridor, Manufacturing	0.34
Corridor, Other*	UWBD[a]
Courtroom	1.49
Computer Room	n.a.
Dining Area, Penitentiary	1.26
Dining Area, Assisted Living	1.32
Dining Area, Bar Lounge/Leisure	1.26
Dining Area, Cafeteria or Fast Food	1.37
Dining Area, Family Dining	1.32
Dining Area, Other	1.32
Electrical/Mechanical, *	UWBD[a]
Emergency Vehicle Garage	0.58
Food Preparation	1.32
Guest Room	1.56
Judge's Chambers	1.49
Laboratory, Classrooms	3.34

(continued)

**ADDITION TO APPENDIX G: TABLE G.5.2
PLUG LOAD MODELING REQUIREMENTS
SPACE-BY-SPACE—continued**

SPACE-BY-SPACE CLASSIFICATIONS	DEFAULT EQUIPMENT POWER DENSITY (W/ft²)
Laboratory, Other	3.34
Laundry/Washing Area	0.52
Loading Dock, Interior	n.a.
Lobby, Assisted Living	1.4
Lobby, Elevator*	UWBD[a]
Lobby, Hotel	1.56
Lobby, Motion Picture Theater	0.74
Lobby, Performing Arts Theater	0.74
Lobby, Other*	UWBD[a]
Locker Room	n.a.
Lounge/Break, Healthcare	1.25
Lounge/Break, Other*	UWBD[a]
Office, Enclosed	0.75
Office, Open Plan	0.75
Parking Area, Interior	n.a.
Pharmacy Area	0.55
Restrooms, Assisted Living	1.4
Restrooms, Other*	UWBD[a]
Sales Area	0.55
Seating Area General, *	UWBD[a]
Stairway, *	UWBD[a]
Storage, Hospital	1.25
Storage, >= 50 ft^2	0.31
Storage, < 50 ft^2	0.31
Vehicular Maintenance	0.5
Workshop	0.43
Assisted Living, Chapel	1.4
Assisted Living, Recreation Room	1.4
Convention Center, Exhibit Space	0.75
Dormitory, Living Quarters	1.96
Fire Station, Sleeping Quarters	1.54
Gymnasium/Fitness Center, Exercise Area	0.67
Gymnasium/Fitness Center, Playing Area	0.67
Healthcare, Emergency Room	1.25
Healthcare, Exam/Treatment	1.25
Healthcare, Supply Room	1.25
Healthcare, Nursery	1.25
Healthcare, Nurses' Station	1.25
Healthcare, Operating Room	1.25
Healthcare, Patient Room	1.25
Healthcare, Physical Therapy	1.25

(continued)

**ADDITION TO APPENDIX G: TABLE G.5.2
PLUG LOAD MODELING REQUIREMENTS
SPACE-BY-SPACE—continued**

SPACE-BY-SPACE CLASSIFICATIONS	DEFAULT EQUIPMENT POWER DENSITY (W/ft²)
Healthcare, Recovery Room	1.25
Library, Reading Area	0.94
Library, Stacks	0.94
Manufacturing Facility, Detailed Manufacturing	0.34
Manufacturing Facility, Equipment Room	0.34
Manufacturing Facility, Extra High Bay (>50 ft Floor to Ceiling Height)	0.34
Manufacturing Facility, High Bay (25–50 ft Floor to Ceiling Height)	0.34
Manufacturing Facility, Low Bay (<25 ft Floor to Ceiling Height)	0.34
Museum, General Exhibition	0.74
Museum, Restoration	0.43
Post Office, Sorting Area	1.67
Religious Building, Fellowship Hall	0.3
Religious Building, Worship/Pulpit/Choir	0.3
Retail, Dressing/Fitting Room	0.82
Retail, Mall Concourse	0
Sports Arena Playing Area, Class I	0.67
Sports Arena Playing Area, Class II	0.67
Sports Arena Playing Area, Class III	0.67
Sports Arena Playing Area, Class IV	0.67
Transportation, Baggage/Carousel Area	0.76
Transportation, Concourse	0.76
Transportation, Ticket Counter	0.76
Warehouse, Medium/Bulky Items on Pallets	0.31
Warehouse, Smaller Hand Carried Items	0.31

a. UWBD = Use whole building data.

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*

C-1 ASSEMBLY SCHEDULES			HOUR ENDING																							
Description	Type	Day	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 pm
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.20	0.20	0.20	0.20	0.10	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.80	0.10	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.20	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.35	0.35	0.35	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.25	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.30	0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.30	0.30	0.30	0.30	0.30	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.40	0.40	0.40	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.30	0.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.30	0.30	0.30	0.30	0.30	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.05	0.05
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00
ClgSetPt	Temperature	WD	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80
		Sat	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80
		Sun	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80
HtgSetPt	Temperature	WD	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60
		Sat	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60
		Sun	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60
Service Hot Water	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.35	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.30	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.30	0.00	0.00	0.00
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-2 HEALTH			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.50	0.50	0.40	0.40	0.40	0.40
		Sat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.50	0.40	0.40	0.40	0.40	0.40
		Sun	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Lights	Fraction	WD	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Sat	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.50	0.50	0.50	0.50	0.50	0.50
		Sun	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Receptacle	Fraction	WD	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.70	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.40
		Sat	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.40	0.40	0.40	0.40	0.40	0.40
		Sun	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Infiltration	Fraction	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sun	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ClgSetPt	Temperature	WD	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sat	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sun	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HtgSetPt	Temperature	WD	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sat	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sun	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Service Hot Water	Fraction	WD	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.17	0.58	0.66	0.78	0.82	0.71	0.82	0.78	0.74	0.63	0.41	0.18	0.18	0.18	0.15	0.15	0.15
		Sat	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.20	0.28	0.30	0.30	0.24	0.24	0.23	0.23	0.23	0.15	0.15	0.15	0.15	0.15	0.15	0.15
		Sun	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-4 MANUFACTURING			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.95	0.95	0.95	0.95	0.50	0.95	0.95	0.95	0.95	0.30	0.10	0.10	0.10	0.10	0.05	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.85	0.85	0.85	0.85	0.75	0.85	0.85	0.85	0.85	0.65	0.65	0.65	0.65	0.65	0.25	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.90	0.90	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.65	0.65	0.65	0.65	0.65	0.25	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80
		Sat	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	80	80	80	80	80	80
		Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HtgSetPt	Temperature	WD	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
		Sat	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.19	0.35	0.38	0.39	0.47	0.57	0.54	0.34	0.33	0.44	0.26	0.21	0.15	0.17	0.08	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.11	0.15	0.21	0.19	0.23	0.20	0.19	0.15	0.12	0.14	0.07	0.07	0.07	0.07	0.09	0.05	0.05
		Sun	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.09	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-3 HOTEL/MOTEL			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.50	0.50	0.50	0.70	0.70	0.80	0.90	0.90
		Sat	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.50	0.50	0.50	0.70	0.70	0.80	0.90	0.90
		Sun	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.50	0.50	0.50	0.70	0.70	0.80	0.90	0.90
Lights	Fraction	WD	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
		Sat	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
		Sun	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
Receptacle	Fraction	WD	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
		Sat	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
		Sun	0.10	0.10	0.10	0.10	0.10	0.30	0.45	0.45	0.45	0.45	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.60	0.80	0.90	0.80	0.60	0.30
Infiltration	Fraction	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sun	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ClgSetPt	Temperature	WD	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
		Sat	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
		Sun	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
HtgSetPt	Temperature	WD	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
		Sat	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
		Sun	60	60	60	60	60	60	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	60	60
Service Hot Water	Fraction	WD	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
		Sat	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
		Sun	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-5 OFFICE			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.95	0.95	0.95	0.95	0.50	0.95	0.95	0.95	0.95	0.30	0.10	0.10	0.10	0.10	0.05	0.05
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.30	0.30	0.20	0.20	0.10	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.90	0.90	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.50	0.40	0.40	0.40	0.40	0.40	0.40
		Sat	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.40	0.50	0.50	0.50	0.50	0.35	0.35	0.35	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30
		Sun	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80
		Sat	80	80	80	80	80	78	77	75	75	75	75	75	75	75	75	75	75	80	80	80	80	80	80	80
		Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HtgSetPt	Temperature	WD	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
		Sat	60	60	60	60	60	64	67	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.19	0.35	0.38	0.39	0.47	0.57	0.54	0.34	0.33	0.44	0.26	0.21	0.15	0.17	0.08	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.08	0.07	0.11	0.15	0.21	0.19	0.23	0.20	0.19	0.15	0.12	0.14	0.07	0.07	0.07	0.07	0.09	0.05	0.05
		Sun	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04	0.04	0.04	0.04	0.06	0.06	0.09	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.04	0.04
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-6 PARKING GARAGE			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50
		Sat	0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Sun	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Receptacle	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sun	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
HtgSetPt	Temperature	WD	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sun	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Service Hot Water	Fraction	WD	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sun	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-7 RESTAURANT			HOUR ENDING																							
Description	Type	Day	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 pm
Occupancy	Fraction	WD	0.05	0.00	0.00	0.00	0.00	0.05	0.10	0.40	0.40	0.40	0.20	0.50	0.80	0.70	0.40	0.20	0.25	0.50	0.80	0.80	0.80	0.50	0.35	0.20
		Sat	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.50	0.50	0.40	0.20	0.45	0.50	0.50	0.35	0.30	0.30	0.30	0.70	0.90	0.70	0.65	0.55	0.35
		Sun	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.50	0.50	0.20	0.20	0.30	0.50	0.50	0.30	0.20	0.25	0.35	0.55	0.65	0.70	0.35	0.20	0.20
Lights	Fraction	WD	0.15	0.15	0.15	0.15	0.15	0.20	0.40	0.40	0.60	0.60	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.30
		Sat	0.20	0.15	0.15	0.15	0.15	0.15	0.30	0.30	0.60	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.90	0.90	0.90	0.90	0.50	0.30
		Sun	0.20	0.15	0.15	0.15	0.15	0.15	0.30	0.30	0.50	0.50	0.70	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.30
Receptacle	Fraction	WD	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.20	0.18	0.09	0.03
		Sat	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.20	0.18	0.09	0.03
		Sun	0.03	0.02	0.03	0.02	0.05	0.12	0.13	0.15	0.18	0.21	0.26	0.29	0.27	0.25	0.23	0.23	0.26	0.26	0.24	0.22	0.20	0.18	0.09	0.03
Infiltration	Fraction	WD	0.25	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.25	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sun	0.25	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ClgSetPt	Temperature	WD	86	86	86	86	86	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sat	86	86	86	86	86	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sun	86	86	86	86	86	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HtgSetPt	Temperature	WD	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sat	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sun	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Service Hot Water	Fraction	WD	0.20	0.15	0.15	0.00	0.00	0.00	0.00	0.60	0.55	0.45	0.40	0.45	0.40	0.35	0.30	0.30	0.30	0.40	0.55	0.60	0.50	0.55	0.45	0.25
		Sat	0.20	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.45	0.50	0.50	0.45	0.40	0.40	0.35	0.40	0.55	0.55	0.50	0.55	0.40	0.30
		Sun	0.25	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.40	0.40	0.30	0.30	0.30	0.40	0.50	0.50	0.40	0.50	0.40	0.20
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-8 RETAIL			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.50	0.50	0.70	0.70	0.70	0.70	0.80	0.70	0.50	0.50	0.30	0.30	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.50	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.20	0.20	0.20	0.10	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.20	0.40	0.40	0.40	0.40	0.40	0.20	0.10	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20	0.40	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.50	0.50	0.20	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.30	0.60	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.50	0.30	0.30	0.10	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.40	0.20	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.40	0.60	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.70	0.20	0.20
		Sat	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.30	0.50	0.80	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.70	0.50	0.50	0.30	0.15
		Sun	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.30	0.60	0.60	0.80	0.80	0.80	0.80	0.80	0.60	0.40	0.15	0.15	0.15	0.15
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85	85
		Sat	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85
		Sun	85	85	85	85	85	85	85	85	85	80	75	75	75	75	75	75	75	75	75	75	85	85	85	85
HtgSetPt	Temperature	WD	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60
		Sat	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60
		Sun	60	60	60	60	60	60	60	60	60	65	70	70	70	70	70	70	70	70	70	70	60	60	60	60
Service Hot Water	Fraction	WD	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.15	0.23	0.32	0.41	0.57	0.62	0.61	0.50	0.45	0.46	0.47	0.42	0.34	0.33	0.23	0.13	0.08
		Sat	0.11	0.10	0.08	0.06	0.06	0.06	0.07	0.20	0.24	0.27	0.42	0.54	0.59	0.60	0.49	0.48	0.47	0.46	0.44	0.36	0.29	0.22	0.16	0.13
		Sun	0.07	0.07	0.07	0.06	0.06	0.06	0.07	0.10	0.12	0.14	0.29	0.31	0.36	0.36	0.34	0.35	0.37	0.34	0.25	0.27	0.21	0.16	0.10	0.06
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-9 SCHOOL			HOUR ENDING																							
Description	Type	Day	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 pm
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.15	0.15	0.15	0.15	0.15	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.18	0.18	0.18
		Sat	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
		Sun	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Receptacle	Fraction	WD	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0.35	0.35
		Sat	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
		Sun	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	80	80	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80	80
		Sat	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
		Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HtgSetPt	Temperature	WD	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60
		Sat	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.34	0.60	0.63	0.72	0.79	0.83	0.61	0.65	0.10	0.10	0.19	0.25	0.22	0.22	0.12	0.09
		Sat	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
		Sun	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-10 WAREHOUSES			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.70	0.90	0.90	0.90	0.50	0.85	0.85	0.85	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.60	0.75	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.75	0.60	0.10	0.10	0.10	0.10	0.10	0.10
		Sat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		Sun	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Receptacle	Fraction	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	0.25	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.25	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
		Sat	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
		Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HtgSetPt	Temperature	WD	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sat	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.02	0.02	0.02	0.02	0.05	0.07	0.07	0.10	0.30	0.36	0.36	0.46	0.57	0.43	0.38	0.40	0.30	0.18	0.03	0.03	0.03	0.03	0.03	0.03
		Sat	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.06	0.12	0.12	0.17	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Sun	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-11 LABORATORY			HOUR ENDING																							
Description	Type	Day	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 pm
Occupancy	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.20	0.90	0.90	0.45	0.45	0.90	0.90	0.90	0.90	0.90	0.30	0.10	0.10	0.10	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05	0.05
Lights	Fraction	WD	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.50	0.90	0.90	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.90	0.50	0.50	0.30	0.30	0.20	0.20
		Sat	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.40	0.40	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		Sun	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.40	0.40	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Receptacle	Fraction	WD	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.40	0.50	0.70	0.80	0.50	0.60	0.70	0.90	0.80	0.50	0.40	0.30	0.20	0.20	0.20	0.20	0.20
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Infiltration	Fraction	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sun	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ClgSetPt	Temperature	WD	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sat	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sun	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HtgSetPt	Temperature	WD	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sat	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sun	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Service Hot Water	Fraction	WD	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
		Sun	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-12 RESIDENTIAL			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.90	0.90	0.90	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.90	0.90	0.90	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.30	0.50	0.90	0.90	0.90	1.00	1.00	1.00
Lights	Fraction	WD	0.10	0.10	0.10	0.10	0.20	0.40	0.40	0.40	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.40	0.60	0.80	1.00	1.00	0.70	0.40	0.20
		Sat	0.10	0.10	0.10	0.10	0.20	0.40	0.40	0.40	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.40	0.60	0.80	1.00	1.00	0.70	0.40	0.20
		Sun	0.10	0.10	0.10	0.10	0.20	0.40	0.40	0.40	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.40	0.60	0.80	1.00	1.00	0.70	0.40	0.20
Receptacle	Fraction	WD	0.50	0.40	0.40	0.40	0.40	0.40	0.50	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.80	1.00	1.00	0.90	0.90	0.80	0.70	0.60
		Sat	0.50	0.40	0.40	0.40	0.40	0.40	0.50	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.80	1.00	1.00	0.90	0.90	0.80	0.70	0.60
		Sun	0.50	0.40	0.40	0.40	0.40	0.40	0.50	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.80	1.00	1.00	0.90	0.90	0.80	0.70	0.60
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sat	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
		Sun	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
HtgSetPt	Temperature	WD	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sat	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
		Sun	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Service Hot Water	Fraction	WD	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
		Sat	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
		Sun	0.00	0.00	0.00	0.05	0.05	0.05	0.80	0.70	0.50	0.40	0.25	0.25	0.25	0.25	0.50	0.60	0.70	0.70	0.40	0.25	0.20	0.20	0.05	0.05
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-13 DATA CENTER			HOUR ENDING																							
Description	Type	Day	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 pm
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.05	0.10	0.25	0.65	0.65	0.65	0.65	0.60	0.60	0.65	0.65	0.65	0.65	0.40	0.25	0.10	0.05	0.05	0.05	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.10	0.20	0.40	0.70	0.80	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.80	0.35	0.10	0.10	0.10	0.10	0.10
		Sat	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.20	0.20	0.20	0.15	0.10	0.10	0.10	0.10	0.10	0.10
		Sun	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10	0.05	0.05	0.05	0.05
Receptacle	Fraction	Jan May Sep	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Feb Jun Oct	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
		Mar Jul Nov	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		Apr Aug Dec	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Infiltration	Fraction	WD	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sun	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
ClgSetPt	Temperature	WD	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
		Sat	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
		Sun	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
HtgSetPt	Temperature	WD	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sat	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.00	0.00	0.00	0.00	0.10	0.10	0.50	0.50	0.50	0.50	0.70	0.90	0.90	0.50	0.50	0.70	0.50	0.50	0.50	0.10	0.10	0.10	0.10	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

TABLE G4
REQUIRED SCHEDULES FOR CALCULATING PROPOSED AND *BASELINE BUILDING PERFORMANCE*—continued

C-14 GYMNASIUM			HOUR ENDING																							
Description	**Type**	**Day**	**1 am**	**2 am**	**3 am**	**4 am**	**5 am**	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**	**12 pm**
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.18	0.18	0.18
		Sat	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
		Sun	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Receptacle	Fraction	WD	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.35	0.35	0.35	0.35	0.35	0.35	0.35
		Sat	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
		Sun	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ClgSetPt	Temperature	WD	85	85	85	85	85	85	85	75	75	75	75	75	75	75	75	75	75	75	75	75	75	85	85	85
		Sat	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
		Sun	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
HtgSetPt	Temperature	WD	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60
		Sat	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
		Sun	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Service Hot Water	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Servers/24/7 load	Fraction	WD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sat	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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RESIDENTIAL PROVISIONS

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CHAPTER 1 [RE]

SCOPE AND ADMINISTRATION

User note:

About this chapter: *Chapter 1 establishes the limits of applicability of this code and describes how the code is to be applied and enforced. Chapter 1 includes two parts: Part 1—Scope and Application (Sections 101–102) and Part 2—Administration and Enforcement (Sections 103–109). Section 101 identifies which buildings and structures come under its purview and references other I-Codes as applicable. Standards and codes are scoped to the extent referenced (see Section 108.1).*

The provisions of Chapter 1 establish the authority and duties of the code official appointed by the authority having jurisdiction and also establish the rights and privileges of the design professional, contractor and property owner.

PART 1—SCOPE AND APPLICATION

SECTION R101
SCOPE AND GENERAL REQUIREMENTS

R101.1 Title. This code shall be known as the 2024 *City of Boulder Energy Conservation Code*, and shall be cited as such. It is referred to herein as "this code."

R101.2 Scope. This code applies to *residential buildings* and the *building* sites and associated systems and equipment.

R101.3 Intent. This code shall regulate the design and construction of *buildings* for the effective use and conservation of energy over the useful life of each building. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this objective. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

R101.4 Applicability. Where, in any specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern.

R101.4.1 Mixed residential and commercial buildings. Where a *building* includes both *residential* building and *commercial building* portions, each portion shall be separately considered and meet the applicable Commercial Provisions of this code or Residential Provisions of this code.

R101.5 Compliance. *Residential buildings* shall meet the Residential Provisions of this code. *Commercial buildings* shall meet the Commercial Provisions of this code.

R101.5.1 Compliance materials. The *code official* is authorized to require *compliance* documentation, certificates, or reports prior to issuance of the building permit, the certificate of occupancy, or prior to passing inspections. The production of this documentation shall be in support of demonstrating compliance with the applicable requirements, construction installation method, or the energy compliance path being utilized.

SECTION R102
ALTERNATIVE MATERIALS, DESIGN AND METHODS OF CONSTRUCTION AND EQUIPMENT

R102.1 General. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. The *chief building official* shall have the authority to approve an alternative material, design or method of construction upon the written application of the owner or the owner's authorized agent. The *chief building official* shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code for strength, effectiveness, fire resistance, durability, energy conservation and safety. The *code official* shall respond to the applicant, in writing, stating the reasons why the alternative was approved or was not *approved*.

R102.1.1 Above code programs. The *chief building official* shall be permitted to deem a national, state or local energy-efficiency program to exceed the energy efficiency required by this code. *Buildings approved* in writing by such an energy-efficiency program shall be considered to be in compliance with this code where such buildings also meet the requirements identified as "mandatory" and in Table R406.1.1 and the building thermal envelope is greater than or equal to the levels of efficiency and solar heat gain coefficients in Tables 402.1.1 and 402.1.3 of the 2009 *International Energy Conservation Code*.

R102.1.2 Compliance with Federal and State Law and Regulations. The *chief building official* may modify for individual cases the provisions of this code to allow a design, installation, or construction not in compliance with the provisions of this code, if otherwise the provisions of this code would result in a violation of federal or state legislation or regulations and the modification would be the minimum modification that provides relief.

PART 2—ADMINISTRATION AND ENFORCEMENT

SECTION R103
CONSTRUCTION DOCUMENTS

R103.1 General. Construction documents, technical reports and other supporting data shall be submitted in one or more sets, or in digital format where allowed by the *code official,* with each application for a permit. The construction documents and technical reports shall be prepared by a *registered design professional* where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary construction documents to be prepared by a registered design professional.

Exception: The *code official* is authorized to waive the requirements for construction documents or other supporting data if the *code official* determines they are not necessary to confirm compliance with this code.

R103.2 Information on construction documents. Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted where *approved* by the *code official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the *building*, systems and equipment as herein governed. Details shall include the following as applicable:

1. Energy compliance path.
2. Insulation materials and their *R*-values.
3. Fenestration *U*-factors and *solar heat gain coefficients* (SHGC).
4. Area-weighted *U*-factor and *solar heat gain coefficients* (SHGC) calculations.
5. Mechanical system design criteria.
6. Mechanical and service water-heating systems and equipment types, sizes, and efficiencies.
7. Equipment and system controls.
8. Duct sealing, duct and pipe insulation and location.
9. Air sealing details.
10. Details of additional electric infrastructure, including branch circuits, conduit, or pre-wiring, and panel capacity in compliance with the provisions of this code.
11. Location of pathways for routing of raceways or cable from the solar ready zone to the electrical service panel.
12. Total area of glazed vertical fenestration as a percentage of conditioned floor area.
13. Location and size of the solar-ready zone.
14. Structural design loads of roof dead load and roof live load.
15. Pathways for routing of conduit from the solar-ready zone to the electrical service panel.
16. Number and location of EV capable light spaces.
17. Number and location of EV capable spaces.
18. Number and location of EV ready spaces.
19. Number and location of EVSE installed spaces.
20. Locations of conduit and termination points serving the aforementioned parking spaces.
21. Location for condensate drainage where combustion equipment for space heating and water heating is installed.
22. Additional Conservation measures selected for compliance with R408.

R103.2.1 Building thermal envelope depiction. The *building thermal envelope* shall be represented on the construction documents in both plan and trans-sectional views and shall outline the extent of the *building thermal* envelope.

R103.3 Examination of documents. The *code official* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances. The *code official* is authorized to utilize a registered design professional, or other *approved* entity not affiliated with the building design or construction, in conducting the review of the plans and specifications for compliance with the code.

R103.3.1 Approval of construction documents. When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified, or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.

One set of construction documents so reviewed shall be retained by the *code official*. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official* or a duly authorized representative.

R103.3.2 Previous approvals. This code shall not require changes in the construction documents, construction, or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.

R103.3.3 Phased approval. The *code official* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided adequate information, and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.

R103.4 Amended construction documents. Work shall be installed in accordance with the *approved* construction documents, and any changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.

R103.5 Retention of construction documents. One set of *approved* construction documents shall be retained by the *code official* for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.

SECTION R104
FEES

R104.1 Fees. A permit shall not be issued until the fees prescribed in Section R104.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

R104.2 Schedule of permit fees. Where a permit is required, a fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

R104.3 Work commencing before permit issuance. Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official* that shall be in addition to the required permit fees.

R104.4 Related fees. The payment of the fee for the construction, *alteration*, removal, or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

R104.5 Refunds. The *code official* is authorized to establish a refund policy.

SECTION R105
INSPECTIONS

R105.1 General. Construction or work for which a permit is required shall be subject to inspection by the *code official* or his or her designated agent, and such construction or work shall remain visible and able to be accessed for inspection purposes until *approved*. It shall be the duty of the permit applicant to cause the work to remain visible and able to be accessed for inspection purposes. Neither the *code official* nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material, product, system or building component required to allow inspection to validate compliance with this code.

R105.2 Required inspections. The *code official* or his or her designated agent, upon notification, shall make the inspections set forth in Sections R105.2.1 through R105.2.5.

R105.2.1 Footing and foundation inspection. Inspections associated with footings and foundations shall verify compliance with the code as to *R-value*, location, thickness, depth of burial and protection of insulation as required by the code and *approved* plans and specifications.

R105.2.2 Framing and rough-in inspection. Inspections at framing and rough-in shall be made before application of interior finish and shall verify compliance with the code as to: types of insulation and corresponding *R-values* and their correct location and proper installation; fenestration properties such as *U*-factor and SHGC and proper installation; and air leakage controls as required by the code; and approved plans and specifications.

R105.2.3 Plumbing rough-in inspection. Inspections at plumbing rough-in shall verify compliance as required by the code, *approved* plans, and specifications as to types of insulation and corresponding *R*-values, protection, and required controls.

R105.2.4 Mechanical rough-in inspection. Inspections at mechanical rough-in shall verify compliance as required by the code, *approved* plans, and specifications as to installed HVAC equipment type and size, required controls, system insulation and corresponding *R*-value, system air leakage control, programmable thermostats, dampers, whole-house ventilation, and minimum fan efficiency.

Exception: Systems serving multiple dwelling units shall be inspected in accordance with Section C105.2.4 of this code.

R105.2.5 Electrical system. Inspections shall verify lighting system controls, components, meters, and additional electric infrastructure, as required by the code, *approved* plans, and specifications.

R105.2.6 Solar ready. As required by the code, approved plans and specifications, inspections shall verify the location and size of the *solar-ready zone* or the capacity of an installed on-site renewable energy system and the electrical capacity and reserved physical space for circuit breakers in the main electrical service panel that are properly labeled.

R105.2.7 Electric Vehicle Ready. As required by this code, approved plans and specifications, inspections shall verify the EV power transfer infrastructure requirements, the branch circuits, conduit and/or raceway, junction boxes, receptacles and EVSE are properly labeled and installed for each parking space type. If applicable, inspections shall also verify the electrical capacity and reserved physical space for circuit breakers in the main electrical service panel are properly labeled.

R105.2.8 Electric ready. As required by this code, approved plans and specifications, inspections shall verify the branch circuits, conduit and/or raceways, wiring, junction boxes and receptacles for *future electric equipment* or appliances are properly labeled and installed, as applicable. Inspections shall also verify reserved physical space for *future electric equipment* or appliances as well as electrical capacity and reserved physical space for circuit breakers in the main electrical service panel are properly labeled.

R105.2.9 Final inspection. The *building* shall have a final inspection and shall not be occupied until *approved*. The final inspection shall include verification of the installation of all required *building* systems, equipment and controls and their proper operation and the required number of lamps and fixtures.

R105.3 Reinspection. A *building* shall be reinspected where determined necessary by the *code official*.

R105.4 Approved third party inspection agencies. The *code official* is authorized to accept reports of third-party inspection agencies not affiliated with the *building* design or construction, provided that such agencies are *approved* as to qualifications and reliability relevant to the *building* components and systems that they are inspecting or testing, and approval is granted prior to issuance of the building permit.

R105.4.1 Authorization of approved third party inspection agency. To be approved, a third-party inspection agency shall provide all requested information for the *code official* to determine that the agency meets the applicable requirements specified in Sections R105.4.1.1 through R105.4.1.3 and to authorize its work in the jurisdiction.

R105.4.1.1 Independence. An *approved* third-party inspection agency shall be an independent business identity. The agency shall perform its duties in accordance with the scope of delegated responsibilities established by the *code official.* The agency shall disclose to the *code official* any conflicts of interest including where fees for service are derived. The agency shall acknowledge in writing that it is only authorized to work within the scope of delegated responsibilities.

R105.4.1.2 Equipment. An *approved* third-party inspection agency shall have adequate equipment to perform inspections and tests required by the *code official* and this code. All testing equipment shall be periodically calibrated as required by the manufacturer, testing standards used in this code, or certifications held by the *approved* third-party inspection agency.

R105.4.1.3 Personnel. Personnel assigned by an approved third-party inspection agency to perform inspections and testing shall be trained or credentialed and documentation of training or credentials shall be available to the *code official* upon request.

R105.4.1.4 Delegated authority. Where an *approved* third-party inspection agency shall have the authority to perform delegated inspections and determine compliance or noncompliance of work with approved construction documents.

R105.4.2 Approved third-party inspection agency reporting. An *approved* third-party inspection agency shall keep records of delegated inspections, tests, and compliance documentation required by this code. The agency shall submit reports of delegated inspections and tests to the code official and to the owner or owner's representative. Reports shall indicate the compliance determination for the inspected or tested work based on approved construction documents. A final report documenting required delegated inspections and tests, and correction of any discrepancies noted in the inspections or tests, shall be submitted, with other required compliance documentation, at a time required by the *code official.*

R105.5 Inspection requests. It shall be the duty of the permit holder or their duly authorized agent to notify the *code official* when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this code.

R105.6 Reinspection and testing. Where any work or installation does not pass an initial test or inspection, the necessary corrections shall be made to achieve compliance with this code. The work or installation shall then be resubmitted to the *code official* for inspection and testing.

SECTION R106
NOTICE OF APPROVAL

R106.1 Approval. After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the *code official*.

R106.2 Revocation. The *code official* is authorized to, in writing, suspend or revoke a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the *building* or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.

SECTION R107
VALIDITY

R107.1 General. If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

SECTION R108
REFERENCED STANDARDS

R108.1 Referenced codes and standards. The codes and standards referenced in this code shall be those indicated in Chapter 6, and such codes and standards shall be considered as part of the requirements of this code to the prescribed extent of each such reference and as further regulated in Sections R108.1.1 and R108.1.2.

R108.1.1 Conflicts. Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

R108.1.2 Provisions in referenced codes and standards. Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

R108.2 Application of references. References to chapter or section numbers, or to provisions not specifically identified by number, shall be construed to refer to such chapter, section, or provision of this code.

R108.3 Other laws. The provisions of this code shall not be deemed to nullify any provisions of local, state, or federal law. This code is intended to comply with and be interpreted and enforced so as to comply with 42 U.S.C. Section 6297(f)(3) and any other federal requirements to avoid preemption. For purposes of 42 U.S.C. Section 6297(f)(3), this code, including all provisions contained herein, is a local building code for new construction.

SECTION R109
STOP WORK ORDER

R109.1 Authority. Where the *code official* finds any work regulated by this code being performed in a manner contrary to the provisions of this code or in a dangerous or unsafe manner, the *code official* is authorized to issue a stop work order.

R109.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property, the owner's authorized agent or the person performing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order and the conditions under which the cited work is authorized to resume.

R109.3 Emergencies. Where an emergency exists, the code official shall not be required to give a written notice prior to stopping the work.

R109.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to fines established by the authority having jurisdiction.

SECTION R110
MEANS OF APPEALS

R110.1 General. Appeals of orders, decisions or determinations made by the code official relative to the application and interpretation of this code shall be heard by the board of building appeals established under Section 2-3-4, "Board of Building Appeals," B.R.C. 1981, unless the city manager determines that, due to the nature of the issues in a particular appeal., to appoint a hearing office under Section 1-3-5, "Hearings and Determinations," B.R.C. 1981.

R110.2 Limitations on authority. An application for appeal shall be based on a claim that the provisions of this code or the rules legally adopted thereunder have been incorrectly interpreted or applied or that an equally good or better material, design, or method of construction is proposed. The board or hearing officer has no authority to waive requirements of this code or interpret the administration of this code.

R110.3 Application. An application for appeal must be filed in writing with the city manager within fourteen days after the date of refusal of the building permit or refusal of approval of the work performed under the permit or revocation or suspension of the building permit or certificate of occupancy or certificate of completion stating the basis for the appeal.

R110.4 Administration. The code official shall take immediate action in accordance with the decision of the board.

R110.5 Fee. An applicant for an appeal shall pay the fee prescribed by Section 4-20-47, "Zoning Adjustment and Building Appeals Filing Fees," B.R.C. 1981. The fee for an appeal heard by a hearing officer shall be the same as the fee for an appeal heard by the board of building appeals.

SECTION R111
VIOLATIONS

R111.1 General. The provisions for violations set forth in Chapter 1 of the City of Boulder Building Code as part of Chapter 10-5, "Building Code," B.R.C. 1981, shall apply to violations of this code.

CHAPTER 2 [RE]

DEFINITIONS

User note:

About this chapter: *Codes, by their very nature, are technical documents. Every word, term and punctuation mark can add to or change the meaning of a technical requirement. It is necessary to maintain a consensus on the specific meaning of each term contained in the code. Chapter 2 performs this function by stating clearly what specific terms mean for the purpose of the code.*

SECTION R201
GENERAL

R201.1 Scope. Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter and Section C202 when applicable.

R201.2 Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

R201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code* or the *International Residential Code* shall have the meanings ascribed to them in those codes.

R201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

SECTION R202
GENERAL DEFINITIONS

ABOVE-GRADE WALL. A wall more than 50 percent above grade and enclosing *conditioned space*. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and *skylight* shafts.

ACCESS (TO). That which enables a device, appliance, or equipment to be reached by ready access or by a means that first requires the removal or movement of a panel or similar obstruction.

ACCESSORY DWELLING UNIT (ADU). A separate and complete single housekeeping unit within a detached dwelling unit or within an accessory structure to the principal dwelling unit of the lot or parcel upon which the unit is located.

AIR BARRIER. One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the *building thermal envelope* and its assemblies.

AIR-HANDLING UNIT. A blower or fan used for the purpose of distributing supply air to a room, space or area.

ALL-ELECTRIC. Refers to an energy source for a system, appliance or piece of equipment that is fueled by electricity.

ALL-ELECTRIC BUILDING. A *building* that uses a permanent supply of electricity as the source of energy for all space heating, water heating (including pools and spas), cooking appliances, and clothes drying appliances, and has no natural gas, propane or fuel-oil plumbing installed in the building.

ALTERATION. Any construction, retrofit or renovation to an existing structure other than *repair* or *addition*. Also, a change in a building, electrical, gas, mechanical or plumbing system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ALTERATION, LEVEL 1. An *alteration* that includes the removal and replacement or the covering of existing materials, elements, equipment, or fixtures using new materials, elements, equipment, or fixtures that serve the same purpose.

ALTERATION, LEVEL 2. An *alteration* that includes the reconfiguration of space, the addition or elimination of any door or window, the reconfiguration or extension of any system, or the installation of any additional equipment.

ALTERATION, LEVEL 3. An *alteration* where the work exceeds 50 percent of the building floor area.

APPROVED. Acceptable to the *code official*.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests furnishing inspection services, or furnishing product certification, where such agency has been *approved* by the *code official*.

AUTOMATIC. Self-acting, operating by its own mechanism when actuated by some impersonal influence, such as, for example, a change in current strength, pressure, temperature, or mechanical configuration (see "Manual").

BALANCED VENTILATION SYSTEM. A ventilation system that simultaneously supplies outdoor air to and exhausts air from a space, where the mechanical supply airflow rate and the mechanical exhaust airflow rate are each within 10% of the average of the two airflow rates.

BASEMENT WALL. A wall 50 percent or more below grade and enclosing *conditioned space*.

BUILDING. Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power

and lighting systems located on the building site and supporting the building.

BUILDING SITE. a contiguous area of land that is under the ownership or control of one entity.

BUILDING THERMAL ENVELOPE. The *basement walls, exterior walls*, floors, ceiling, roofs, and any other *building* element assemblies that enclose *conditioned space* or provide a boundary between *conditioned space* and exempt or unconditioned space.

CARBON DIOXIDE EQUIVALENT (CO2e). A measure used to compare the impact of various greenhouse gases based on their global warming potential (GWP.) CO2e approximates the time-integrated warming effect of a unit mass of a given greenhouse gas relative to that of carbon dioxide (CO2). Also known as embodied carbon.

CAVITY INSULATION. Insulating material located between framing members.

CHIEF BUILDING OFFICIAL. The authority responsible for the administration and enforcement of building codes as well as interpretation of policy and procedure as adopted by the city; head code official.

CIRCULATING HOT WATER SYSTEM. A specifically designed water distribution system where one or more pumps are operated in the service hot water piping to circulate heated water from the water-heating equipment to fixtures and back to the water-heating equipment.

CLIMATE ZONE. A geographical region based on climatic criteria as specified in this code.

CODE OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

COMBUSTION EQUIPMENT. Any equipment or appliances used for space heating, cooling, water heating (including pools and spas), cooking, clothes drying or lighting that uses natural gas, propane, other fuel gas, or fuel oil.

COMMERCIAL BUILDING. For this code, all buildings that are not included in the definition of "Residential building."

COMMON AREAS. All conditioned spaces within Group R occupancy buildings that are not dwelling units or sleeping units.

COMPLIANCE DOCUMENTS. Documents that are not required to be prepared by a registered design professional that demonstrate compliance with this code and are reviewed prior to the issuance of the building permit or before certificate of occupancy is released.

CONDITIONED FLOOR AREA. The horizontal projection of the floors associated with the *conditioned space*.

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

CONTINUOUS AIR BARRIER. A combination of materials and assemblies that restrict or prevent the passage of air through the *building thermal envelope*.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior, or is integral to any opaque surface, of the *building* envelope.

CONTINUOUS PILOT. A pilot which, once placed in operation, is intended to remain ignited continuously until it is manually interrupted.

CO2 INDEX. An operational carbon index derived when using ANSI/RESNET/ICC 301 2022 Addendum B CO2e Rating Index.

CRAWL SPACE WALL. The opaque portion of a wall that encloses a crawl space and is partially or totally below grade.

CURTAIN WALL. Fenestration products used to create an external non load-bearing wall that is designed to separate the exterior and interior environments.

DAMPER. A manually or automatically controlled device to regulate draft or the rate of flow of air or combustion gases.

DEMAND RECIRCULATION WATER SYSTEM. A water distribution system where one or more pumps prime the service hot water piping with heated water upon demand for hot water.

DIMMER. A control device that is capable of continuously varying the light output and energy use of light sources.

DUCT. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

DUCT SYSTEM. A system that consists of space conditioning equipment, ductwork, and includes any apparatus installed in connection therewith.

DUCTWORK. The assemblies of connected ducts, plenums, boots, fittings, dampers, supply registers, return grilles, and filter grilles through which air is supplied to or returned from the space to be heated, cooled, or ventilated. Supply ductwork delivers air to the spaces from the space conditioning equipment. Return ductwork conveys air from the spaces back to the space conditioning equipment. Ventilation ductwork conveys air to or from any space.

DWELLING UNIT. A single unit providing completely independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

DWELLING UNIT ENCLOSURE AREA. The sum of the area of ceiling, floors, and walls separating a *dwelling unit's conditioned space* from the exterior or from adjacent conditioned or unconditioned spaces. Wall height shall be measured from the finished floor of the *dwelling unit* to the underside of the sheetrock unless the ceiling cavity above the unit is blocked at unit separation and corridor walls then it shall extend to the underside of the floor above.

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, including but not limited to, passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service, EVSE, a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current. Off-road, self-propelled electric mobile equipment, including but not limited to, industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, and boats are not considered electric vehicles.

ELECTRIC VEHICLE CAPABLE LIGHT SPACE (EV CAPABLE LIGHT SPACE). A designated vehicle parking space that has conduit and/or raceway installed to support future implementation of *electric vehicle* charging installation and has sufficient physical space adjacent to the existing electrical equipment for future electric upgrades.

ELECTRIC VEHICLE CAPABLE SPACE (EV CAPABLE SPACE). A designated vehicle parking space that has the electric panel capacity and conduit and/or raceway installed to support future implementation of *electric vehicle* charging.

ELECTRIC VEHICLE READY SPACE (EV READY SPACE). A designated vehicle parking space that has the electric panel capacity, raceway wiring, receptacle, and circuit overprotection devices installed to support future implementation of *electrical vehicle* charging.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). An electric vehicle charging system or device that is used to provide electricity to a plug-in *electric vehicle* or plug-in hybrid electric vehicle, is designed to ensure that a safe connection has been made between the electrical grid and the vehicle, and is able to communicate with the vehicle's control system so that electricity flows at an appropriate voltage and current level.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) INSTALLED SPACE. A vehicle parking space that is provided with dedicated *EVSE* connection.

ENERGY ANALYSIS. A method for estimating the annual energy use of the *proposed design* and *standard reference design* based on estimates of energy use.

ENERGY COST. The total estimated annual cost for purchased energy for the building functions regulated by this code, including applicable demand charges.

ENERGY IMPACT OFFSET FUND. A city-approved and city-managed offset fund providing a payment option in lieu of complying with city program renewable energy and/or offset requirements.

ENERGY RATING INDEX (ERI). A numerical integer value that represents the relative energy performance of a rated design or constructed dwelling unit as compared with the energy performance of the ERI Reference Design, where an ERI value of 100 represents the energy performance of the ERI Reference Design and an ERI value of 0 represents a rated design or constructed dwelling unit with zero net energy performance.

ENERGY SIMULATION TOOL. An *approved* software program or calculation-based methodology that projects the annual energy use of a *building*.

ERI REFERENCE DESIGN. A version of the *rated design* that meets the minimum requirements of the 2006 *International Energy Conservation Code.*

EXISTING BUILDING. A building erected prior to the date of adoption of the appropriate code, or one for which a legal building permit has been issued.

EXTERIOR WALL. Walls including both above-grade walls and *basement walls*.

FENESTRATION. Products classified as either *vertical fenestration* or *skylights*.

Skylights. Glass or other transparent or translucent glazing material installed at a slope of less than 60 degrees (1.05 rad) from horizontal.

Vertical fenestration. Windows that are fixed or operable, opaque doors, glazed doors, glazed block, and combination opaque/glazed doors composed of glass or other transparent or translucent glazing materials and installed at a slope of not less than 60 degrees (1.05 rad) from horizontal including unit skylights, tubular daylighting devices, and glazing materials in solariums, sunrooms, roofs, and sloped walls.

FENESTRATION PRODUCT, SITE-BUILT. A fenestration designed to be made up of field-glazed or field-assembled units using specific factory cut or otherwise factory-formed framing and glazing units. Examples of site-built fenestration include storefront systems, curtain walls and atrium roof systems.

GLOBAL WARMING POTENTIAL (GWP). A measurement that combines the impact of the various greenhouse gases relative to an equivalent unit of carbon dioxide (kg C02e) over a given period of time.

HEATED SLAB. Slab-on-grade construction in which the heating elements, hydronic tubing, or hot air distribution system is in contact with, or placed within or under, the slab.

HISTORIC BUILDING. Any building or structure that is locally designated by ordinance as an individual landmark or recognized as a contributing resource within a historic district.

INDUSTRY-WIDE TYPE III ENVIRONMENTAL PRODUCT DECLARATION (IW-EPD). Type III environmental product declaration (EPD) that estimates the average global warming potential of a specific product within an industry. IW-EPD's must comply with the goal and scope for the production stage of at least cradle-to-gate in accordance with ISO Standards 14025 and 21930 and be available in a publicly accessible database. The EPD results represent production weighted average data across multiple manufacturers.

INFILTRATION. The uncontrolled inward air leakage into a *building* caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.

INSULATED SIDING. A type of continuous insulation with manufacturer-installed insulating material as an integral part of the cladding product having an *R*-value of not less than R-2.

LABELED. Equipment, materials, or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, *approved* agency or other organization concerned with product evaluation that maintains periodic inspection of the production of such labeled items and whose labeling indicates either that the equipment, material, or product meets identified standards or has been tested and found suitable for a specified purpose.

LISTED. Equipment, materials, products, or services included in a list published by an organization acceptable to the *code official* and concerned with evaluation of products or services that maintains periodic inspection of production of *listed* equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LOW-VOLTAGE LIGHTING. Lighting equipment powered through a transformer such as a cable conductor, a rail conductor and track lighting.

MANUAL. Capable of being operated by personal intervention (see "Automatic").

MIXED-FUEL BUILDING. A *building* and building site that contains *combustion equipment*, or plumbing for *combustion equipment*, for space heating, cooling, water heating (including pools and spas), cooking, or clothes drying.

OCCUPANT SENSOR CONTROL. An automatic control device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be regulated accordingly.

OCCUPIABLE SPACE. An enclosed space intended for human activities, excluding those spaces intended primarily for other purposes, such as storage rooms and equipment rooms, that are only intended to be occupied occasionally and for short periods of time.

OFF-SITE SOLAR SUBSCRIPTION. A 20-year subscription to a solar generation facility where the beneficial use of the electricity generated by the facility belongs to subscribers to the solar generation facility as authorized in §40-2-127, C.R.S.

ON-SITE RENEWABLE ENERGY. Energy from renewable energy resources harvested at the building site.

OPAQUE DOOR. A door that is not less than 50-percent opaque in surface area.

PHOTOVOLTAIC MODULE. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate DC power.

PHOTOVOLTAIC PANEL. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.

PHOTOVOLTAIC PANEL SYSTEM. A system that incorporates discrete photovoltaic panels, that converts solar radiation into electricity, including rack support systems.

PLUG-IN HYBRID ELECTRIC VEHICLE. An *electric vehicle* having a second source of motive power.

PRODUCT. Any material or product procured for permanent installation in the building that has the same specification requirements and is classified by the same product category rule.

PROPOSED DESIGN. A description of the proposed *building* used to estimate annual energy use for determining compliance based on total building performance.

PRODUCT-SPECIFIC TYPE III ENVIRONMENTAL PRODUCT DECLARATION (EPD). Type III environmental product declaration (EPD) that estimates the average global warming potential of a specific product. A product-specific Type III environmental product declaration (EPD) must comply with the goal and scope for the production stage of at least cradle-to-gate in accordance with ISO Standards 14025 and 21930 and be available in a publicly accessible database. The data can represent the impacts of a specific design and manufacturer across multiple facilities or be facility specific. Also known as manufacturer specific EPD.

RATED DESIGN. A description of the proposed *building* used to determine the energy rating index.

READY ACCESS (TO). That which enables a device, appliance, or equipment to be directly reached without requiring the removal or movement of any panel or similar obstruction.

REGISTERED DESIGN PROFESSIONAL. An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

RENEWABLE ENERGY CERTIFICATE (REC). An instrument that represents the environmental attributes of one megawatt hour of renewable energy; also known as an energy attribute certificate (EAC).

RENEWABLE ENERGY RESOURCES. Energy derived from solar radiation, wind, waves, tides, landfill gas, biogas, biomass or extracted from hot fluid or steam heated within the earth.

REPAIR. The reconstruction or renewal of any part of an existing *building* for the purpose of its maintenance or to correct damage.

REROOFING. The process of recovering or replacing an existing roof covering. See "Roof recover" and "Roof replacement."

RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and townhouses, and *Group* R-3 and R-4 buildings three stories or less in height above grade plane with separate means of egress.

ROOF ASSEMBLY. A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly

includes the roof covering, underlayment and roof deck, and can also include a thermal barrier, an ignition barrier, insulation, or a vapor retarder.

ROOF RECOVER. The process of installing an additional roof covering over an existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance.

ROOF REPLACEMENT. The process of removing the existing roof covering, repairing any damaged substrate, and installing a new roof covering.

***R*-VALUE (THERMAL RESISTANCE).** The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady state conditions, per unit area ($h \cdot ft^2 \cdot °F/Btu$) [$(m^2 \cdot K)/W$].

SERVICE WATER HEATING. Supply of hot water for purposes other than comfort heating.

SOLAR HEAT GAIN COEFFICIENT (SHGC). The ratio of the solar heat gain entering the space through the fenestration assembly to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation that is then reradiated, conducted, or convected into the space.

SOLAR-READY ZONE. A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.

SPACE CONDITIONING. The treatment of air so as to control the temperature, humidity, filtration, or distribution of the air to meet the requirements of a conditioned space.

SPACE CONDITIONING EQUIPMENT. The heat exchangers, air-handling units, filter boxes, and any apparatus installed in connection therewith used to provide space conditioning.

STANDARD REFERENCE DESIGN. A version of the *proposed design* that meets the minimum requirements of this code and is used to determine the maximum annual energy use requirement for compliance based on total building performance.

SUBSTANTIAL THERMAL ENVELOPE ALTERATION. An *alteration* greater than or equal to 50 percent of the *building thermal envelope*.

SUBSTANTIAL MECHANICAL ALTERATION. An *alteration* in which the *space conditioning equipment* or *service water heating equipment* is replaced.

SUNROOM. A one-story structure attached to a dwelling with a glazing area in excess of 40 percent of the gross area of the structure's *exterior walls* and roof.

THERMAL DISTRIBUTION EFFICIENCY (TDE). The resistance to changes in air heat as air is conveyed through a distance of air duct. TDE is a heat loss calculation evaluating the difference in the heat of the air between the air duct inlet and outlet caused by differences in temperatures between the air in the duct and the duct material. TDE is expressed as a percent difference between the inlet and outlet heat in the duct.

THERMAL ISOLATION. Physical and space conditioning separation from *conditioned spaces*. The *conditioned spaces* shall be controlled as separate zones for heating and cooling or conditioned by separate equipment.

THERMOSTAT. An automatic control device used to maintain temperature at a fixed or adjustable setpoint.

***U*-FACTOR (THERMAL TRANSMITTANCE).** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films ($Btu/h \cdot ft^2 \cdot °F$) [$W/(m^2 \cdot K)$].

UNIVERSAL VEHICLE CHARGING STATIONS. Parking spaces provided for electric vehicle charging stations that can be utilized for all users and complies with Chapter 11.

VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

VENTILATION AIR. That portion of supply air that comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

VISIBLE TRANSMITTANCE (VT). The ratio of visible light entering the space through the fenestration product assembly to the incident visible light, Visible Transmittance, includes the effects of glazing material and frame and is expressed as a number between 0 and 1.

WHOLE BUILDING LIFECYCLE ANALYSIS (WB LCA). An analysis of a building and its building components lifetime environmental impact, including but not limited to embodied and operational carbon impact, on the environment locally and globally.

WHOLE HOUSE MECHANICAL VENTILATION SYSTEM. An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates.

ZONE. A space or group of spaces within a *building* with heating or cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single controlling device.

CHAPTER 3 [RE]
GENERAL REQUIREMENTS

User note:

About this chapter: *Chapter 3 covers general regulations for energy conservation features of buildings. The climate zone for a building is established by geographic location tables and figures in this chapter.*

SECTION R301
LOCATION

R301.1 General. This code applies to projects located in the City of Boulder and the City Boulder is in *Climate Zone* 5B.

SECTION R302
DESIGN CONDITIONS

R302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

SECTION R303
MATERIALS, SYSTEMS AND EQUIPMENT

R303.1 Identification. Materials, systems, and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

R303.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation that is 12 inches (305 mm) or greater in width. Alternatively, the insulation installers shall provide a certification that indicates the type, manufacturer and *R*-value of insulation installed in each element of the *building thermal envelope*. For blown-in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be indicated on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and the *R*-value of the installed thickness shall be indicated on the certification. For reflective insulation, the number of reflective sheet(s), the number and thickness of the enclosed reflective air space(s) and the R-value for the installed assembly determined in accordance with Section R303.1.6, shall be listed on the certification. For insulated siding, the *R*-value shall be on a label on the product's package and shall be indicated on the certification. The insulation installer shall sign, date, and post the certification in a conspicuous location on the job site.

Exception: For roof insulation installed above the deck, the *R*-value shall be labeled as required by the material standards specified in Table 1508.2 of the *International Building Code* or Table R906.2 of the *International Residential Code*, as applicable.

R303.1.1.1 Blown-in or sprayed roof and ceiling insulation. The thickness of blown-in or sprayed fiberglass and cellulose roof and ceiling insulation shall be at not less than one for every 300 square feet (28 m^2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch (25 mm) in height. Each marker shall face the attic access opening. The thickness and installed *R*-value of sprayed polyurethane foam insulation shall be indicated on the certification provided by the insulation installer.

R303.1.2 Insulation mark at installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable at inspection. For insulation materials that are installed without an observable manufacturer's R-value mark, such as blown or draped products, an insulation certificate complying with Section R303.1.1 shall be left immediately after installation by the installer, in a conspicuous location within the building, to certify the installed R-value of the insulation material.

R303.1.3 Fenestration product rating. *U*-factors of fenestration products such as windows, doors and *skylights* shall be determined in accordance with NFRC 100.

Exception: Where required, garage door *U*-factors shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

U-factors shall be determined by an accredited, independent laboratory, and labeled and certified by the manufacturer.

Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table R303.1.3(1) or R303.1.3(2). The *solar heat gain coefficient* (SHGC) and *visible transmittance* (VT) of glazed fenestration products such as windows, glazed doors and *skylights* shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC or VT shall be assigned a default SHGC or VT from Table R303.1.3(3).

R303.1.4 Insulation product rating. The thermal resistance, *R*-value, of insulation shall be determined in accordance with Part 460 of US-FTC CFR Title 16 in units of h • ft^2 • °F/Btu at a mean temperature of 75°F (24°C).

TABLE R303.1.3(1)
DEFAULT GLAZED WINDOW, GLASS DOOR AND SKYLIGHT U-FACTORS

FRAME TYPE	WINDOW AND GLASS DOOR		SKYLIGHT	
	Single pane	Double pane	Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

TABLE R303.1.3(2)
DEFAULT OPAQUE DOOR U-FACTORS

DOOR TYPE	OPAQUE *U*-FACTOR
Uninsulated Metal	1.20
Insulated Metal (Rolling)	0.90
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, not exceeding 45% glazing, any glazing double pane	0.35

TABLE R303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

R303.1.4.1 Insulated siding. The thermal resistance, *R*-value, of insulated siding shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer's instructions.

R303.1.5 Air-impermeable insulation. Insulation having an air permeability not greater than 0.004 cubic feet per minute per square foot [0.002 L/(s × m^2)] under pressure differential of 0.3-inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall be determined air-impermeable insulation.

R303.1.6 Air spaces. Where the R-value of an enclosed reflective air space or enclosed nonreflective air space is used for compliance with this standard, the air space shall be enclosed in a cavity bounded on all sides by building components and constructed to minimize airflow into and out of the enclosed air space. Airflow shall be deemed minimized where one of the following conditions occur:

1. The enclosed air space is unventilated.
2. The enclosed air space is bounded on one or more sides by an anchored masonry veneer, constructed in accordance with Chapter 7 of the International Residential Code, and vented by veneer weep holes located only at the bottom portion of the air space and spaced not less than 15 inches (381 mm) on center with the top of the cavity air space closed.

   Exception: For ventilated cavities, the effect of the ventilation of air spaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall covering material shall be determined in accordance with ASTM C1363 modified with an airflow entering the bottom and exiting the top of the air space at an air movement rate of not less than 70 mm/second.

R303.2 Installation. Materials, systems and equipment shall be installed in accordance with the manufacturer's recommended installation instructions and this code, the *International Building Code* or the *International Residential Code*, as applicable.

R303.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of *basement walls*, crawl space walls and the perimeter of slab-on-grade floors shall have a rigid, opaque, and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

R303.3 Maintenance information. Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a readily visible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

CHAPTER 4 [RE]

RESIDENTIAL ENERGY EFFICIENCY

User note:

About this chapter: *Chapter 4 provides requirements for the thermal envelope of a building, including minimum insulation values for walls, ceiling, and floors; maximum fenestration U-factors; minimum fenestration solar heat gain coefficients; and methods for determining building assembly and a total building U-factor. A performance alternative and an energy rating alternative are also provided to allow for energy code compliance other than by the prescriptive method.*

SECTION R401
GENERAL

R401.1 Scope. This chapter applies to *residential buildings*.

R401.2 New and existing residential application. New residential buildings less than or equal to 1,000 square feet of *conditioned floor area* shall comply with either Sections R401.2.1 or R402.2.2. New buildings greater than 1,000 square feet of *conditioned floor area* shall comply with Section R402.2.2. *Additions, alterations, repairs* and changes of occupancy to an existing building shall comply with Chapter 5 as applicable.

R401.2.1 Prescriptive Compliance Option. The Prescriptive Compliance Option is available for newly constructed *residential buildings* and *additional dwelling units (ADUs)* that are 1,000 square feet or less, and shall require compliance with Sections R401 through R404, R407 and R408.

R401.2.2 Energy Rating Index Compliance. The *Energy Rating Index* (ERI) Option is available for newly constructed *residential buildings* and ADUs of ANY size, and shall require compliance with Section R406 and Table R406.2.

R401.3 Documentation.

R401.3.1 Certificate. A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall indicate the following:

1. The predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls*, crawl space walls and floors and ducts outside *conditioned spaces*.
2. *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration, and the results from any required duct system and *building* envelope air leakage testing performed on the *building*. Where there is more than one value for any component, the certificate shall indicate the value covering the largest area and the area-weighted average value if applicable.
3. The results from any required duct system and building envelope air leakage testing performed on the building.
4. The types, sizes, fuel sources and efficiencies of heating, cooling, and service water heating equipment. Where a gas-fired unvented room heater, electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces, and electric baseboard heaters.
5. Where on-site *photovoltaic panel systems* have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.
6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without on-site generation, as determined in accordance with Section R406, shall be listed on the certificate.
7. The code edition under which the structure was permitted and the compliance path used.
8. The additional conservation package options selected.
9. The fuel sources for cooking and clothes drying equipment.
10. Where combustion equipment is installed, the certificate shall indicate information on the installation of additional electric infrastructure including which equipment and/or appliances include additional electric infrastructure, capacity reserved on the electrical service panel for replacement of each piece of combustion equipment and/or appliance.
11. Where a solar-ready zone is provided, the certificate shall indicate the location, dimensions, and capacity reserved on the electrical service panel.

R401.3.2 Homeowner's manual. The builder or owner's agent shall provide the owner with a binder of all equipment and appliance manufacturers' installation manuals and maintenance instructions in accordance with Section R303.3, except for manuals that are required to be affixed to the equipment. These include the energy rating

report and ERI certificate. If the *code official* approved a community solar garden subscription attributed to the property as a means to meet the requirements of this chapter, the manual shall include any requirements for a continued subscription to a community solar garden necessary to meet the requirements of this chapter.

SECTION R402
BUILDING THERMAL ENVELOPE

R402.1 General The *building thermal envelope* shall comply with the requirements of Sections R402.1.1 and R402.1.2.

Exceptions:

1. The following low-energy *buildings*, or portions thereof, separated from the remainder of the building-by-*building thermal envelope* assemblies complying with this section shall be exempt from the *building thermal envelope* provisions of Section R402.
   1.1. Those with a peak design rate of energy usage less than 3.4 Btu/h • ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 of floor area for space-conditioning purposes.
   1.2. Those that do not contain *conditioned space*.
2. Log homes designed in accordance with ICC 400.

R402.1.1 Vapor retarder. Wall assemblies in the *building thermal envelope* shall comply with the Class two or three vapor retarder requirements of Section R702.7 of the *International Residential Code* or Section 1404.3 of the *International Building Code,* as applicable. A minimum vented air space shall be defined as one that is $^3/_8$ of an inch or bigger.

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2. Assemblies shall have a U-factor equal to or less than that specified in Table R402.1.4. Fenestration shall have a U-factor and glazed fenestration SHGC equal to or less than that specified in Table R402.1.2 or R402.1.4.

R402.1.2.1 R-value alternative. Assemblies with R-value of insulation materials equal to or greater than that specified in Table R402.1.2 shall be an alternative to the U-factor in Table R402.1.4.

R402.1.2.2 *R*-value computation. Cavity insulation alone shall be used to determine compliance with the cavity insulation R-value requirements in Table R402.1.2. Where cavity insulation is installed in multiple layers, the R-values of the cavity insulation layers shall be summed to determine compliance with the cavity insulation R-value requirements. The manufacturer's settled *R*-value shall be used for blown-in insulation. Continuous insulation (ci) alone shall be used to determine compliance with the continuous insulation R-value requirements in Table R402.1.2. Where continuous insulation is installed in multiple layers, the R-values of the continuous insulation layers shall be summed to determine compliance with the continuous insulation R-value requirements. Cavity insulation R-values shall not be used to determine compliance with the continuous insulation R-value requirements in Table R402.1.2. Computed *R*-values shall not include an *R*-value for other building materials or air films. Where insulated siding is used for the purpose of complying with the continuous insulation requirements of Table R402.1.2, the manufacturer's labeled *R*-value for the insulated siding shall be reduced by R-0.6.

TABLE R402.1.2
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

Fenestration U-Factor	0.27
Skylight *U*-Factor	0.50
Glazed Fenestration SHGC	0.40
Ceiling *R*-Value	R-60
Insulation Entirely Above Roof Deck *R*-Value	R-0+39 ci
Wood Frame Wall *R*-Value[f]	R-30 or R-20&5ci or R-13&10ci or R-0&20ci
Mass Wall *R*-Value[e]	15/20
Floor *R*-Value	R-38 or R-4 per inch
Basement Wall *R*-Value[b, f]	15ci or R-20 or R-15&5ci
Unheated Slab R-Value & Depth[c]	15ci, 2 ft
Heated Slab *R*-Value & Depth[d]	20ci, 2ft and 10ci full slab
Crawl Space Wall *R*-Value	15ci or R-20 or R-15&5ci

For SI: 1 foot = 304.8 mm.

ci = continuous insulation.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. "15ci or R-20 or R-15&5ci" means R-15 continuous insulation (ci) on the interior or exterior surface of the wall; or R-20 cavity insulation on the interior side of the wall; or R-15 cavity insulation on the interior of the wall in addition to R-5 continuous insulation on the interior or the exterior surface of the wall.

c. Unheated slab insulation refers to slab edge insulation that shall be installed in accordance with Section R402.2.9.1. Slab edge depth (2 feet) may be comprised of insulation from the top of slab down + horizontal insulation installed in a continuous manner under the slab.

d. A heated slab requires insulation at both the slab edge and under the full slab. Slab edge depth may be comprised of insulation from the top of slab down + horizontal insulation installed under the slab.

e. Mass walls shall be in accordance with Section R402.2.6. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

f. The first value is cavity insulation; the second value is continuous insulation. Therefore, as example, (R-20&5ci" means R-20 cavity insulation plus R-5 continuous insulation.

TABLE R402.1.4
MAXIMUM ASSEMBLY *U*-FACTORS[a] AND FENESTRATION REQUIREMENTS

Fenestration *U*-Factor	0.27
Skylight *U*-Factor	0.50
Glazed Fenestration SHGC [c]	0.40
Ceiling *R*-Value	0.024
Insulation Entirely Above Roof Deck	0.025
Wood Frame Wall R-Value	0.040
Mass Wall R-Value [b]	0.056
Floor *R*-Value	0.029
Basement Wall *R*-Value	0.042
Unheated Slab R-Value & Depth	F-0.64
Heated Slab *R*-Value & Depth	F-0.50
Crawl Space Wall R-Value	0.042

For SI: 1 foot = 304.8 mm.

NR = Not Required.

ci = continuous insulation.

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation, or an approved source

b. Mass walls shall be in accordance with Section R402.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.065.

c. The SHGC value applies to all glazed fenestrations, including skylights.

R402.1.2.3 Total UA alternative. The building shall be considered to be in compliance with Section R402.1.2 when the total *building thermal envelope* UA of the proposed design is equal to or less than the total UA resulting from multiplying the *U*-factors in Table R402.1.2 by the same assembly area as in the proposed *building*. The UA calculation shall be performed using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. In addition to UA compliance, the SHGC requirements of Table R402.1.2 in this code, and the maximum fenestration U-factors of Section R402.5 in this code shall be met.

R402.2 Specific insulation requirements. In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.12.

R402.2.1 Ceilings with ventilated attic spaces. Where Section R402.1.2.1 requires R-60 ceiling insulation is installed, installing R-49 over 100 percent of the ceiling or attic area requiring insulation shall satisfy the requirement for R-60 insulation wherever the full height of uncompressed R-49 insulation extends over the wall top plate at the eaves. The reduction shall not apply to the insulation and fenestration criteria in Section R402.1.2 and the Total UA alternate in Section R402.1.2.3.

R402.2.2 Unvented Attic or Ceilings without attics. Whenever the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation R-value shall be R-30. The installed insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. The reduction of insulation from the requirements of Section R402.1.2.1 shall be limited to 500 square feet (46 m^2) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the Total UA alternative in Section R402.1.23.

R402.2.3 Eave baffle. For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain a net free area opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material. The baffle shall be installed to the outer edge of the exterior wall top plate so as to provide maximum space for attic insulation coverage over the top plate. Where soffit venting is not continuous, baffles shall be installed continuously to prevent ventilation air in the eave soffit from bypassing the baffle.

R402.2.4 Access hatches and doors. Access Hatches and doors from *conditioned spaces* to *unconditioned spaces* such as vented attics and crawl spaces shall be weather-stripped and insulated to the same R-value required by Table R402.1.2 or Section R406 for the wall or ceiling in which they are installed. Where loose-fill insulation is installed, a wood-framed or equivalent baffle or retainer shall be installed to prevent the loose-fill insulation from spilling into the living space when the attic access is opened. The baffle or retainer shall provide a permanent means of maintaining the required installed *R*-value of the loose-fill insulation. Access that prevents damaging or compression of the required insulation R-value shall be provided to all equipment installed in the space. Equipment platforms installed in the space shall be installed to prevent damaging or compression of the required installed insulation R-value.

R402.2.5 Mass walls. Mass walls where used as a component of the *building thermal envelope* shall be one of the following:

1. Above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber, mass timber or solid logs.
2. Any wall having a heat capacity greater than or equal to 6 Btu/ft^2 • °F (123 kJ/m^2 • K).

R402.2.6 Steel-frame ceilings, walls, and floors. Steel-frame ceilings, walls, and floors shall comply with the insulation requirements of Table R402.2.6 or the *U*-factor requirements of Table R402.1.4. The calculation of the *U*-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

TABLE R402.2.6
STEEL-FRAME CEILING, WALL, AND FLOOR INSULATION *R*-VALUES

WOOD FRAME *R*-VALUE REQUIREMENT	COLD-FORMED STEEL-FRAME EQUIVALENT *R*-VALUE[a]
Steel Truss Ceilings[b]	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
Steel Joist Ceilings[b]	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
Steel-Framed Wall, 16 inches on center	
R-13	R-13 + 4.2 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1
R-13 + 5	R-0 + 15 or R-13 + 19 or R-15 + 8.5 or R-19 + 8 or R-21 + 7
R-13 + 10	R-0 + 20 or R-13 + 15 or R-15 + 14 or R-19 + 13 or R-21 + 13
R-20	R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-21 + 7.5
R-20 + 5	R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9
R-21	R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7
Steel Framed Wall, 24 inches on center	
R-13	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-13 + 5	R-0 + 15 or R-13 + 7.5 or R-15 + 7 or R-19 + 6 or R-21 + 6
R-13 + 10	R-0 + 20 or R-13 + 13 or R-15 + 12 or R-19 + 11 or R-21 + 11
R-20	R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9
R-20 + 5	R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1
R-21	R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9
Steel Joist Floor	
R-13	R-19 in 2 × 6, or R-19 + 6 in 2 × 8 or 2 × 10
R-19	R-19 + 6 in 2 × 6, or R-19 + 12 in 2 × 8 or 2 × 10

a. The first value is cavity insulation *R*-value, the second value is continuous insulation *R*-value. Therefore, for example, "R-30+3" means R-30 cavity insulation plus R-3 continuous insulation.

b. Insulation exceeding the height of the framing shall cover the framing.

R402.2.7 Floors. Floor *cavity insulation* shall be enclosed on all sides and comply with one of the following:

1. Insulation shall be installed to maintain permanent contact with the underside of the subfloor decking in accordance with manufacturer instructions to maintain required *R*-value or readily fill the available cavity space.
2. Floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing separating the cavity and the unconditioned space below. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.
3. A combination of cavity and continuous insulation shall be installed so that the cavity insulation is in contact with the top side of the continuous insulation that is installed on the underside of the floor framing separating the cavity and the unconditioned space below. The combined R-value of the cavity and continuous insulation shall equal the required R-value for floors. Insulation shall extend from the bottom to the top of all perimeter floor framing members and the framing members shall be air sealed.

R402.2.8 Basement walls. Basement walls shall be insulated in accordance with Table R402.1.2 or the R-value determined by section R406.

Exception: *Basement walls* associated with unconditioned basements where all of the following requirements are met:

1. The floor overhead including the underside stairway stringer leading to the basement, is insulated in accordance with the proposed design and applicable provisions of Sections R402.2 and R402.2.7.
2. There are no uninsulated ductwork, domestic hot water piping, or hydronic heating surfaces exposed to the basement.
3. There are no HVAC supply or return diffusers serving the basement.
4. The walls surrounding the stairway and adjacent to conditioned space are insulated in accordance with the proposed design which shall be in compliance with Section R402.1.2.1 and the applicable provisions of Section R402.2.
5. The door(s) leading to the basement from conditioned spaces are insulated in accordance with the proposed design, which shall be in compliance with Section R402.1.2.1 and the applicable provisions of Section R402.2, and weather stripped in accordance with Section R402.4.
6. The building thermal envelope separating the basement from adjacent conditioned spaces complies with Section R402.4.

R402.2.8.1 Basement wall insulation installation. Where basement walls are insulated, the insulation shall be installed from the top of the basement wall down to 10 feet (3048 mm) below grade or to the basement floor, whichever is less. Where installed, Basement wall insulation shall be secured to the wall and extend downward from the sill plate to not less than the top of the foundation wall footing.

Exception: Where the basement wall insulation is installed on the interior side of the wall it shall be secured to the wall and extend downward from the top of the concrete wall at the sill plate to not less than 3 inches from the basement slab.

R402.2.9 Slab-on-grade floors. Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table R402.1.2 and Section R402.2.9.1 or R402.2.9.2.

R402.2.9.1 Slab-on-grade floor insulation installation. Where installed, the insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall and shall create a thermal break between attached slabs that are located outside of the building's thermal envelope. Insulation located below grade shall be extended the distance provided in Table R402.1.2 or the distance of the proposed design, as applicable, by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending away from the building shall be protected by pavement or by not less than 10 inches (254 mm) of soil. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the *exterior wall.* For heated slabs, full slab insulation shall be continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Slab edge insulation required at the heated slab perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

R402.2.9.2 Alternative slab-on-grade insulation configurations. For buildings complying with Section R406, slab-on-grade insulation shall be installed in accordance with the proposed design or rated design. The proposed design or rated design shall use an alternative insulation configuration and associated F-factor complying with Appendix A of ASHRAE 90.1. Where used to comply with Section R401.2.1, the F-factor shall be equal to or less than the F-factor required by Table R402.1.4 for a heated or unheated slab, as applicable.

R402.2.10 Crawl space walls. Crawl space walls shall be insulated in accordance with Table R402.1.2.

Exception: Crawl space walls associated with a crawl space that is vented to the outdoors and the floor overhead is insulated in accordance with Table R402.1.2 and Section R402.2.7.

R402.2.10.1 Crawl space wall insulation installation. Where installed, crawl space wall insulation shall be secured to the wall and extend downward from the sill plate to not less than the top of the foundation wall footing. Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the International Building Code or International Residential Code, as applicable. Joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (153 mm) up stem walls and shall be attached to the stem walls.

Exception: Where the crawl space wall insulation is installed on the interior side of the wall and the crawl space floor is more than 24 inches (610 mm) below the exterior grade, the crawl space wall insulation shall be permitted to extend downward from the top of the concrete wall at the sill plate at the top of the foundation to not less than the interior floor of the crawl space.

R402.2.10.2 Alternative crawl space wall insulation configurations. For buildings complying with Sections R406, crawl space wall insulation shall be installed in accordance with the proposed design or rated design. The proposed design or rated design shall use an alternative insulation configuration and associated U-factor or C-factor complying with Appendix A of ASHRAE 90.1. Where used to comply with Section R401.2.1, the U-factor or C-factor shall be equal to or less than the U-factor required by Table R402.1.4 for crawl space walls.

R402.2.11 Masonry veneer. Insulation shall not be required on the horizontal portion of a foundation that supports a masonry veneer.

R402.2.12 Sunroom and heated garage insulation. *Sunrooms* enclosing *conditioned space* and heated garages shall meet the insulation requirements of this code.

Exception: For *sunrooms* and heated garages with *thermal isolation*, and enclosing *conditioned space*, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation *R*-value shall be R30.
2. The minimum wall insulation *R*-value shall be R-15. Walls separating a *sunroom* or heated garage with a *thermal isolation* from *conditioned space* shall comply with the *building thermal envelope* requirements of this code.

R402.3 Fenestration. In addition to the requirements of Section R402, fenestration shall comply with Sections R402.3.1 through R402.3.5.

R402.3.1 *U*-factor. An area-weighted average of fenestration products shall be permitted to satisfy the *U*-factor requirements.

R402.3.2 Glazed fenestration SHGC. An area-weighted average of fenestration products more than 50-percent glazed shall be permitted to satisfy the SHGC requirements.

Dynamic glazing shall be permitted to satisfy the SHGC requirements of Table R402.1.2 provided that the ratio of the higher to lower labeled SHGC is greater than or equal to 2.4, and the *dynamic glazing* is automatically controlled to modulate the amount of solar gain into the space in multiple steps. *Dynamic glazing* shall be considered separately from other fenestration, and area-weighted averaging with other fenestration that is not dynamic glazing shall be prohibited.

Exception: Dynamic glazing shall not be required to comply with this section where both the lower and higher labeled SHGC comply with the requirements of Table R402.1.2.

R402.3.3 Glazed fenestration exemption. Not greater than 15 square feet (1.4 m^2) of glazed fenestration per *dwelling unit* shall be exempt from the *U*-factor and SHGC requirements in Section R402.1.2. This exemption shall not apply to the Total UA alternative in Section R402.1.2.3.

R402.3.4 Opaque door exemption. One side-hinged opaque door assembly not greater than 24 square feet (2.22 m^2) in area shall be exempt from the *U*-factor requirement in Section R402.1.2. This exemption shall not apply to the Total UA alternative in Section R402.1.2.3.

R402.3.5 Sunroom and heated garage fenestration. *Sunrooms* and heated garage enclosing *conditioned space* shall comply with the fenestration requirements of this code. New fenestration that is part of an assembly providing *thermal isolation* between a *sunroom* or heated garage and *conditioned space* shall comply with the *thermal envelope* requirements of this code.

Exception: For *sunrooms* and heated garages with *thermal isolation* and enclosing *conditioned space*, the fenestration *U*-factor shall not exceed 0.45 and the *skylight U*-factor shall not exceed 0.70.

R402.4 Air leakage. The *building thermal envelope* shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.6.

R402.4.1 Building thermal envelope. The *building thermal envelope* shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

R402.4.1.1 Installation. The components of the *building thermal envelope* as indicated in Table R402.4.1.1 shall be installed in accordance with the manufacturer's installation instructions and the criteria indicated in Table R402.4.1.1, as applicable to the method of construction. Where required by the *code official*, an *approved* third party shall inspect all components and verify compliance.

TABLE R402.4.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material. Air permeable insulation installed in building cavities assemblies shall be enclosed by an air barrier on all sides.
Ceiling/attic	An air barrier shall be installed in any dropped ceiling or soffit to separate it from unconditioned space. Access openings, drop downstairs or knee wall doors to unconditioned attic spaces shall be air sealed with gasketing materials that allow for repeated entrance over time.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier. Access hatches and doors shall be installed and insulated in accordance with Section R402.2.4. Eave Baffles shall be installed in accordance with Section R402.2.3.
Above grade walls	The junction of the foundation and sill plate shall be air sealed. The junction of the top plates and the drywall adjacent to unconditioned spaces shall be air sealed. The junction of the bottom plate to the subfloor on exterior walls separating conditioned space from unconditioned space shall be air sealed.	Air permeable insulation installed in wall cavities shall be enclosed by an air barrier on all sides. Building thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Corners in exterior frame walls shall be insulated with a material having a thermal resistance, R-value, of not less than R-3 per inch. Headers on exterior walls framed with 2x6 lumber or greater in size shall be insulated to a minimum R-5. Engineering evidence may be requested for header locations where insulation cannot be added due to structural requirements of the design.
Knee wall	Knee walls shall have a sealed air barrier on the unconditioned side of the assembly to separate conditioned from unconditioned space.	Insulation installed in a knee wall assembly shall be installed in accordance with the above-grade walls section from this Table.
Windows, skylights and doors	The rough opening gap between framing and the frames of skylights, jambs of windows, and doors shall be sealed in accordance with fenestration manufacturer's instructions.	Framing cavities around windows, skylights and doors shall be insulated per window manufacturer's instructions
Rim joists	Rim joists shall include an exterior air barrier [b] The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed.	Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.[b] Air permeable insulation installed in rim joists shall be enclosed by an air barrier.
Floors, separating conditioned from unconditioned space, including cantilevered floors and floors above garages	The air barrier shall be installed at any exposed edge of insulation. Floor framing members that are part of the building thermal envelope shall be air sealed to maintain a continuous air barrier.	Air permeable insulation installed in floor cavities shall be enclosed on all sides Floor framing cavity insulation shall be installed in accordance with the requirements of Section R402.2.7.

(continued)

TABLE R402.4.1.1-continued
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
Basement crawl space and slab foundations	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder/air barrier in accordance with Section R402.2.10.1. Penetrations through concrete foundation walls and slabs shall be air sealed. Class 1 vapor retarders shall not be used as an air barrier on below-grade walls and shall be installed in accordance with Section R702.7 of the *International Residential Code*.	Crawl space insulation, where provided instead of floor insulation, shall be installed in accordance with Section R402.2.10. Conditioned basement foundation wall insulation shall be installed in accordance with Section R402.2.8.1. Slab-on-grade floor insulation shall be installed in accordance with Section R402.2.9.1.
Shafts, penetrations	Duct and flue shafts, and other similar penetrations to exterior or unconditioned space shall be sealed to allow for expansion, contraction, and mechanical vibration. Utility penetrations of the air barrier shall be caulked, gasketed or otherwise sealed and shall allow for expansion, contraction of materials and mechanical vibration.	Insulation shall be fitted tightly around utilities passing through shafts and penetrations in the building thermal envelope to maintain required R-value.
Narrow cavities	Narrow cavities of 1 inch or less that are not able to be insulated shall be air sealed.	Batts to be installed in narrow cavities shall be cut to fit or narrow cavities shall be filled with insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.	Insulated portions of the garage separation assembly shall be installed in accordance with Sections R303, and R402.2.7.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air sealed in accordance with Section R402.4.5.	Recessed light fixtures installed in the building thermal envelope shall be airtight and IC rated and shall be buried or surrounded with insulation.
Plumbing, wiring or other obstructions	All holes created by wiring, plumbing or other obstructions in the air barrier assembly shall be air sealed.	Insulation shall be installed to completely fill the available space and surround wiring, plumbing, or other obstructions, unless the required R-value can be met by installing insulation and air barrier systems completely to the exterior side of the obstructions.
Showers, tubs, and fireplaces adjacent to the *building thermal envelope*	An air barrier shall separate insulation in the *building thermal envelope* from the shower, tub, or fireplace assembly adjacent to it. Tub and shower drain trap penetrations through the subfloor shall be air sealed. Fireplaces shall comply with the requirements of Section R402.4.2	Exterior framed walls adjacent to showers,-tubs, and fireplace shall be insulated to the same level as the proposed above grade or foundation wall they are adjacent to.
Electrical communication, and other equipment boxes, housings, and enclosures	Boxes, housings, and enclosures that penetrate the *air barrier* shall be caulked, taped, gasketed, or otherwise sealed to the *air barrier* element being penetrated. All concealed openings into the box, housing, or enclosure shall be sealed. Alternatively, air-sealed boxes shall be installed in accordance with R402.4.6	Boxes, housing, and enclosures shall be completely buried in or surrounded by insulation.
HVAC register boots	HVAC supply and return register boots shall be sealed to the subfloor, wall covering, or ceiling penetrated by the boot.	HVAC supply and return register boots located within the *buildings thermal envelope* assembly shall be completely buried in or surrounded by insulation.
Concealed sprinklers	Where required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer.	—
Common walls or double walls separating attached single-family dwellings or townhouses	An interior air barrier shall be provided. Air sealing at the intersections with building thermal envelope shall be provided. Where installed in a fire resistance rated wall assembly, air sealing materials shall comply with one of the following: 1. be in accordance with an approved design for the fire resistance-rated assembly. 2. be supported by approved data that shows the assembly as installed complies with the required fire-resistance rating	Insulation materials recognized in the approved common wall or double wall design and installed in accordance with the approved design, shall be permitted to be used.

a. Inspection of log walls shall be in accordance with the provisions of ICC 400.
b. Air barrier and insulation full enclosure is not required in unconditioned/ventilated attic spaces and at rim joists.

R402.4.1.2 Testing. The *building* or dwelling unit shall be tested for air leakage. The maximum air leakage rate for any building or dwelling unit under any compliance path shall not exceed 3.0 air changes per hour for single family buildings or 0.16 cubic feet per minute (CFM) per square foot (0.81 L/s • m^2) of dwelling unit enclosure area for other than a single-family building. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2-inch w.g. (50 Pascals). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope* have been sealed. Mechanical ventilation shall be provided in accordance with Section M1505 of the International Residential Code or Section 403.3.2 of the International Mechanical Code, as applicable, or with other approved means of ventilation.

Exceptions:

1. The b*uilding thermal envelope* and *continuous air barrier* shall separate and isolate heated and nonheated, attached private garage spaces and heated and nonheated, detached private garage spaces from all other habitable, *conditioned spaces* in accordance with the items in Table R402.4.1.1. The volume of these garage spaces shall not be included in the calculated habitable conditioned volume for the purpose of calculating the air changes per hour compliance metric. Doors between habitable conditioned spaces and all attached garages shall be closed during air leakage testing unless the blower door testing assembly is installed in the doorway. Where required by the *code official*, an approved third party independent from the installer shall inspect both air barrier and insulation installation criteria.
2. When testing individual dwelling units, an air leakage rate not exceeding 0.20 cubic feet per minute per square foot (1.0 L/s • m^2) of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2-inch w.g. (50 Pa), shall be an accepted alternative permitted for:
    a. Attached single-family and multiple-family building dwelling units.
    b. Buildings or dwellings units that are 1,000 square feet (93m2) or smaller.

R402.4.2 Fireplaces and wood burning stoves. Only EPA Phase II or Colorado Phase III certified woodburning devices shall be permitted to be installed. Colorado Phase III stoves must pass both particulate matter and carbon monoxide emission standards. EPA Phase II certified stoves must only pass standards for particulate emissions.

R402.4.3 Fenestration air leakage. Windows, *skylights* and sliding glass doors shall have an air infiltration rate of not greater than 0.3 cfm per square foot (1.5 L/s/m^2), and for swinging doors, not greater than 0.5 cfm per square foot (2.6 L/s/m2), when tested in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer.

Exception: Site-built windows, *skylights,* and doors.

R402.4.4 Rooms containing fuel-burning appliances. Where open combustion air ducts provide combustion air to open combustion fuel-burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room that is fully isolated from conditioned space inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the basement wall R-value requirement. The door into the room shall be fully gasketed and any penetrations from water/electrical lines and ducts into the room insulated in accordance with Section R403 and sealed per Table R402.4.1.1. The combustion air duct shall be insulated where it passes through conditioned space to an R-value of not less than R-8.

Exceptions:

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Section R402.4.2 of this code and Section R1006 of the International Residential Code.

R402.4.5 Recessed lighting. Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Recessed luminaires shall be IC-rated and labeled as having an air leakage rate of not greater than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf (75 Pa). Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering.

R402.4.6 Air-Sealed electrical and communication outlet boxes. Air-sealed electrical and communication outlet boxes that penetrate the air barrier of the building thermal envelope shall be caulked, taped, gasketed, or otherwise sealed to the air barrier element being penetrated. Air sealed boxes shall be buried in or surrounded by insulation. Air-sealed boxes shall be tested and marked in accordance with NEMA OS 4. Air-sealed boxes shall be installed in accordance with the manufacturer's instructions.

R402.5 Maximum fenestration U-factor and SHGC. The area-weighted average maximum fenestration U-factor permitted using tradeoffs from Section R402.2.1.3 shall be 0.48 for vertical fenestration and 0.75 for skylights.

Exception: The maximum U-factor and solar heat gain coefficient (SHGC) for fenestration shall not be required in storm shelters complying with ICC 500.

SECTION R403
SYSTEMS

R403.1 Mechanical System energy sources. All mechanical systems such as for heating, cooling, water heating, cooking, clothes drying, pool and spa heating, snow- and ice- melt systems and any mechanical systems outside the building shall be all-electric or fueled by other non-fossil fuel derived energy sources.

R403.2 Controls. Not less than one thermostat shall be provided for each separate heating and cooling system.

R403.2.1 Programmable thermostat. The thermostat controlling the primary heating or cooling system of the *dwelling unit* shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature setpoints at different times of the day and different days of the week. This thermostat shall include the capability to set back or temporarily operate the system to maintain *zone* temperatures of not less than 55°F (13°C) to not greater than 85°F (29°C). The thermostat shall be programmed initially by the manufacturer with a heating temperature setpoint of not greater than 70°F (21°C) and a cooling temperature setpoint of not less than 78°F (26°C).

R403.2.2 Heat pump supplementary heat. Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.

R403.3 Hot water boiler temperature reset. The manufacturer shall equip each boiler (other than a boiler equipped with a tankless domestic water heating coil) with automatic means of adjusting the water temperature supplied by the boiler to ensure incremental change of the inferred heat load will cause an incremental change in the temperature of the water supplied by the boiler. This can be accomplished with outdoor reset, indoor reset, or water temperature sensing.

R403.4 Duct Systems. Ducts and air handlers shall be installed in accordance with Sections R403.4.1 through R403.4.7. The air handler shall be installed within the conditioned space of the building or dwelling unit.

R403.4.1 Ducts located outside conditioned space. Supply and return ducts located outside *conditioned space* shall be insulated to an *R*-value of not less than R-8 and shall comply with Section R403.4.3. Duct work shall not be buried beneath a building or underground.

R403.4.2 Ducts located in conditioned space. For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.4.3 and all of the following conditions shall exist:
    2.1. The air handler is located completely within the *continuous air barrier* and within the building thermal envelope.
    2.2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.4.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m^2) of conditioned floor area served by the duct system.
    2.3. The ceiling insulation *R*-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation *R*-value, less the *R*-value of the insulation on the duct.
3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:
    3.1. A continuous air barrier installed between unconditioned space and the duct.
    3.2. Insulation installed in accordance with Section R402.2.7.
    3.3. A minimum R-19 insulation installed in the cavity width separating the duct from unconditioned space.
4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:
    4.1. A continuous air barrier installed between unconditioned space and the duct.
    4.2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
    4.3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

R403.4.3 Ducts buried within ceiling insulation. Supply and return air ducts located in unconditioned attic or ceiling spaces shall comply with all of the following:

1. The supply and return ducts shall have an insulation *R*-value not less than R-8.
2. The duct shall be installed against the truss bottom cord or ceiling joist closest to the ceiling finish material separating conditioned space from unconditioned space and the sum of the ceiling insulation *R*-value above the top of the duct, and against the sides of the duct, shall enclose the duct in insulation and shall be greater than or equal to the proposed ceiling insulation R-value.

R403.4.3.1 Effective *R*-value of deeply buried ducts. When using the Energy Rating Index compliance option Section R406, ducts that are installed in accordance with Section R403.4.3 shall be considered as having an effective duct insulation *R*-value of R-25.

R403.4.4 Sealing. Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with either the *International Mechanical Code* or *International Residential Code*, as applicable.

R403.4.4.1 Sealed air handler. Air handlers shall have a manufacturer's designation for an air leakage of not greater than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.

R403.4.5 Duct testing. Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1-inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All portions of the duct system, including air handler, filter box, supply and return boots shall be tested.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1-inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All portions of the duct system, including air handler, filter box, supply and return boots shall be tested.
3. Postconstruction test: When using the Energy Rating Index compliance option Section R406, duct leakage to outside testing shall be measured in accordance with ANSI/RESNET/IECC 380.

   A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*.

   Exception: A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems.

R403.4.6 Duct leakage. The total leakage of the ducts system, where measured in accordance with Section R403.4.5, shall be determined by one of the following methods:

1. Rough-in test: The total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area where the air handler is installed at the time of the test.

   Exceptions:

   a. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

   b. If the HVAC duct system is serving less than or equal to 1,200 square feet of conditioned floor area, the allowable duct leakage shall be 50 cubic feet per minute or less.
2. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

   Exception: If the HVAC duct system is serving less than or equal to 1,200 square feet of conditioned floor area, the allowable duct leakage shall be 50 cubic feet per minute or less.
3. Postconstruction duct leakage to outside: duct leakage to outside the *building thermal envelope* shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area when using the Energy Rating Index compliance option Section R406. This option is available for unique circumstances and shall obtain the code officials approval prior to proceeding with the test.

R403.4.7 Building cavities. *Building* framing cavities shall not be used as ducts or plenums.

R403.5 Mechanical system and service hot water piping insulation. Mechanical system piping capable of carrying fluids greater than 105°F (41°C) or less than 55°F (13°C) shall be insulated to an *R*-value of not less than R-3.

R403.5.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind. The protection shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall be prohibited.

R403.6 Service hot water systems. Service hot water systems shall be *all-electric* or fueled by other non-fossil fuel derived energy sources. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.6.1 through R403.6.3. Service hot water systems shall not be permitted to service accessory structures from the main building.

R403.6.1 Heated water circulation and temperature maintenance systems. Where installed heated water circulation systems shall be in accordance with Section R403.6.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.6.1.2. Automatic controls, temperature sensors and pumps shall be in a location with access. Manual controls shall be in a location with *ready access.*

R403.6.1.1 Circulation systems. Heated water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold-water supply pipe. Gravity and thermosyphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water. The controls shall limit the temperature of the water entering the cold-water piping to not greater than 104ºF (40ºC).

R403.6.1.1.1 Demand recirculation water systems. Where installed, *demand recirculation water systems* shall have controls that start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance.

R403.6.1.2 Heat trace systems. Where installed, electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

R403.6.2 Hot water pipe insulation. Insulation for service hot water piping with a thermal resistance, *R*-value, of not less than R-3 shall be applied to the following:

1. Piping $^{3}/_{4}$ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space.*
2. Piping serving more than one dwelling unit.
3. Piping located outside the *conditioned space*.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
6. Buried piping.
7. Supply and return piping in circulation and recirculation systems other than cold water pipe return demand recirculation systems.

R403.6.3 Drain water heat recovery units. Where installed, drain water heat recovery units shall comply with CSA B55.2. Drain water heat recovery units shall be tested in accordance with CSA B55.1. Potable water-side pressure loss of drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers.

R403.7 Mechanical ventilation. *Residential buildings* and *dwelling units* shall be provided with mechanical ventilation that complies with the requirements of Section M1505 of the *International Residential Code* or *International Mechanical Code*, as applicable, or with other *approved* means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

R403.7.1 Heat or energy recovery ventilation. *Dwelling units* shall be provided with a heat recovery or energy recovery ventilation system. The system shall be a balanced ventilation system with a sensible recovery efficiency (SRE) of no less than 65 percent at 32°F (0°C) at an airflow greater than or equal to the design airflow. The SRE shall be determined from a listed value or from interpolation of listed values.

R403.7.2 Whole-dwelling mechanical ventilation system fan efficacy. Fans used to provide whole-dwelling mechanical ventilation shall meet the efficacy requirements of Table R403.7.1 at one or more rating points. Fans shall be tested in accordance with HVI 916 and listed. The airflow shall be reported in the product listing or on the label. Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERV, balanced, and in-line fans shall be determined at a static pressure of not less than 0.2-inch w.c. (49.85 Pa). Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure of not less than 0.1-inch w.c. (24.91 Pa).

TABLE R403.7.1
WHOLE-DWELLING MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)
HRV, ERV	Any	1.2 cfm/watt [a]
Range hood	Any	2.8 cfm/watt
In-line supply or exhaust fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
Other exhaust fan	> 90	3.5 cfm/watt
Air-handler that is integrated to tested and listed HVAC equipment	Any	1.2 cfm/watt

For SI: 1 cubic foot per minute = 28.3 L/min.

a. For balanced systems, HRVs, and ERVs determine the efficacy as the outdoor airflow divided by the total fan power.

R403.7.3 Testing. Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by Section R403.7 in accordance with ANSI/ RESNET/ICC 380. Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

Exception: Kitchen range hoods that are ducted to the outside with 6-inch (152 mm) or larger duct and not more than one 90-degree (1.57 rad) elbow or equivalent in the duct run.

R403.7.4 Intermittent exhaust control for bathrooms and toilet rooms. Where an exhaust system serving a bathroom or toilet room is designed for intermittent operation, the exhaust system controls shall include one or more of the following:

1. A timer control with one or more delay setpoints that automatically turns off exhaust fans when the selected setpoint is reached. Not fewer than one delay-off setpoint shall be 30 minutes or less.
2. An occupant sensor control with one or more delay setpoints that automatically turns off exhaust fans in accordance with the selected delay setpoint after all occupants have vacated the space. Not fewer than one delay-off setpoint shall be 30 minutes or less.
3. A humidity control with an adjustable setpoint ranging between 50 percent or more and 80 percent or less relative humidity that automatically turns off exhaust fans when the selected setpoint is reached.
4. A contaminant control that responds to a particle or gaseous concentration and automatically turns off exhaust fans when a design setpoint is reached.

Manual-off functionality shall not be used in lieu of the minimum setpoint functionality required by this section.

Exception: Bathroom and toilet room exhaust systems serving as an integral component of an outdoor air ventilation system or a whole-house mechanical ventilation system.

R403.8 Space heating and cooling equipment sizing and efficiency rating. Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on *building* loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies. Where the installed heating and cooling delivery system uses duct work, ACCA Manual D or other approved design manual shall be used. New space heating and cooling equipment shall be *all-electric* or fueled by other non-fossil fuel derived energy sources and have an efficiency rating greater than or equal to the minimum required by federal law for the geographic location where the equipment is installed.

R403.9 Systems serving multiple dwelling units. Systems serving multiple dwelling units shall be all-electric or fueled by other non-fossil fuel derived energy sources and comply with Sections C403 and C404 of the Commercial Provisions of this code instead of Section R403.

R403.10 Snow melt and ice system controls. Snow- and ice-melting systems, supplied through energy service to the building, shall comply with Sections R403.10.1 and R403.10.2.

R403.10.1 Controls. Snow- and ice-melting systems shall include automatic controls capable of shutting off the system when the pavement temperature is greater than 50°F (10°C) and precipitation is not falling, and an automatic or manual control that will allow shutoff when the outdoor temperature is greater than 40°F (4.8°C).

R403.9.2 Renewable energy offset. Energy use by snow- and ice-melting systems shall be offset by on-site renewable energy generation equipment designed to provide 34,425 BTUs per square foot for the installed snow- and ice-melting system per year. Plans shall be submitted that detail the type, size, and location of the on-site renewable energy generation equipment.

Note: A separate building permit is required for on-site renewable energy generation equipment.

R403.11 Energy consumption of pools and spas. Pools and permanent spas shall be controlled by the requirements in Sections R403.11.1 through R403.11.3.

R403.11.1 Heaters. The electric power to heaters shall be controlled by an on-off switch that is an integral part of the heater mounted on the exterior of the heater in a location with ready access, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Only heat pumps rated for cold climates shall be permitted or other non-fossil fueled equipment.

Exception: Unheated pools.

R403.11.2 Time switches. Time switches or other control methods that can automatically turn off and on heaters and pump motors according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate solar- and waste-heat-recovery pool heating systems.

R403.11.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other *approved* vapor-retardant means.

Exception: Where more than 75 percent of the energy for heating, computed over an operation season of not fewer than three calendar months, is from a heat pump or an on-site renewable energy system, covers or other vapor-retardant means shall not be required.

R403.11.4 Filters. Swimming pool filters shall be cartridge-type filters.

R403.11.5 Pumps. Swimming pool pumps shall be multi-speed pumps.

R403.11.6 Load calculations. For the purpose of calculating the energy use of swimming pools, the following are assumed:

1. Swimming pool season.
    1.1. Outdoor pools: 3 months.
    1.2. Indoor pools: 12 months.
2. Pool heating temperature: 82°F (28°C) or less.
3. On-site renewable energy requirements: 29,000 BTUs per square foot of pool surface area per year.

Note: This section is not intended to limit the season or temperature of swimming pools.

R403.12 Portable spas. The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

R403.13 Residential pools and permanent residential spas. Where installed, the energy consumption of residential swimming pools and permanent residential spas shall be controlled in accordance with the requirements of APSP 15.

R403.14 Spas. Any energy use by indoor or outdoor spas must be offset by on-site renewable energy generation equivalent to the energy use by the spa. Plans must show the annual energy use of the spa, the calculation method used to determine the expected energy use, and the on-site renewable energy system(s) that will be used to offset the energy used by the spa. All spas must be equipped with an insulated cover that is listed to provide a minimum *R*-value of at least 12.

Exception: Spas and hot tubs that have been tested and listed for compliance with the requirements of the California Energy Commission (CEC) Title 20 [standby power for portable electric spas shall be not greater than $5(V^2/3)$ watts where V = the total volume of the spa in gallons], and are less than 64 square feet (5.9 m^2) in surface area shall be exempted from the requirement to offset their energy usage by on-site renewable energy generation. Spas larger than 64 square feet (5.9 m^2) in surface area that are certified to meet the requirements of

the CEC shall offset their requirements at the rate of 140,000 BTUs per square foot per year.

R403.14.1 Design criteria for spas. The requirements of this section apply to spas that do not meet the exception in Section R403.14.

Spa season: 12 months

On-site renewable energy requirements: 430,000 BTUs per square foot per year

SECTION R404
ELECTRICAL POWER AND LIGHTING SYSTEMS

R404.1 Lighting equipment. Lighting equipment shall comply with the requirements of this section.

R404.1.1 Exterior lighting. Connected exterior lighting for residential buildings shall comply with Section C405.4.

Exceptions:

1. Detached one- and two- family dwellings.
2. Townhouses.
3. Solar-powered lamps not connected to any electrical service.
4. Luminaires controlled by a motion sensor.
5. Lamps and luminaires that comply with Section R404.1.

R404.1.2 Fuel gas lighting equipment. Fuel gas lighting systems shall not be permitted.

R404.2 Interior lighting controls. Permanently installed lighting fixtures shall be controlled with either a dimmer or an occupant sensor control or other control that is built into the fixture.

Exception: Lighting controls shall not be required for the following:

1. Bathrooms.
2. Hallways.
3. Exterior lighting fixtures.
4. Lighting designed for safety or security.

R404.3 Exterior lighting controls. Where the total permanently installed exterior lighting power is greater than 30 watts, the permanently installed exterior lighting shall comply with the following:

1. Lighting shall be controlled by a manual on and off switch which permits automatic shut-off actions.

Exception: Lighting serving multiple dwelling units.

2. Lighting shall be automatically shut off when daylight is present and satisfies the lighting needs.
3. Controls that override automatic shut-off actions shall not be allowed unless the override automatically returns automatic control to its normal operation within 24 hours.

R404.4 Electric vehicle (EV) charging for new construction. The building shall be provided with electric vehicle (EV) charging in accordance with this section and the *National Electrical Code* (NFPA 70). Where parking spaces are added or modified without an increase in building size, only the new parking spaces are subject to this requirement. The number of parking spaces can be determined by actual spaces provided or consistent with Boulder's Municipal Code, Title 9: Land Use Code, Chapter 9: Development Standards, 9-9-6: Parking Standards.

R404.4.1 One- and two-family dwellings and townhouses. Each dwelling unit with a dedicated attached or detached garage or other onsite designated parking provided for the dwelling unit shall be provided with at least one electric vehicle ready space.

R404.4.1.1 EV Ready Spaces. Each EV ready space shall have a branch circuit that complies with all of the following:

1. Terminates at a receptacle, located within 3 feet of each EV ready space it serves. EV ready includes two adjacent parking spaces if the receptacle for the electrical facilities of this section is installed adjacent to and between both parking spaces.
2. Has a minimum circuit capacity of 8.3 kVA (40A 208/240V).
3. The electrical panel, electrical distribution equipment directory, and all outlets or enclosures shall be marked "For future electric vehicle supply equipment".

Exception: A receptacle need not be provided if a hard-wired EVSE is installed.

R404.4.2 Identification. Construction documents shall designate the EV ready space and indicate the locations of raceway and/or conduit and the termination points serving them. The circuits or spaces reserved in the electrical panel for EV ready spaces shall be clearly identified in the panel or subpanel directory.

R404.4.3 Group-R occupancies. Group-R occupancies with three or more dwelling units and/or sleeping units shall be provided with electric vehicle charging in accordance with Table C405.13.1. Calculations for the number of spaces shall be rounded up to the nearest whole number. If there is off street parking that is not otherwise assigned to individual units, it must comply with C405.13 for R-2 occupancies.

R404.4.4 Accessible parking. Where new EVSE installed spaces and/or new EV ready spaces and new accessible parking, as defined by the *City of Boulder Building Code,* Chapter 11, "Accessibility," are both provided, parking facilities shall be designed so that at least one accessible parking space shall be EV ready or EVSE installed.

R404.4.5 Number and features of universal vehicle spaces. Refer to section C405.13.5 for requirements.

SECTION R405
RESERVED

SECTION R406
ENERGY RATING INDEX COMPLIANCE ALTERNATIVE

R406.1 Scope. This section establishes criteria for compliance using an Energy Rating Index (ERI) analysis.

R406.1.1 ERI compliance. Compliance based on the Energy Rating Index (ERI) requires that the rated design meet all of the following:

1. The Energy Rating index score shall be developed using the most recent version of RESNET/ICC/ ANSI Standard 301.
2. The requirements of the sections indicated within Table R406.1.1, Mandatory Requirements.
3. Maximum ERI of Table R406.3.
4. Compliance with all sections listed in Table R406.2.

TABLE R406.1.1
MANDATORY REQUIREMENTS

SECTION[a]	TITLE
R303	Materials, systems, and equipment
R401.3	Documentation
R402.1.1	Vapor retarder
R402.2	Specific Insulation Requirements
R402.4	Air leakage Requirements
R402.5 (ERI Path Only)	Maximum fenestration U-factor and SHGC
R403	Systems
R404	Electrical Power and Lighting Systems
R407	Solar ready
R408	Additional conservation requirements

a. Reference to a code section includes all the relative subsections.

R406.2 Building thermal envelope. Building and portions thereof shall comply with Table R406.1.1 Mandatory Requirements.

R406.2.1 ERI with and without on-site renewable energy sources. The building shall comply with the ERI scores as defined in Table R406.3. The proposed and confirmed design compliance reports shall be provided for the building both without On-site renewables and with onsite renewables respectively.

R406.3 Energy Rating Index. The Energy Rating Index (ERI) shall be determined in accordance with RESNET/ICC 301.

Where roof space is maximized for renewable energy, the post solar ERI target shall be adjusted so as to not require off-site renewable energy to achieve compliance. Energy used to recharge or refuel a vehicle used for transportation on roads that are not on the building site shall not be included in the *ERI reference design* or the *rated design*.

TABLE R406.3
MAXIMUM ENERGY RATING INDEX (ERI)[a] COMPLIANCE SCORES

NEW CONSTRUCTION: ≥3000 ft²	
Pre-Renewable ERI Score	**Post-Renewable ERI Score**
50	0
NEW CONSTRUCTION: 0 to 2999 ft²	
Pre-Renewable ERI Score	**Post-Renewable ERI Score**
50	30

a. The target Energy Rating Index shall be determined utilizing the square footage as calculated for the Energy Rating Index.

R406.4 Reserved.

R406.5 ERI-based compliance. Compliance based on an ERI analysis requires that the *rated proposed design* and confirmed built dwelling be shown to have an ERI less than or equal to the appropriate value indicated in Table R406.3 when compared to the *ERI reference design*. Compliance shall be shown for the required ERI scores before and, if provided, with on-site renewable energy production. Projects with on-site renewable energy production shall comply with Sections R406.5.1, R406.5.2, and R406.5.3.

R406.5.1 Pre-Renewables ERI Target. Prior to incorporating on-site renewable energy production into the project design, the project shall achieve the ERI target set in Table R406.3 before on-site renewable energy production (pre-renewables ERI score).

R406.5.2 Post-Renewables ERI Target. Once a pre-renewables ERI score has been determined for compliance, the project shall achieve the ERI target set in Table R406.3 with on-site renewable energy production (post-renewables ERI score).

Exception:

1. **Technical infeasibility.** The *chief building official* has the authority to modify the ERI requirement to the lowest ERI score that is reasonably feasible to be achieved in the following circumstances:
   a. It has been demonstrated to the *chief building official* that it is not possible to install an on-site solar array that is unshaded for more than 70 percent of daylight hours annually that is of sufficient size to meet the requirements. The submittal documents for such requests shall include an ERI compliance report that includes the size and annual kWh production of the hypothetical on-site renewable energy system that would be required to achieve an ERI score of 0.

R406.5.3 On-site renewable energy. On-site renewable energy systems shall be used for compliance with Section 406.5. On-site renewable energy systems must be permanently installed on the property of the building.

Exception:

1. ERI achieved without on-site renewable sources. No on-site renewable energy system is required if it has been demonstrated to the *chief building official* that the building has achieved the required post-renewables ERI score per Table R406.3 for new construction without on-site renewable energy production.

R406.6 Verification by approved agency. Verification of compliance with Section R406 as outlined in Sections R406.3and R406.6 shall be completed by an approved third party. Verification of compliance with Section R406.2 shall be completed by the authority having jurisdiction or an approved third-party inspection agency in accordance with Section R105.4.

R406.7 Documentation. Documentation of the software used to determine the ERI and the parameters for the

residential building shall be in accordance with Sections R406.7.1 through R406.7.3.

R406.7.1 Compliance software tools. Software tools used for determining the ERI shall be Approved Software Rating Tools in accordance with RESNET/ICC 301.

R406.7.2 Compliance report. Compliance software tools shall generate a report that documents that the home and the ERI score of the *rated design* complies with R406.2, R406.3 and R406.5. The compliance documentation shall be created for the proposed design and shall be submitted with the application for the building permit. Confirmed compliance documents of the built dwelling unit shall be created, registered with RESNET, and submitted to the *code official* for review before a certificate of occupancy is issued. Compliance reports shall include information in accordance with Sections R406.7.2.1 and R406.7.2.2.

R406.7.2.1 Proposed compliance report for permit application. Compliance reports submitted with the application for a building permit shall include the following:

1. Building street address, or other building site identification.
2. Declare ERI on title page and building plans.
3. The name of the individual performing the analysis and generating the compliance report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the reference design and/or the rated home.
6. A certificate indicating that the proposed design has an ERI less than or equal to the appropriate score indicated in Table R406.3 when compared to the ERI reference design. The certificate shall document the building component energy specifications that are included in the calculation, including: component level insulation R-values or U-factors; assumed duct system and building envelope air leakage testing results; and the type and rated efficiencies of proposed heating, cooling, mechanical ventilation, and service water-heating equipment to be installed. If *on-site renewable energy systems* are installed, the certificate shall report the type and production size of the proposed system.
7. When a site-specific report is not generated, the proposed design shall be based on the worst-case orientation and configuration of the rated home.

R406.7.2.2 Confirmed compliance report for a certificate of occupancy. A confirmed compliance report submitted for obtaining the certificate of occupancy shall be made site and address specific and include the following:

1. Building street address or other building site identification.
2. Declaration of ERI on title page and on building plans.
3. The name of the individual performing the analysis and generating the report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the reference design and/or the rated home.
6. A final confirmed certificate indicating that the confirmed rated design of the built home complies with Sections R406.3 and R406.5 and is registered with RESNET. The certificate shall report the energy features that were confirmed to be in the home, including: component-level insulation R-values or U-factors; results from any required duct system and building envelope air leakage testing; and the type and rated efficiencies of the heating, cooling, mechanical ventilation, and service water-heating equipment installed. Where *on-site renewable energy systems* have been installed on or in the home, the certificate shall report the type and production size of the installed system.

R406.7.3 Renewable energy compliance documentation. Where on-site renewable energy is utilized for compliance with an ERI, the renewable energy system will need to pass final inspection prior to final approval of ERI report.

R406.7.4 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *ERI reference design*.
2. A certification signed by the builder providing the building component characteristics of the *rated design.*
3. Documentation of the actual values used in the software calculations for the *rated design*.

R406.7.5 Specific approval. Performance analysis tools meeting the applicable sections of Section R406 shall be *approved*. Documentation demonstrating the approval of performance analysis tools in accordance with Section R406.7.1 shall be provided.

R406.7.6 Input values. Where calculations require input values not specified by Sections R402, R403 and R404, those input values shall be taken from RESNET/ICC 301.

SECTION R407
SOLAR READY

R407.1 General. *Residential buildings* with not less than 600 square feet (55.74 m^2) of roof area oriented between 110 degrees and 270 degrees true north shall comply with this section.

Exceptions:

1. New residential buildings with a permanently installed on-site renewable energy system.
2. A building where all areas of the roof that would otherwise meet the requirements of Section R407.5

are in full or partial shade for more than 70 percent of daylight hours annually.

R407.2 Minimum renewable energy system capacity. New *residential buildings* shall be provided with an onsite renewable energy system(s) capable of producing annual renewable energy output of no less than is needed to achieve the Energy Rating Index score listed in Table R406.3 with onsite power production.

R407.3 Construction document requirements. System specifications and system renewable calculations demonstrating that the system(s) meet(s) the requirements of Section R407 shall be included in the construction documents. The onsite renewable energy system(s) used to comply with this section shall not be included in the calculations for Section R406.5.1 ERI compliance without onsite renewables**.**

R407.5 Solar-ready zone area. The total *solar-ready zone* area for each dwelling unit shall be not less than 300 square feet (27.87 m^2), exclusive of mandatory access or setback areas as required by the *City of Boulder Fire Code,* except that the total *solar-ready zone* area for a townhouse three stories or less in height above grade plane and with a total floor area less than or equal to 2,000 square feet (185.8 m^2) of conditioned space shall be not less than 150 square feet (13.94 m^2). The *solar-ready zone* shall be composed of areas not less than 5 feet (1524 mm) in width and not less than 80 square feet (7.43 m^2), exclusive of access or setback areas as required by the *City of Boulder Fire Code.*

R407.5.1 Obstructions. *Solar-ready zones* shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.

R407.5.2 Shading. The *solar-ready zone* shall be set back from any existing or new permanently affixed object on the building or site that is located south, east, or west of the *solar-ready zone* a distance not less than two times the object's height above the nearest point on the roof surface. Such objects include, but are not limited to, taller portions of the building itself, parapets, chimneys, antennas, signage, rooftop equipment, trees, and roof plantings either existing at the time of permit application or planned for on the construction documents.

R407.5.3 Roof load documentation. The structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

R407.6 Interconnection pathway. Construction documents shall indicate at least one potential pathway for routing of conduit and/or raceway from the *solar-ready zone* to the electrical service panel or service hot water system and shall be labeled as "Potential Pathway" on the construction documents.

R407.7 Electrical service reserved space. The main electrical service panel shall have space to allow installation of a dual pole circuit breaker for solar electric installation and shall be labeled "For Future Solar Electric." The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

R407.8 Construction documentation certificate. A permanent certificate, indicating the solar-ready zone and other requirements of this section, shall be posted near the electrical distribution panel, water heater or other conspicuous location by the builder or *registered design professional*.

SECTION R408
ADDITIONAL CONSERVATION REQUIREMENTS

R408.1 Additional Conservation requirements. This Section R408 establishes an additional conservation objective for *residential buildings.* For *additions* and *alterations* to *existing buildings* see Section R502 and R503 for the requirements. New *residential buildings* shall comply with the following to achieve the compliance:

1. When producing the final confirmed ERI score in accordance with Section R406.7.2.2 the Operational Carbon CO2 index shall be produced and submitted. In addition, a CO2 Emissions Comparison report shall be produced and submitted.
2. All new residential construction shall achieve a total of 10 credits from Table R408.1. Credit calculations shall be as specified in relevant subsections of Section R408.
3. Credits claimed pertaining to embodied carbon in Table R408.1 shall provide a product-specific Type III environmental product declarations (EPD). Credit sections that claim "X" percent pertains to the percentages from Table R408.1.
4. Confirmation of the product's $kgCO2e/m^2$ and *product specific Type III EPDs* shall be reported to the *code official* and verified by a *registered design professional* or *approved third party* on the project, and a summary shall be made available to the *code official* that includes a list of each product and associated kgCO2e/(unit specified), per the *product specific Type III EPD*.
    a. See Example kgCO2e/unit Summary Reporting Form at the end of this section.
5. All credits taken shall be specified on the plans for permitting. Prior to project completion, documentation shall be provided for all credits pursued under R408.

TABLE R408.1
ADDITIONAL CONSERVATION CREDITS

EMBODIED CARBON CONSERVATION CREDIT OPTIONS	CREDIT VALUE AND CREDIT VALUE PER PERCENT REDUCTION							
Measure Description	**Credit**	**50%**	**40%**	**25%**	**15%**	**10%**	**5%**	**2%**
R408.2 Whole building lifecycle analysis (WB LCA)	10							
R408.3 Embodied CO2e in Concrete Products		3		2		1		
R408.4 Embodied CO2e in Grade Lumber Products						3	2	1
R408.5 Embodied CO2e of Prefabricated Joist Products				3	1	1		
R408.6 Embodied CO2e of Glued Cross-laminated Timber Products		3		2		1		
R408.7 Embodied CO2e of Structural Composite Lumber Products				3	2	1		
R408.8 Embodied CO2e of Particleboard and Fiberboard Products				3	2	1		
R408.9 Embodied CO2e in Steel Product manufacturing				3	2	1		
R408.10 Embodied CO2e of Structural Steel Products		3		2		1		
R408.11 Embodied CO2e of Nonstructural Steel Products				3	2	1		
R408.12 Embodied CO2e of Steel Reinforcing Bar Products		3		2		1		
R408.13 Embodied CO2e of Insulation Products			3	2		1		
R408.14 Embodied CO2e of Foam Plastic Insulation Products				3	2	1		
R408.15 Embodied CO2e of Gypsum Products			3	2		1		
R408.16 Embodied CO2e of Interior Floor Covering Products			3	2		1		
R408.17 Embodied CO2e of Glazing Products				3	2	1		
R408.18 Embodied CO2e of Siding Products			3	2		1		
R408.19 Embodied CO2e of Clay Bricks				3	2	1		
R408.20 Embodied CO2e of Masonry Cement				3	2	1		
R408.21 Embodied CO2e of Roofing Products			3		2	1		
R408.22 Battery Storage:	10							
R408.23 Energy Monitoring System	5							
R408.24 Smart electrical panel	5							
R408.25 Energy Star Appliances (2pt additional for Most Efficient)	4							
R408.26 Condensing Clothes Dryer	2							
R408.27 Reduced Air-Leakage w/ ERV Installed	4							
R408.28 Roof Reflectance/Cool Roof	2							
R408.29 Ground Source Heat Pump	7							
R408.30 Heat Pump Water Heater w/ Demand Response Controls	5							
R408.31 Duct Leakage (≤ 2 CFM per square foot of floor area)	3							
R408.32 100% the duct system installed within the building thermal envelope	5							
R408.33 Reserved	-							
R408.34 Drain Water Heat Recovery (IgCC Section 607.5)	5							
R408.35 Hot water delivery and demand control circulation system	5							
R408.36 Reserved	-							
R408.37 Passive House certification	-							
Additional Conservation Requirement options for Section a*dditions* and a*lterations* only (R502 and R503)								
Measure Description	**Credit**	**50%**	**40%**	**25%**	**15%**	**10%**	**5%**	**2%**
R408.38 Energy Audit performed on the existing building prior to permit application	10							
R408.39 Use ERI Compliance option R502.2.2 or R503.2.2	10							
R408.40 Whole House Controlled mechanical ventilation	5							
R408.41 ENERGYSTAR Cold Climate Air Source Heat Pump	5							

R408.2 *Whole building lifecycle analysis (WB LCA)*: Conduct a whole building life-cycle assessment, including operating energy, against a baseline building that demonstrates a minimum of 10% reduction for at least three of the six impact categories listed below, one of which must be global warming potential. The building envelope, structural elements including footings and foundations, interior ceilings, walls, and floors; and exterior finishes shall be studied for the assessment. The baseline and proposed buildings must be of comparable size, function, complexity, orientation, and operating energy performance. The service life of the baseline and proposed buildings must be the same and at least 60 years. The same life-cycle assessment software tools and data sets shall be used to evaluate both the baseline building and the proposed building. The construction documents shall report all listed impact categories. Data sets must comply with the standards of ISO 14044.

Impact Categories:

1. global warming potential (greenhouse gases), in kg CO2e.
2. depletion of the stratospheric ozone layer, in kg CFC-11e.
3. acidification of land and water sources, in moles H+ or kg SO2e.
4. eutrophication, in kg nitrogen eq or kg phosphate eq.
5. formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
6. depletion of nonrenewable energy resources, in MJ using CML / depletion of fossil fuels in TRACI.

R408.3 Embodied CO2e in concrete products. Credits for embodied CO2e in concrete products are achieved if X% or more of all concrete mixes used in the building's primary structural foundations does not exceed the project limit (CO2Emax) determined by 125% of *IW-EPD's* kgCO2e/y3. Precast and cast in place concrete products may be considered in this category. Products shall have a *product-specific Type III EPD*.

R408.4 Embodied CO2e in grade lumber products: Credits for embodied CO2e in grade lumber products are achieved if X% or more of all softwood and redwood lumber products used in the building, based on cost or volume, do not exceed 125% of *IW- EPD's* kg-CO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.5 Embodied CO2e of prefabricated joist products. Credits for prefabricated joist products are achieved if X% or more of all prefabricated wood I-joist products used in the building, based on cost or length, do not exceed 125% of *IW-EPD's* kgCO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.6 Embodied CO2e of glued cross-laminated timber products: Credits for embodied CO2d of glued cross-laminated timber products are achieved if X% or more of all glued laminated timber products used in the building, based on cost or volume, do not exceed 125% of *IW-EPD's* kgCO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.7 Embodied CO2e of structural composite lumber products. Credits for embodied CO2e of structural composite lumber products if X% or more of all laminated veneer lumber and laminated strand lumber products used in the building, based on cost or volume, do not exceed 125% of *IW-EPD's* kgCO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.8 Embodied CO2e of particleboard and fiberboard products. Credits for embodied CO2e of particle board and fiberboard are achieved if X% of all medium density fiberboard, cellulosic fiberboard, and particleboard products used in the building, based on cost or volume, do not exceed 125% of *IW-EPD's* kgCO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.9 Embodied CO2e in steel product manufacturing: Credits for embodied CO2e in steel product manufacturing are achieved if X% or more of steel products used in the construction of the building, based on cost or weight, is produced in a facility or facilities where at least 50% of the energy sourced for production at the facility is a renewable energy resource as documented by one or more of the following:

a. On-site renewable energy system.

b. Off-site renewable energy system owned by the production facility owner.

c. Community renewable energy facility.

d. Power Purchase Agreement (PPA).

R408.10 Embodied CO2e of structural steel products. Credits for embodied CO2e of structural steel products is achieved if X% or more, of all structural steel used in the building's primary structural frame does not exceed 125% of *IW-EPD's* kgCO2e/metric ton. Products shall have a *product-specific Type III EPD*.

R408.11 Embodied CO2e of nonstructural steel products. Credits for embodied CO2e of nonstructural steel products is achieved if X% or more of all nonstructural steel building products used in the building do not exceed 125% of *IW-EPD's* kgCO2e/metric ton. Products shall have a *product-specific Type III EPD*.

R408.12 Embodied CO2e of steel reinforcing bar products. Credits for embodied CO2e of steel reinforcing bar products are achieved if X% or more of all concrete reinforcing bars used in the building do not exceed 125% of *IW-EPD's* kgCO2e/metric ton. Products shall have a *product-specific Type III EPD*.

R408.13 Embodied CO2e of insulation products. Credits for embodied CO2e of insulation products are achieved if X% or more of the installed insulation used in the building, based on product cost or area, does not exceed 125% of *IW-EPD's* kgCO2e/m2- RSI. Products shall have a *product-specific Type III EPD*.

R408.14 Embodied CO2e of foam plastic insulation products. Credits for embodied CO2e of foam plastic insulation products are achieved if X% or more of all insulation products, including expanded polystyrene (EPS) and polyurethane foam insulation (HFC or HFO) used in the building, based on

cost and area, do not exceed 125% of *IW-EPD's* kgCO2e/m2-RSI. Products shall have a *product-specific Type III EPD*.

R408.15 Embodied CO2e of gypsum products. Credits for embodied CO2e of gypsum products are achieved if X% or more of all gypsum board, gypsum sheathing, and glass-mat gypsum board products used in the building, based on cost or area, do not exceed 125% of *IW-EPD's* kgCO2e/m^2. Products shall have a *product-specific Type III EPD*.

R408.16 Embodied CO2e of interior floor covering products. Credits for embodied CO2e of floor covering products are achieved if X% or more of solid and engineered flooring, ceramic tile, natural stone floor, and resilient flooring (homogeneous and heterogeneous vinyl, and rigid core) used in the building, based on cost or area, does not exceed 125% of *IW-EPD's* kgCO2e/m^2. Products shall have a *product-specific Type III EPD*.

R408.17 Embodied CO2e of glazing products. Credits for embodied CO2e of glazing products are achieved if X% or more of all flat glass used in window products installed in the building, based on cost or weight, does not exceed 125% of *IW-EPD's* kgCO2e/metric ton. Products shall have a *product-specific Type III EPD*.

R408.18 Embodied CO2e of siding products. Credits for embodied CO2e of siding products are achieved if X% or more of all siding products used in the building, based on cost or area, do not exceed 125% of *IW-EPD's* kgCO2e/m^2.

R408.19 Embodied CO2e of clay bricks. Credits for embodied CO2e of clay bricks area achieved if X% or more of all clay brick products used in the building, based on cost or volume, do not exceed 125% of *IW-EPD's* kgCO2e/m^3. Products shall have a *product-specific Type III EPD*.

R408.20 Embodied CO2e of masonry cement. Credits for embodied CO2e of masonry cement if X% or more of all masonry cement used in the building, based on cost or weight, does not exceed 125% of *IW-EPD's* kgCO2e/metric ton. Products shall have a *product-specific Type III EPD*.

R408.21 Embodied CO2e of roofing products. Credits for embodied CO2e of roofing products are achieved if X% or more of all roofing products used in the building, based on product cost or area, do not exceed 125% of *IW-EPD's* kgCO2e/m^2. Products shall have a *product-specific Type III EPD*.

R408.22 Battery storage. Credits for battery storage are achieved if 10kWh of battery storage is installed. The battery storage system shall be installed in accordance with all NEC and IRC codes and shall be clearly documented on an electrical plan for the project. Signage shall be installed on the exterior of the home informing owners and residents that a battery storage system is installed.

R408.23 Energy monitoring system. Credits for an energy monitoring system are achieved if each residential unit has an energy monitoring system. Documentation of the installation shall be provided to the *code official*.

R408.24 Smart electrical panel. Credits are achieved for a smart electrical panel if each residential unit has a smart electrical panel installed in compliance with the NEC. Documentation of the installation shall be provided to *the code official.*

R408.25 Energy Star Appliances. Credits for ENERGYSTAR appliances are achieved if an ENERGYSTAR qualified refrigerator, dishwasher, clothes washer, and clothes dryer are installed in each residential unit and documentation of the installation shall be provided to the *code official* at the time of final inspection. Any ceiling fans that were installed shall also be ENERGYSTAR qualified. Two additional points will be achieved if all appliances installed, as mentioned above, are from the current year's ENERGYSTAR Most Efficient list.

R408.26 Condensing clothes dryer. Credits for a condensing clothes dryer are achieved if the residential unit has a condensing clothes dryer at time of final inspection.

R408.27 Reduced air-leakage w/ ERV installed. Credits for reduced air-leakage are achieved if the air leakage rate of the building is less than 2.0 air changes per hour when calculated in accordance with Section R402.4.1.2, and all ventilation air is provided by and an energy recovery ventilator with a sensible recovery efficiency of not less than 75%.

R408.28 Roof reflectance/cool roof. Credits for reflectance/cool roof are achieved for a low sloped (less than 2/12 pitch or 2 percent) roofed building if roofing material is used for the entire roof that has a minimum 3-year aged solar reflectance of .63 and a minimum thermal emittance of .75 or a standard reflectance Index of 75. Credits are achieved for steep sloped roofed buildings if roofing material is used for the entire roof that has a minimum 3-year aged solar reflectance of .20 and a minimum thermal emittance of .75 or a standard reflectance Index of 16.

R408.29 Ground source heat pump. Credits for a ground source heat pump are achieved if the has a ground source heat pump HVAC system design is sized in accordance with Section R403.8.Documentation of the installation shall be provided to the *code official*.

R408.30 Heat pump water heater w/ demand response controls. Credits for pump water heater with demand response area are achieved if the building has a heat pump water heating system with demand response controls listed for participation in a demand response program that serves the building site and a UEF of not less than 2.0.

R408.31 Low duct leakage (≤ 2 CFM per square foot of floor area). Credits for low duct leakage are achieved if the duct leakage rate of the building is ≤ 2 CFM per 100 square foot of floor area served when tested in accordance with Section R403.4.5 at a post construction test.

R408.32 100% the duct system installed within the building thermal envelope. Credits for a duct system within the building thermal envelope are achieved if all components of the duct system as defined by this code are located within the building thermal envelope in accordance with Section R403.4.2.

R408.33 Reserved.

R408.34 Drain Water Heat Recovery. Credits for drain water heat recover are achieved if the building has a drain water heat recovery unit for all shower, bathtub, laundry and sink drains with a heat recovery efficiency of at least 50%.

R408.35 Hot water delivery and demand control circulation system. Credits for hot water delivery and demand control circulation systems are achieved if the building has a demand control hot water circulation system that stores no more than 0.5 gallons (1.9 liters) of water in any piping/manifold between the hot water source and any hot water fixture. The system shall be field verified per the DOE Zero Energy Ready Homes v2 Calculation method or field verification method and results shall be provided to the *code official*.

R408.36 Reserved.

R408.37 Certification under the Passive House program. The building shall be certified and labeled under the 2021 or newer PHIUS Zero Passive House Institute US program, or the Passive House Institute classic or higher program category.

R408.38 Energy audit: Credits for an energy audit are achieved if documentation is submitted showing that a RESNET or BPI Energy Audit was performed on the existing building prior to permit application. Credits for this measure are only available for additions and alterations to existing buildings.

R408.39 Use ERI compliance option R502.2.2 or R503.2.2.

R408.40 Whole house controlled mechanical ventilation: Credits for whole house controlled mechanical ventilation is achieved when it is installed in accordance with Section M1505 of the 2021 International Residential Code (IRC) or newer version. Credits for this measure are only available for additions and alterations to existing buildings.

R408.41 ENERGYSTAR Cold Climate Air Source Heat Pump: Credits for CCASHP shall be achieved if the CCASHP has a minimum HSPF 9.5 or HSPF2 8.1 and a minimum SEER 16 or SEER2 15.3. The unit shall have the capacity maintenance of max at 5°F/Rated 47°F of at least 70% and documentation of the installation shall be provided to the *code official*. Credit for this measure are only available for additions and alterations to existing buildings.

Example kgCO2e/unit Summary Reporting Form

Documentation requires that Environmental Product Declarations (EPDs) are "verified by a registered design professional on the project, and a summary shall be made available to the *code official* that includes a list of each product and associated kgCO2e/unit, per the EPD." The following is an example table summary:

Product	Required Percent Of Compliance	Procured Product Amount	Total Product Amount	Percentage Confirmed	Target KGCO2E/UNIT 150% IW-EPD	Actual KGCO2E/ UNIT PER THE EPD	Confirmed Compliance
Ex. Blown - Fiberglass	50%	2,200 sf	2,200 sf	50%	0.73	0.983	

CHAPTER 5 [RE]
EXISTING BUILDINGS

User note:

About this chapter: *Many buildings are renovated or altered in numerous ways that could affect the energy use of the building as a whole. Chapter 5 requires the application of certain parts of Chapter 4 in order to maintain, if not improve, the conservation of energy by the renovated or altered building.*

SECTION R501
GENERAL

R501.1 Scope. The provisions of this chapter shall control the *alteration*, *repair*, *addition* and change of occupancy of existing *buildings* and structures.

R501.1.1 General. Except as specified in this chapter, this code shall not be used to require the removal, *alteration* or abandonment of, nor prevent the continued use and maintenance of, an existing *building* or *building* system lawfully in existence at the time of adoption of this code. Unaltered portions of the existing building or building supply system shall not be required to comply with this code unless triggered by a higher level of alteration.

R501.2 Compliance. *Additions*, *alterations*, *repairs* or *changes of occupancy* to, or relocation of, an existing *building*, *building* system or portion thereof shall comply with Section R502, R503, R504 or R505, respectively, in this code and the provisions for alterations, repairs, additions, and changes of occupancy or relocation, respectively, in *the International Residential Code, International Building Code, International Existing Building Code, International Fire Code, International Fuel Gas Code, International Mechanical Code, International Plumbing Code, International Property Maintenance Code, International Private Sewage Disposal Code* and NFPA 70 as applicable. Changes where unconditioned space is changed to conditioned space shall comply with Section R502. Where both *additions* and *alterations* are included in the scope of work, the larger portion of work will govern the direction (R502 or R503) for compliance.

R501.2.1 Consecutive permits. Any two or more building permits for the same dwelling unit that are applied for in any 24-month period shall be considered as one permit for the purpose of determining and meeting the requirements of Section R501.2.

R501.3 Maintenance. *Buildings* and structures, and parts thereof, shall be maintained in a safe and sanitary condition. Devices and systems that are required by this code shall be maintained in conformance to the code edition under which installed. The owner or the owner's authorized agent shall be responsible for the maintenance of *buildings* and structures. The requirements of this chapter shall not provide the basis for removal or abrogation of energy conservation, fire protection and safety systems and devices in existing structures.

R501.4 New and replacement materials. Except as otherwise required or permitted by this code, materials permitted by the applicable code for new construction shall be used. Like materials shall be permitted for *repairs*, provided that hazards to life, health or property are not created. Hazardous materials shall not be used where the code for new construction would not allow their use in *buildings* of similar occupancy, purpose and location.

R501.5 Designated historic buildings. The provisions of this code relating to the construction, *repair, alteration,* restoration and movement of structures, and change of occupancy shall apply to *designated historic buildings.* The *chief building official* shall have the authority to waive certain requirements for a *designated historic building* if the *chief building official* finds that compliance with a requirement would have an adverse impact upon the historic character of the individual landmark or, if the building is contributing to a historic district, upon the historic character of the contributing building or the historic district.

R501.6 Change in space conditioning. Any unconditioned or low-energy space that is altered to become conditioned space shall be required to be brought into full compliance with Section R502.

SECTION R502
ADDITIONS

R502.1 General. *Additions* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction. *Additions* shall not create an unsafe or hazardous conditions or overload existing *building* systems. *Additions* shall demonstrate compliance in accordance with Sections R502 through R502.7.

R502.2 Compliance. *Additions* shall comply with Section R502.2.1 or R502.2.2 except that a*dditions* greater than 1,000 square feet of conditioned floor area shall comply with R502.2.2.

R502.2.1 Existing building plus addition prescriptive compliance option. The prescriptive compliance option requires compliance with the provisions of Section R401.2.1. The applicant shall demonstrate that the *addition* alone complies with this code including section R402.4 air leakage testing of the addition plus the existing structure.

Exception: Where the measured air leakage rate exceeds 3.0 air changes per hour or 0.16 cubic feet per minute (CFM) per square foot of dwelling unit

enclosure area but is less than 7.0 ACH when tested in accordance with Section R402.4.1.2, a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized or depressurized along with a visual inspection of the air barrier. Noted air leaks shall be sealed where such sealing can be made without the destruction of existing or new building components. A report documenting corrective actions taken to seal leaks and pre- and post-corrective action blower door results shall be submitted to the *code official* and shall be deemed to comply with the requirements of this section if testing does not exceed 7 ACH.

R502.2.1.1 Prescriptive option compliance reports. The following compliance reports shall be submitted for permitting and to obtain the certificate of occupancy.

1. For permitting: Submit a plan set documenting the proposed R-values to be installed per Table R402.1.2 or Section R402.1.2.3 Total UA compliance report.
2. For certificate of occupancy: Submit a blower door and duct leakage compliance report.

R502.2.2 Existing building plus addition Energy Rating Index (ERI) compliance option. The energy rating index compliance option requires compliance with the provisions of Section R406. The applicant shall demonstrate that the existing building plus the addition achieves a maximum ERI of 50 or a 30% reduction from the existing building ERI. This method requires the project to create energy rating index verification at two stages as outlined in Section R502.2.2.1.

R502.2.2.1 ERI option compliance reports. The following compliance reports shall be submitted for permitting and to obtain the certificate of occupancy:

1. For permitting: Submit a baseline energy rating index compliance report of the existing structure prior to construction.
2. For permitting: Submit a projected energy rating index compliance report of the existing building plus the addition based on the proposed design for the building in its entirety demonstrating an ERI of 50 or less or that the building plus the addition uses 30% less than the existing *building* did prior to the addition.
3. For certificate of occupancy: Submit a final confirmed energy rating index compliance report prior to final inspection.
4. For certificate of occupancy: Submit a blower door and duct leakage compliance report.

R502.3 Building thermal envelope. New *building* envelope assemblies that are part of the *addition* shall comply with Table R401.2.1.

R502.4 Heating and cooling systems. HVAC ductwork newly installed as part of an *addition* shall comply with Section R403, including R403.7.

Exception: Where ductwork from an existing heating and cooling system is extended to an *addition*, that does not exceed 400 square feet.

R502.5 Service hot water systems. New service hot water systems that are part of the *addition* shall comply with Section R403.6.

R502.6 Lighting. New lighting systems that are part of the *addition* shall comply with Section R404.1.

R502.7 Additional Efficiency credits requirements for additions. *Additions* shall comply with sufficient measures from Table R408.1 to achieve not less than 5 credits. *Alterations* to the existing building that are not part of the *addition* but permitted with the *addition*, shall be permitted to use the same credit(s) to achieve this requirement.

Exceptions:

1. *Additions* that increase the building's total conditioned floor area by less than 25 percent.
2. *Additions* that do not include the addition or replacement of equipment covered in Sections R403.6 or R403.8.
3. *Additions* that do not increase the conditioned space of the building.

SECTION R503
ALTERATIONS

R503.1 General. *Alterations* to any *building* or structure shall comply with the requirements of Section C503. *Alterations* shall be such that the existing *building* or structure is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration*.

Alterations shall not create an unsafe or hazardous condition or overload *existing* building systems. *Alterations* shall comply with the requirements of Section R503.2 through R503.8.

R503.2 Compliance. *Alterations* to existing *buildings* shall comply with Sections R503.2.1 or R503.2.2, except that *alterations* that are part of an *addition* with more than 1,000 square feet of conditioned floor area shall comply with Section R503.2.2. Where the *building* undergoes a *Level 3 alteration*, the *building* shall comply with Section R503.2.2 and demonstrate that the *rated design* of the existing building plus the alteration has a maximum ERI of 50 pr show a 30% reduction over the existing building's ERI prior to the alteration. Where the *building* undergoes a *Level 3 alteration* with *substantial mechanical alteration* and *substantial thermal envelope alteration*, primary space and water heating equipment shall be all-electric or fueled by other non-fossil fuel derived energy source and the *building* shall comply with

Section R503.2.2 and demonstrate that the *rated design* of the existing building plus the alteration has a maximum ERI of 50 or show a 30% reduction over the existing building's ERI prior to the alteration. The alteration shall comply with Section R408 for existing buildings.

R503.2.1 Existing building, plus alteration prescriptive compliance option. The prescriptive compliance option requires compliance with Section R401.2.1 shall demonstrate that the *alteration* complies with this code including section R402.4 air leakage testing of the *alteration* plus the existing structure.

Exception: Where the measured air leakage rate exceeds 3.0 air changes per hour (ACH) or 0.16 cubic feet per minute (CFM) per square foot of dwelling unit enclosure area when tested in accordance with Section R402.4.1.2, a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized or depressurized along with a visual inspection of the air barrier. Noted air leaks shall be sealed where such sealing can be made without the destruction of existing or new building components. A report documenting corrective actions taken to seal leaks and pre- and post-corrective action blower door results shall be submitted to the *code official* and shall be deemed to comply with the requirements of this section if testing does not exceed 7 ACH. Level 1 and 2 alterations are exempt from blower door testing requirements.

R503.2.1.1 Prescriptive option compliance reports. The following compliance reports shall be submitted for permitting and to obtain the certificate of occupancy.

1. For permitting: Submit a plan set documenting the proposed R-values to be installed per Table R402.1.2 or a Section R402.1.2.3 Total UA compliance report to demonstrate compliance with Section R503.3 and that the existing *building* or structure is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration*.
2. For permitting: submit a blower door test compliance report to demonstrate the existing homes air tightness before beginning the *alteration*.
3. For certificate of occupancy: Submit a blower door and duct leakage compliance report when applicable.

R503.2.2 Energy Rating Index compliance option. The energy rating index compliance option requires compliance with the provisions of Section R406. The applicant shall demonstrate that the existing building plus the alteration is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration.* This method requires the project to create an energy rating index verification report at three stages as outlined in Section R503.2.2.1.

R503.2.2.1 ERI option compliance reports. The following compliance reports shall be submitted for permitting and to obtain the certificate of occupancy.

1. For permitting: Submit a baseline energy rating index compliance report of the existing structure prior to the *alteration*.
2. For permitting: Submit a projected energy rating index compliance report of the existing building plus the alteration based on the proposed design for the building in its entirety demonstrating that the building plus the alteration is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration.*
3. For certificate of occupancy: Submit a final confirmed energy rating index compliance report prior to final inspection.
4. For certificate of occupancy: Submit a blower door duct leakage compliance report as applicable.

R503.3 Building thermal envelope. *Building thermal* envelope assemblies that are part of the *alteration* shall comply with Section R503.3. New building thermal envelope assemblies that are part of the alteration shall comply with Section R402. The *R*-value of insulation shall not be reduced, nor the U-factor of a building thermal envelope assembly be increased as part of a building thermal envelope alteration except where the building, after the alteration complies with section R503.2.

Exception: The following *alterations* shall not be required to comply with the requirements for new construction provided that the energy use of the *building* is not increased:

1. Storm windows installed over existing fenestration.
2. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
3. Construction where the existing roof, wall or floor cavity is not exposed.
4. Roof re-cover.
5. Roofs with insulation in the rafter cavities provided that where the decking is exposed during reroofing it is insulated either above or below the sheathing.
6. Surface-applied window film installed on existing single pane fenestration assemblies to reduce solar heat gain provided that the code does not require the glazing or fenestration assembly to be replaced.
7. Roof replacement where roof assembly insulation is integral to or located below the structural roof deck.

R503.4 New and replacement fenestration. New and replacement fenestration units, including sash and glazing, shall meet the applicable requirements for *U*-factor and

SHGC as specified in Table R402.1.2. Where more than one replacement *fenestration* unit is to be installed, an area-weighted average of the *U*-factor, SHGC or both of all replacement *fenestration* units shall be an alternative that can be used to show compliance.

R503.25 Heating and cooling systems. HVAC ducts newly installed as part of an *alteration* shall comply with Section R403.

Exception: Where ducts from an existing heating and cooling system are extended to an addition that is less than 25% of the existing building's floor area.

R503.6 Service hot water systems. New service hot water systems that are part of the *alteration* shall comply with Section R403.5.

R503.7 Lighting. New lighting systems that are part of the *alteration* shall comply with Section R404.1.

Exception: *Alterations* that replace less than 10 percent of the luminaires in a space, provided that such *alterations* do not increase the installed interior lighting power.

R503.8 Electric ready (level 3 alterations only). The provisions of this section apply only to level 3 alterations that include replacement of mechanical or water heating equipment.

Exception: Level 3 alterations that include substantial mechanical alteration and substantial thermal envelope alteration.

R503.8.1 Additional electric infrastructure. *Combustion equipment* that is replaced as part of a level 3 alteration in *residential buildings* must meet the requirements of Sections R503.8.2 through R503.8.6.

Exception: Level 3 alterations that include substantial mechanical alteration and substantial thermal envelope alteration.

R503.8.2 Combustion equipment. *Combustion equipment* shall be provided with all of the following:

1. A dedicated, appropriately phased branch circuit sized to accommodate future electric equipment or appliances to serve a comparable capacity to meet the heating load.
2. An electric receptacle or junction box that meets the requirements of Section RE302.5, and is connected to the electrical panel through the branch circuit. Each electrical receptacle or junction box shall have reasonable access to the combustion equipment or dedicated physical space for future electric equipment with no obstructions other than the current combustion equipment.
3. Where combustion equipment is used for space or water heating, dedicated physical space shall be provided for future electric equipment, including an electric resistance backup coil for ducted systems, if applicable.

Exceptions:

1. Dwelling units with installed air conditioning systems are not required to provide additional dedicated physical space for an outdoor heat pump.
2. Dwelling units with insufficient panel space and/or service capacity.

R503.8.3 Electrical panel space. The electrical panel shall have a reserved space for a minimum two-pole circuit breaker for each branch circuit provided for future electric equipment or appliances.

R503.8.4 Labeling. The junction box or receptacle and the dedicated circuit breaker space serving future electric equipment or appliances in the electrical panel shall be labeled for their intended use.

R503.8.5 Adjacency. The electrical receptacle or junction box must be provided within 3 feet of the combustion equipment or appliances, or within 3 feet of the dedicated physical space for future electric equipment or appliances.

Exception: For combustion equipment dedicated to space or water heating, the electrical receptacle or junction box shall be located not more than 6 feet from the combustion equipment or the dedicated physical space for future electric equipment.

R503.8.6 Condensate Drain. Where combustion equipment for space heating and water heating is installed, a location shall be provided for condensate drainage.

R503.9 Additional Efficiency credits requirements for alteration. Alterations shall achieve the additional energy conservation objective through the credit system established in Section R408. Alterations shall achieve at least 5 credits through implementation of measures set forth in Table R408. *Alterations* to the existing building that are not part of the addition, but permitted with the addition, may be used the same credit(s) to achieve this requirement..

Exceptions:

1. Level 1 and 2 alterations
2. Alterations that do not include the addition or replacement of equipment covered in Sections R403.6 or R403.8.

SECTION R504
REPAIRS

R504.1 General. *Buildings*, structures and parts thereof shall be repaired in compliance with Section R501.3 and this section. Work on nondamaged components necessary for the required *repair* of damaged components shall be considered to be part of the *repair* and shall not be subject to the requirements for *alterations* in this chapter. Routine maintenance required by Section R501.3, ordinary *repairs* exempt from *permit*, and abatement of wear due to normal service conditions shall not be subject to the requirements for *repairs* in this section.

R504.2 Application. For the purposes of this code, the following shall be considered to be *repairs*:

1. Glass-only replacements in an existing sash and frame.
2. Roof *repairs*.

3. *Repairs* where only the bulb, ballast or both within the existing luminaires in a space are replaced provided that the replacement does not increase the installed interior lighting power.

SECTION R505
CHANGE OF OCCUPANCY OR USE

R505.1 General. Any space that is converted to a dwelling unit or portion thereof from another use or occupancy shall comply with this code.

Exception: Where ERI-based compliance in Section R406.4 is used to comply with this section, the building shall comply with Section R406 as new construction. Rated designs are permitted to be 10 percent greater than allowed by Section R406.4.

R505.1.1 Unconditioned space. Any unconditioned or low-energy space that is altered to become a conditioned space shall comply with Section R502.

CHAPTER 6 [RE]

REFERENCED STANDARDS

User note:

***About this chapter**: This code contains numerous references to standards promulgated by other organizations that are used to provide requirements for materials and methods of construction. Chapter 6 contains a comprehensive list of all standards that are referenced in this code. These standards, in essence, are part of this code to the extent of the reference to the standard.*

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section R107

AAMA

American Architectural Manufacturers Association
1827 Walden Office Square
Suite 550
Schaumburg, IL 60173-4268

AAMA/WDMA/CSA 101/I.S.2/A C440—17: North American Fenestration Standard/Specifications for Windows, Doors, and Unit Skylights
R402.4.3

ACCA

Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206

Manual J—16: Residential Load Calculation Eighth Edition
R403.7

Manual S—14: Residential Equipment Selection
R403.7

APSP

The Association of Pool & Spa Professionals
2111 Eisenhower Avenue, Suite 500
Alexandria, VA 22314

ANSI/APSP/ICC 14—2014: American National Standard for Portable Electric Spa Energy Efficiency
R403.11

ANSI/APSP/ICC 15a—2011: American National Standard for Residential Swimming Pool and Spa Energy Efficiency—includes Addenda A Approved January 9, 2013
R403.12

ASHRAE

ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329

ASHRAE—2017: ASHRAE Handbook of Fundamentals
R402.1.6

ASHRAE 193—2010(RA 2014): Method of Test for Determining the Airtightness of HVAC Equipment
R403.3.4.1

ASTM

ASTM International
100 Barr Harbor Drive, P.O. Box C700
West Conshohocken, PA 19428-2959

C1363—11: Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
R303.1.4.1

ASTM—continued

E283—2004(2012): Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen
R402.4.4

E779—10: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
R402.4.1.2

E1554/E1554M—E2013: Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization
R403.3.5

E1827—2011(2017): Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
R402.4.1.2

E2178—2013: Standard Test Method for Air Permanence of Building Materials
R303.1.5

CSA

CSA Group
8501 East Pleasant Valley Road
Cleveland, OH 44131-5516

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights
R402.4.3

CSA B55.1—2015: Test Method for Measuring Efficiency and Pressure Loss of Drain Water Heat Recovery Units
R403.5.3

CSA B55.2—2015: Drain Water Heat Recovery Units
R403.5.3

DASMA

Door & Access Systems Manufacturers Association
1300 Sumner Avenue
Cleveland, OH 44115-2851

105—2016: Test Method for Thermal Transmittance and Air Infiltration of Garage Doors and Rolling Doors
R303.1.3

HVI

Home Ventilating Institute
1000 North Rand Road, Suite 214
Wauconda, IL 60084

916—09: Airflow Test Procedure
Table R403.6.1

ICC

International Code Council, Inc.
500 New Jersey Avenue NW
6th Floor
Washington, DC 20001

ANSI/APSP/ICC 14—2019: American National Standard for Portable Electric Spa Energy Efficiency
R403.11

ANSI/APSP/ICC 15a—2020: American National Standard for Residential Swimming Pool and Spa Energy Efficiency—includes Addenda A Approved January 9, 2013
R403.12

IBC—21: International Building Code®
R201.3, R303.1.1, R303.2, R402.1.1, R501.4

ICC 400—17: Standard on the Design and Construction of Log Structures
R402.1, Table R402.5.1.1

ICC 500—2020: ICC/NSSA Standard for the Design and Construction of Storm Shelters
R402.5

IEBC—21: International Existing Building Code®
R501.4

ICC—continued

IECC—18: International Energy Conservation Code®
R101.4.1, R403.8

IECC—06: 2006 International Energy Conservation Code®
R202

IFC—21: International Fire Code®
R201.3, R501.4

IFGC—21: International Fuel Gas Code®
R201.3, R501.4

IMC—21: International Mechanical Code®
R201.3, R403.3.4, R403.3.3, R403.6, R501.4

IPC—21: International Plumbing Code®
R201.3, R501.4

IPSDC—21: International Private Sewage Disposal Code®
R501.4

IPMC—21: International Property Maintenance Code®
R501.4

IRC—21: International Residential Code®
R201.3, R303.1.1, R303.2, R402.1.1, R402.2.10, R403.3.4, R403.3.3, R403.6, R501.4

ANSI/RESNET/ICC 301—2019: Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index
R406.4

ANSI/RESNET/ICC 380—2019: Standard for Testing Airtightness of Building, Dwelling Unit and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems and Airflow of Mechanical Ventilation Systems
R402.4.1.2

IEEE

Institute of Electrical and Electronic Engineers, Inc.
3 Park Avenue, 17th Floor
New York, NY 10016-5997

515.1—2012: IEEE Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
R403.5.1.2

NBI

New Buildings Institute
151 SW 1st Ave, Suite 300
Portland, OR 97204

Embodied Carbon Building Code (2023): An overlay o model code language for limiting the climate impact of building products
Table R408.1

NEMA

National Electrical Manufacturers Association
1300 17th Street North No. 900
Arlington, VA 22209

OS 4—2016: Requirements for Air-Sealed Boxes for Electrical and Communication Applications
R402.4.6

NFPA

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471

70—20: National Electrical Code
R501.4

NFRC

National Fenestration Rating Council, Inc.
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

100—2020: Procedure for Determining Fenestration Products *U*-factors
R303.1.3

200—2020: Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence
R303.1.3

400—2020: Procedure for Determining Fenestration Product Air Leakage
R402.4.3

RESNET

Residential Energy Services Network, Inc.
P.O. Box 4561
Oceanside, CA 92052-4561

ANSI/RESNET/ICC 301—2019: Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index
R406.4, R406.7.1, R406.7.5

ANSI/RESNET/ICC 380—2019: Standard for Testing Airtightness of Building, Dwelling and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems
R402.4.1.2

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062

127—2011: Standard for Factory Built Fireplaces—with Revisions through July 2016
R402.4.2

515—2015: Electrical Resistance Heat Tracing for Commercial and Industrial Applications Including Revisions through July 2015
R403.5.1.2

US-FTC

United States-Federal Trade Commission
600 Pennsylvania Avenue NW
Washington, DC 20580

CFR Title 16 (2015): R-value Rule
R303.1.4

WDMA

Window and Door Manufacturers Association
2025 M Street NW, Suite 800
Washington, DC 20036-3309

AAMA/WDMA/CSA 101/I.S.2/A440—17: North American Fenestration Standard/Specification for Windows, Doors, and Unit Skylights
R402.4.3

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Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
Many foundational ones, but CC has directed staff to ignore cost implications for a decade or more. CC is to blame for the outsize cost to build in Boulder. On affordability we are in a DEEP hole, and we continue to dig. No one reads these comments, so I'll have some fun.	Lots of reliance on closed cell insulation now, for arguably minimized returns as we go to R-30 walls and R-60 ceilings. Dept Energy report says the new code will save a zone 5 ownerless than $150/year in energy costs. Extra 4-6" of closed cell insulation will cost 20x that, alone. Zip sheathing is pricey. Will now need to spec as a norm. Affordability yadda. See note above inre diminishing returns for added R-10 to exterior walls. County this is the norm. ALL clients building in the County are super wealthy. County prefers this too! The real kick in the nuts is your invented 'with and without' onsite solar. ERI 50 without onsite solar is HARD for some projects. Rich folks will buy expensive windows etc. PV was always the way to get there. This takes away a lot of alternative options that save on cost for non rich Boulderites. This is class war, really. The few remaining middle class folks will... not do projects I guess. That's the goal right? City owns and manages the middle and lower class housing all over this city? R407.5. Please keep the energy reviewers out of our already difficult form, shape and zoning issues. It is hard enough to solve all of the zoning, siting, Compat Dev, solar shadow issues and NOW you are going to empower an energy code staff to fuck with us on TREES/utility poles/neighbor building/etc etc in the path of a solar ready zone?	FFS delete R407.5.1 and .2. We already aim for this, don't infantilize designers. This is a power trip couple of lines. Pun intended, sparky. (Solar zones are virtue signals, performative code and cost - just stop) "Optional Energy Codes" or "How I Learned to Stop Worrying and Love my CC Overlords (I just wanted to renovate my house)": LEAVE THESE SECTIONS TO COMMERCIAL ONLY - AND NEVER BRING THEM INTO HOMES: Section R408 + R506. Delete all. Holy fuck. These are houses and additions. New reports, new submittals, new costs. WE ARE IN AN AFFORDABILTY CRISIS. Why do this? Huge complexity and overhead effort for ALL applicants to source and provide meaningless reports and drivel for staff to file away. FOR WHAT PURPOSE? We are not currently all rich here in town. But I think we will be ... in 2030 just in time for Energy Zero. Weird, huh? The incremental updates here (envelope insulation for example) are fine. The window U value drop will add cost - significantly - but fine we'll buy Alpen windows at 2x the cost of cheaper units. The embodied carbon issues are total overreach by a careerist staff (no offense - call em like I see em). There are some weird control/review items thrown in that should be thrown tf right back out (solar ready obstacles - we often have little control for that if off site).	None
With the goal of electrification in mind, the switch in ASHRAE 90.1-2019 and still in 90.1-2022 to having Appendix G mandate gas baseline for Climate Zone 5 dramatically hurts all-electric designs when considering annual utility costs. This is due to the fact that gas is significantly cheaper per Btu than electricity. The 5% credit for all-electric design in CoBECC C407.4.1 does not counter balance this effect leading to the situation were electric heating and hot water systems are disadvantages in energy analysis.	Either allow for the use of EUI in place of annual energy cost when calculating compliance targets or increase the reduced PIt reduction target from exceeding 20% to exceeding by 10-15% or provide additional compliance benefits for all-electric design.		This is valueable feedback. We are looking at a site EUI target for the 2024 CoBECC. We are also looking to set the performance requirement at 10-15% above as to your comments

Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
Boulder Housing Partners is pleased to comment on the recommended updates to the City of Boulder's Energy Code. We want to recognize that in passing this updated energy code, there exists a pronounced and competing priority within the City of Boulder, namely clean energy goals aimed at slowing or preventing climate change and housing affordability goals aimed at promoting equity and inclusivity. The increased costs that are required to build in accordance with the new energy code exacerbate the challenges in financing affordable housing. Accordingly, in order to meet the requirements of Boulder's updated 2024 Energy Conservation Code, affordable housing developers will require additional funding to accomplish affordable housing development. In consideration of the City's goals around inclusivity and equity, coupled with the goals of the 2024 Energy Conservation Code, we recommend some portion of the City's Climate Tax be set aside for the development or redevelopment of affordable housing.	We support sustainability and responsible, green development. There needs to be an understanding of the cost implications of implementation and to that end, recommend real cost data inform the adoption of the final code update.		Thank you for your feedback and support. We are working through the costing information as there will be an upfront cost to bear but also want to take into account the cost savings of no gas infrastructure as well as the saving overtime for the solar systems.
CONFUSED IF THE LEVEL 3 ALTERATIONS TO AN EXISTING BUILDING ENERGY REQUIREMENTS ARE CHANGING FROM THE CURRENT CODE. IS IT 110% OR 125% OF EUI? SECTIONS C503.7 AND C503.8 ARE UNCLEAR. C503.7 Level 3 alterations. Level 3 alterations shall also comply with Section C407.3 where the proposed design EUI shall be not greater than 125 percent of the EUI otherwise permitted by Section C407.3. C503.8 Level 4 alterations. Level 3 alterations that include substantial mechanical and thermal envelope alteration shall also comply with Section C407.3 where the proposed design EUI shall be not greater than 110			Thank you for catching this in the draft. This have been corrected for the next draft that will be out in February. **C503.8 Level 3 alterations**. Level 3 alterations shall also comply with Section C407.3 where the proposed design EUI shall be not greater than 125 percent of the EUI otherwise permitted by Section C407.3. Level 3 alterations that also include substantial mechanical alteration and substantial thermal envelope alteration shall install only space conditioning equipment fueled by an energy source other than fossil fuels as the principle/primary space conditioning system.
Lack of basic energy efficiency recommendations found in passive solar fundamentals.	Add a leading chapter on how to incorporated fundamental passive energy design concepts, and how this would save money on capital equipment and long-term energy purchases.		Thank you for the feedback. We don't disagree some basic energy efficiency fundamentals around passive design beneficial, we just feel that the code book is not the best platform t understand the basics buidling science.

Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
I'm concerned that MEP Engineer was not included in the "Please tell us a little about yourself." section above.	C403.3 Mechanical System energy source, Exceptions: suggest including additional onsite renewables or carbon free power along with the onsite solar power requirement to include potential for future technology. Also the word 'more' looks to be missing from the final sentence. C405.15.1 Solar Zone location note 4: Suggest updating to "within 165 and 195 degrees of true North." to stay consistent with the convention use in C405.15.2 Orientation. C405.15.1 Solar Zone Roof Area total roof area exclusions note 2: Suggest either providing a calculation for "Solar insolation" and a baseline value for solar insolation without shade or updating to be similar to section C405.15.3 Shading note 2. C405.15.2 Orientation: Suggest providing a rise per 12" to better define "steep sloped roofs".		Thank you for the feedback on this, apologies for the MEP engineer not being list on the feedback listed as an option (we didn't create the form) it should have been. Thank you for writing in. For C403.3, we added language '..all-electric or other non-fossil fuel derived energy source' to allow for new technologies that may become available. We updated C405.15.2 to align with the state code for the zone to be between 110 degrees and 270 degrees of true north. On C405.15.1 and C405.15.2, we plan to look back at these and re-evaluate. Thank you fo catching that steep sloped roof's needs to be defined.
I met with your team earlier, this is Andrew Ehrnstein, owner of Solar 4 Planet A LLC. Solar installation area: For residential and commercial you do exclude the fire setbacks from the minimum installable area, which is good. However, since solar panels used in residential installations are generally about 6' long, I'm concerned that property owners cannot have a financially and operationally effective system installed with the installable areas you've described. Commercial panels can range a little larger in size, and it's also much more common that we're dealing with flat/low-slope roofs, which require racking to tilt the panels. When doing so we either have to add ballast or penetrate the roof material. Ballast per panel can be minimized if we have blocks of at least 9 panels to tie together. I have made my suggestions below. In general, your awareness of insolation requirements for solar to make financial sense at a particular site is much appreciated. I think the proposed code changes are reasonable in general, just need the tweaks detailed below for it to be implementable.	Solar installation area: For residential, in sections R407.1-407.5 you do exclude the fire setbacks from the minimum installable area, which is good. However, since solar panels used in residential installations are generally about 6' long, please increase the minimum dimension for any "solar installation zone" to 6' for sloped roofs. For flat/low-slope roofs, racking is required and I would recommend areas at least 15' running N-S, and 22' running E-W. This gives us space for 9 panels in a ballasted array. Otherwise we will have to install tilt racks using penetrating attachments, which is not advisable on membrane roof materials. This critique also applies to section C405.15.1 Please change "The solar zone total area shall be comprised of one or more rectangular areas that are not less than 80 square feet and no side of any rectangular area shall be less than 5 feet in length." to read instead: "The solar zone total area shall be comprised of one or more rectangular areas. For sloped roofs each area must be not less than 200 square feet and no side of any rectangular area shall be less than 11 feet in length.	For low-sloped or flat roofs, each area must be not less than 330 square feet, with a minimum length running generally north to south of 15' and a minimum length running generally east to west of 22'and no side of any rectangular area shall be less than 11 feet in length."	Thank you for this valuable feedback. We have looked at incrporating some of the lanugage that you recommended to make it more feasible for future solar versus a solar-ready zone that it outside of panel design dimensions.

Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
C407.4.2 Performance backstop. Suggest rewording "prescriptive requirements" to mandatory requirements. C407.4.2 Performance backstop. Consider making slab-on-grade perimeter insulation mandatory. 2022 Denver Energy Code performance path projects to date have not included slab-on-grade insulation. C407.7 Performance feedback. Suggest rewording "predicted energy use" as compliance modeling following ASHRAE 90.1 is a separate activity from predicted energy modeling (predictive energy modeling should include an error tolerance).	There is interest in alignment in energy / carbon codes between Denver and Boulder. Will be back in touch with additional review of redline version. C406 Based on timelines for REScheck/COMcheck from DOE PNNL, suggest you contact pnnl to get in their queue when your code is in a solid draft and prior to Council approval. C407 Consider the DOE supported ASHRAE Standard 90.1 Compliance Form. Denver has adopted this with a custom Companion Tool prepared by DOE. Happy to show you our internal review process and templates.		Thank you for the feedback, we have updated the language as recommended in C407.4.2. As for the slab-on-grab insulation, when modeling if the desire is to use better walls/windows/systems to trade off slab insulation than that would be allowed. There is a reason it is required prescriptively, but it is up to the deisgn team if modeling how they want to proceed. We have updated the language to provide more clarity in C407.7 like suggested. In terms of the COMchecks/REScheckes, we currently don't allow these other than for alterations. WE are still considering the ASHRAE companion tool and thank you for willingness to show us how it works.
No concerns, just encouraging the City of Boulder to adopt the 2021 IECC with minimal amendments and changes to make professional design and compliance consistent with other jurisdictions adopting the same code. Thank you for your consideration and advancement of building efficiency that benefit your citizens by adopting up-to-date and more efficient codes for your buildings.			Thank you for the feedback, unfortuantely at this time the City of Boulder is on path to adopt it's localized version of the International Energy Code, the 2024 CoBECC. The City of Boulder originally parted ways with the Internaitional Ernergy Conservation Code as it wasn't aligning with climate and energy eficiency targets of the city. By the time the 2027 code cycle comes around we might seriously look at coming back into the IECC but with amendments. I appriciate your encouragment for alignment across the front range with energy efficiency.

Attachment C - 2024 Energy Code Formstack Feedback - With Responses

Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
The Colorado Restaurant Association on behalf of its Boulder Chapter, is writing to express its concern with the proposed 2024 Energy Conservation Code Update language as published on the city's web page. While we understand and appreciate the city's efforts to address climate change, we are concerned the proposed exemption for new or renovated commercial kitchens to continue to use natural gas only if the energy consumption is 100 percent off-set by renewable energy installed on site sets a standard that is impossible to comply with and would result in a de-facto ban on natural gas for commercial kitchens. While the restaurant industry is by no means monolithic, the industry standard for most cooks and chefs in commercial settings has been to work with some or all natural gas power appliances in their kitchen. Many chefs and cooks learn techniques and processes of food preparation using natural gas appliances over an entire career that cannot be easily transferred to electric alternatives. Indeed in certain cases, such as wok cooking in Asian cuisine, there is no electric appliance alternative that can achieve the heat application required to properly cook many dishes. This is why many electrification efforts around the state and country have explicitly exempted commercial kitchens from electrification requirements.	(cont. from concerns with proposed changes?) Cities such as Denver and Crested Butte have enacted similar electrification requirements but both municipalities specifically exempted commercial kitchens from their requirements with no requirement for an on-site renewable offset. Indeed, even the residential portion of this 2024 Energy Conservation Code Update allows for the purchase of off-site credits and owners to apply for exemptions from that requirement. In discussing this proposed code with commercial developers in Boulder, we have been told that the square footage required to install renewable energy to comply with the 100 percent on-site off-set requirement is functionally impossible to achieve for almost every commercial building currently in the city which would have a chilling effect on both renovations and new build restaurants in the city. If the code were to allow for the purchase of off-site credits (similar to what is proposed in the residential code) the average one-time cost for a typical commercial kitchen would be upwards of $150,000.00. While this would present a significant financial challenge for most restaurants, it is certainly preferable to the de-facto ban that takes place in the current code.	The Colorado Restaurant Association on behalf of its Boulder Chapter, would like to request a "clean" exemption from the prohibition on natural gas in new and renovated commercial kitchens similar to what has been enacted in Denver and Crested Butte. In lieu of that, we request that any off set requirement can be satisfied with the purchase of off-site credits with an option to apply for an exemption, similar to what is being proposed in the residential code.	Thank you for your feedback, we hear you and understand your concerns. We have updated the code to provide an exception that would exemption commercial cooking and process heat from the renewable offset requirements. It would still require space and water heating to be electric but no offset required for commercial cooking or process heat.
Yes, the requirements of these changes do not look attainable for the restaurant industry. 100% do not support.	Make an exemption of offsetting natural gas usage for commercial kitchens.		Thank you for this feedback and we have heard you. We are providing an exception for commercial cooking and process heat that would exempt it from the 100% renewable offset. The only piece that would remain is that space and water heating would be all electric.

Do you have any concerns with the proposed changes?	Do you have any suggestions for the updated code?	Do you have any suggestions for the updated code? (continued)	Response
BioMed supports City of Boulder updating energy code to support the future of Boulder. Energy conservation and sustainability is a key value of BioMed that we plan for in our developments. We have been reviewing the code in detail and do want to ensure we are aligned with the city on how this will work for the future of R&D/ laboratories in Boulder. For context, our question below on C403.3, we are looking for optionality in the code so we can still achieve energy goals.	Code section C403.3 'Mechanical System energy source' states the following exceptions for mechanical system not to be fully electric - Laboratories, Hospitals, S-1, Emergency Generators, Commercial cooking equipment. The exception language states that if the energy source is not electric than the energy usage shall be offset by 100 percent onsite solar power. If it is not feasible to provide sufficient onsite solar power to meet 100 percent onsite solar power, due to site limitations, can it be demonstrated, similar to the residential sections of the energy code, that 100 percent onsite solar power is not required? If not, can the use exceptions above be eligible to purchase an 'offsite solar subscription' or Renewable Energy Credits (RECs) to make up the shortfall?		Thank you for the feedback here. We have heard you and are providing exceptions for commercial cooking or in the instaces of labs process heat. WE also have updated the code to that if you can demonstrate infeasibility in terms of solar the building offical has the ability to waive the requirement (or if some solar can be installed but not all). We know solar that is on-site is utilized, we are moving away from requiring RECs and off-site subscriptions as they are harder to manage.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters, and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1 or from Table C404.5.2.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where

heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

C404.6 Heated water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be in a location with *access*. Manual controls shall be in a location with *ready access*.

C404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. The system return pipe shall be a dedicated return pipe or a cold-water supply pipe. Gravity and thermo-syphon circulation systems shall be prohibited. Controls for circulating hot water system pumps shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water. The controls shall limit the temperature of the water entering the cold-water piping to not greater than 104ºF (40°C).

C404.6.1.1 Demand recirculation controls. Demand recirculation water systems shall have controls that start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture, or sensing the flow of hot or tempered water to a fixture fitting or appliance.

C404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy. Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

C404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

C404.7 Demand responsive water heating. Electric storage water heaters with a rated water storage volume of 40 gallons (150 L) to 120 gallons (450 L) and a nameplate input rating equal to or less than 12kW shall be provided with demand responsive controls in accordance with Table C404.10 or another equivalent approved standard**.**

Table 404.10
DEMAND RESPONSIVE CONTROLS FOR WATER HEATING

EQUIPMENT TYPE	CONTROLS	
	BEFORE 7/1/2025 [a]	AFTER 7/1/2025 [a]
Electric storage water heaters	ANSI/CTA-~~2045-B Level 1~~ and also capable of initiating water heating to meet the temperature set point in response to a *demand response signal*.	ANSI/CTA-2045-~~B Level 2~~, except "Price Stream Communication" functionality as defined in the standard.

Exceptions:

1. Water heaters that provide a hot water delivery temperature of 180F (82C) or greater.
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code.
3. Water heaters that use 3-phase electric power.

C404.8 Water heating equipment location. Water heaters with *combustion equipment* shall be located in a space meeting the following requirements:

1. Minimum dimensions of 3 feet by 3 feet by 7 feet high.
2. Minimum volume of 760 cubic feet, or the equivalent of one 16-inch by 24-inch grill to a heated space and one 8-inch duct of no more than 10 feet in length for cool exhaust air.
3. Contains a condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance, installed within 3 feet of the water heater.

Exceptions:

1. Instantaneous water heaters located within 10 feet of the point of use.
2. Water heats with an input capacity of more than 300,000 Btu/h.

C404.9 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For *Group R* occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

C404.10 Energy consumption of pools and permanent spas. The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.10**.1** through C404.10.3.

a. Manufacture date.

C407.2 Mandatory requirements. Compliance under the total building performance path of Section C407 requires compliance with the sections of this code identified in Table C407.2.

TABLE C407.2
MANDATORY REQUIREMENTS

Section	Title
C401	General
C402.5	Air leakage—thermal envelope
C403.1	General
C403.2	System design
C403.3	Mechanical system energy source
C403.4	Heating and cooling system controls
C403.5.5	Economizer fault detection and diagnostics
C403.7 (except C403.7.5.1)	Ventilation and exhaust systems
C403.8 (except C403.8.6)	Fans and fan controls
C403.9	Large-diameter ceiling fans
C403.11 (except C403.11.3)	Refrigeration equipment performance
C403.12	Construction of HVAC system elements
C403.13	Mechanical systems located outside of the building thermal envelope
C404	Service Water Heating
C405 (except C405.3)	Electrical Power and Lighting Systems
C406	~~Additional conservation requirements~~ Reserved
C408	Maintenance information and system commissioning

a. Reference to a code section includes all the relative subsections except as indicated in the table.

C407.3 Performance-based compliance. Compliance based on building performance shall be determined in accordance with Section C407.3.1, C407.3.2 or C407.3.3. Energy use for the *proposed design* shall be reported to the *code official* as *energy use intensity* (EUI) in kBtu/sf/yr.

C407.3.1 Modeled baseline. Projects shall comply with Section 4.2.1.1 of ASHRAE Standard 90.1-2022, as modified in Section C407.4. Projects complying using this Section C407.3.1 to demonstrate compliance shall use a site energy index as defined in Appendix I of ASHRAE 90.1-2022 and as defined in Section C407.4.

C407.3.2 Fixed performance target. Only project types listed in Table C407.3.2 may use this section for compliance with Section C407.3. Eligible projects may demonstrate compliance by meeting the EUI targets identified in the Table C407.3.2. The *proposed building model* predicted performance shall be demonstrated using the energy modeling procedures for the proposed building performance in Appendix G of ASHRAE 90.1-2022, as modified in Section C407.4. Buildings with multiple occupancy types listed in Table C407.3.2 shall develop a performance target based on area weighted-average EUI calculated by floor area of each occupancy type.

TABLE C407.3.2
FIXED EUI TARGETS

BUILDING TYPE	PERFORMANCE TARGETS (kBtu/ft²)
Medium office (5,000–50,000 sf)	23
Mid-rise apartment (Type R2)	32
Primary school	34
Large Office (>50,000 sf)	40
Small office (< 5000 sf)	19
Secondary school	31
Warehouse	11
Retail Store	40
Small Hotel	35
Hospital	76
Restaurant	200
Strip Mall	40

C407.3.3 Measured performance outcome. With approval of the *chief building official*, projects may demonstrate compliance with this code by documenting that the building has achieved the EUI target calculated per C407.3.1 or C407.3.2 within 10 percent based on metered energy use after occupancy.

C407.3.3.1 Excluded energy use. Energy used for data centers and EV charging equipment may be excluded from the total EUI of the building, provided that this energy use is separately metered per the requirements of Section C407.6.

C407.3.3.2 Demonstration of operating energy use. Metered energy data shall be reported to the *code official* using Energy Star Portfolio Manager and adjusted for the percentage of occupied floor area. The applicant shall demonstrate that, while at least 75 percent occupied, the building operates at or below its assigned EUI target established in Section C407.3.2 for any recording period of 12 consecutive months that is completed within three years of the date of the Certificate of Occupancy. The owner shall notify the *code official* when this 12-month period has been successfully completed.

C407.3.3.3 Adjustments to EUI targets. The *chief building official* may approve an adjustment to a building's EUI target based on unanticipated changes to building operation and conditions as set forth in Items 1 through 3 below. The applicant shall demonstrate the need for adjustment based on the standards set forth Items 1 through 3 with specific documentation of the need.:

1. **Adjustment for change in occupancy.** When the occupancy of the building or a portion of the building changes from that assumed in the permit submittal, the *code official* will adjust the assigned EUI target to reflect the new occupancy. If the new occupancy is not listed in Section C407.3.2, either the *code official* shall assign it an EUI target based on the best-performing local examples of that occupancy type, or a metering system shall be provided that excludes the energy loads for the additional occupancy.

APPENDIX CA

BOULDER MODIFIED APPENDIX G PROTOCOL

User note:

About this appendix: *This appendix contains sections of ASHRAE 90.1-2022 Normative Appendix G that have been modified to reflect specific requirements of the 2024 City of Boulder Energy Conservation Code (CoBECC). Only sections of Appendix G that have been modified from the original language are included in this document.*

Section G1 GENERAL

Section G1.2. Performance Rating

G1.2.1 Mandatory Provisions

This *performance rating method* requires conformance with the following provisions:

a. All mandatory requirements of Chapter 4 of the *2024 City of Boulder Energy Conservation Code (COBECC)* must be met. These supersede the mandatory requirements in Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 of ASHRAE Standard 90.1-2022.
b. The interior lighting power shall not exceed the *interior lighting power allowance* determined using either:
   1. Tables G3.7-1 and G3.7-2 and the methodology described in Section 9.5.2, or
   2. Table G3.8 and the methodology described in Section 9.5.1.
c. Energy *efficiency* levels of installed components and *systems* shall meet or exceed the efficiency levels used to calculate the *proposed building performance*.
d. The proposed envelope U factors shall not exceed the performance requirements of ASHRAE 90.1-2016 listed in Table 5.5-5. No tradeoffs of envelope performance below these levels are allowed.
e. Verification, testing and *commissioning* requirements of Section C408 of the 2024 City of Boulder Energy Conservation Code shall supersede the requirements of Section 4.2.5.
f. The proposed HVAC equipment efficiencies at a minimum shall meet the performance requirements determined in Tables 6.8.1-1 through Table 6.8.1-21.

G1.2.2 Performance Rating Calculation

All new construction in Boulder with a construction value of $500,000 or more must comply with Section G1.2.2.1, G1.2.2.2 or G1.2.2.3, below.

G1.2.2.1 Modeled Baseline

Compliance with Section C407.3.1 of the 2024 CoBECC, Modeled Baseline path requires that the Performance Index target (PI_t) (site energy) for the *proposed design* be reduced by 15 percent for mixed-fuel buildings and 10 percent for all-electric buildings from a PI_t (site energy) target that complies with the ASHRAE 90.1-2022 as modified by Appendix I for "site energy".

The performance of the *proposed design* is calculated in accordance with the provisions of this protocol using the equation G1.2.2.1.1 or G1.2.2.1.2 below as applicable. Both the proposed building performance and baseline building performance shall include all end-use load components within and associated with the building when calculation the Performance EUI for Site Energy.

Mixed Fuel Buildings:

$$PIt_{site} = \frac{0.85 \times (BBUE + (BPF_{site} \cdot BBRE) - PRE)}{BBP} \quad \text{(Eq. G1.2.2.1.1)}$$

All Electric Buildings:

$$PIt_{site} = \frac{0.90 \times (BBUE + (BPF_{site} \cdot BBRE) - PRE)}{BBP} \quad \text{(Eq. G1.2.2.1.2)}$$

where:

PIt_{site} = The maximum Performance Index (Site Energy) for the *proposed design* to comply with the Boulder Energy Code

BBUE = Baseline Building Unregulated *Site Energy*, the portion of the annual site energy of a *baseline building design* that is due to *unregulated energy use*.

BBRE = Baseline *Building* Regulated *Site Energy*. The portion of the annual *site energy* of a *baseline building design* that is due to *regulated energy use*.

BPF_{site} = *Building* Performance Factor (BPF) from Table G1.2 below. For *building* area types not listed in the table, use "All Others." Where a *building* includes multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types. (Table G1.1 replaces Table 4.2.1.1 in 90.1- 2022)

BBP = *Baseline Building Performance*. The annual *site energy* of the *baseline building design* including both *regulated* and *unregulated energy use*.

~~$PRE = PBP_{nre} - PBP_{pre}$~~

~~where:~~

~~PRE =~~ ~~Prescriptive renewable *energy.*~~

~~PBP =~~ ~~*Proposed building performance*, including the reduced, annual *site energy* associated with all *on-site renewable energy* generation systems.~~

~~PBP_{nre} =~~ ~~*Proposed building performance* without any credit for reduced annual *site energy* from *on-site renewable energy* generation *systems*. (no renewable energy)~~

~~PBP_{pre} =~~ ~~*Proposed building performance*, excluding any *renewable energy system* in the *proposed design* and including an *on-site renewable energy system* that meets but does not exceed the requirements of Section 10.5.1.1 of ASHRAE 90.1 2022 modeled following the requirements for a *budget building design* in Table 12.5.1 of ASHRAE 90.1 2022. (prescriptive renewable energy)~~

~~When $(PBP_{pre} - PBP)/BBP > 0.05$, new *buildings* shall also comply with the following:~~

~~$PI + [(PBP_{pre} - PBP)/BBP] < PI_t$ (Eq. G1.2.2.1.3)~~