

Vermont Codes Update Trainings Commercial Building Energy Standards

June 11, 2019
Burlington, VT

<http://publicservice.vermont.gov/content/building-energy-standards-update>



Presentation Overview

- 1. Welcome and Introductions (12:30 – 12:50)** Richard Faesy (RF)
 - Background & Framework
 - Schedule & Process
 - Opportunity for Input
- 2. Proposed CBES 2019 (12:50 – 4:25)** Eveline Killian/Keith Downes
 - Summary and Performance Cost Index
 - Building Envelope
 - Mechanical and Service Water Heating
 - Electric Power and Lighting Systems
 - Additional Efficiency Package Options, Commissioning and Existing Buildings
- 3. Wrap Up (4:25 – 4:30)** – RF

Introduction



DEPARTMENT OF PUBLIC SERVICE

Code Overview: Who

- ▶ **Lead State Agency**
 - Public Service Department
 - Kelly Launder: Assistant Director
 - Keith Levenson: Energy Program Specialist
 - Barry Murphy: EM&V Program Manager
- ▶ **Code Update Lead and Residential Code**
 - Energy Futures Group
 - Richard Faesy, Gabrielle Stebbins & Emily Bergan
- ▶ **Commercial Code Update**
 - Navigant Consulting
 - Keith Downes & Stu Slote
 - Cx Associates
 - Eveline Killian & Jen Chiodo
- ▶ **Roadmap**
 - New Building Institute
 - Jim Edelson
 - Eric Makela
- ▶ **Code Implementation Support**
 - Efficiency Vermont
 - Brian Just



Who is in the room?

- ▶ Builders / General Contractors
- ▶ Architects / Designers
- ▶ Elec / Mech Engineers
- ▶ Trades / Subcontractors
- ▶ Home Performance Contractors
- ▶ Energy Efficiency Utilities
- ▶ Electric Utility or VT Gas
- ▶ Affordable Housing
- ▶ Consultants
- ▶ Other: _____?

Background & Framework



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Energy Code Background

- ▶ Vermont Commercial Building Energy Standard (CBES) – 30 V.S.A. § 53
- ▶ “At least every three years after January 1, 2011, the commissioner of public service.... shall amend and update the CBES promptly after the issuance of updated standards for commercial construction under the IECC or ASHRAE/ANSI/IESNA standard 90.1”
- ▶ IECC 2018 and ASHRAE 90.1 was recently released
- ▶ All commercial buildings and residential buildings 4 stories or more

Code Update: Framework

Multiple statutory requirements and policy goals pertaining to energy in Vermont:

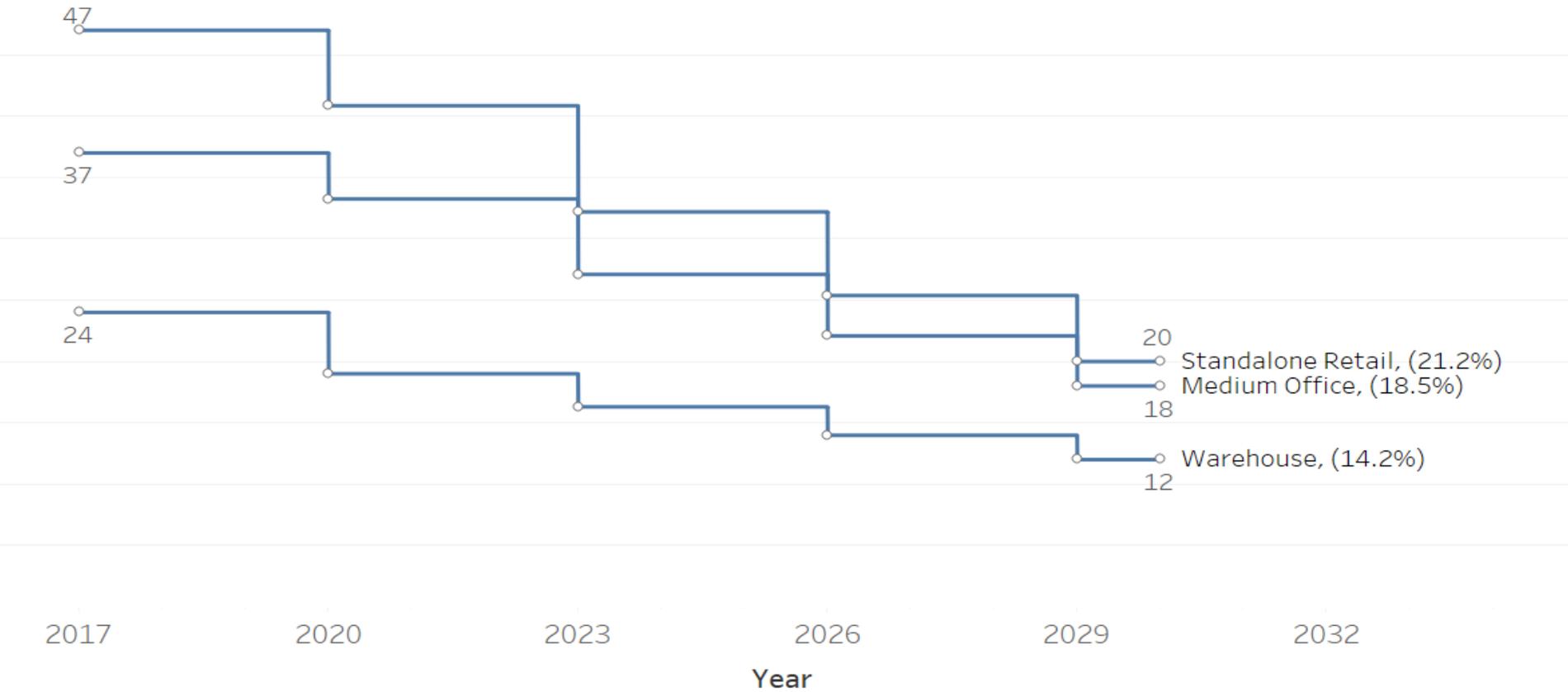
- ▶ 10 V.S.A. § 581 (building efficiency goals)
- ▶ 10 V.S.A. § 578 (greenhouse gas reduction)
- ▶ 30 V.S.A. § 8002–8005 (Renewable Energy Standard)
 - Additional net-metering (mostly solar)
 - Tier Three (requirement to shift from fossil fuels to electricity)
- ▶ 2011 Comprehensive Energy Plan (all new buildings designed to net zero by 2030)
- ▶ And more...resolutions and agreements regarding strategic electrification, electric vehicles, limiting emissions, etc.

Progress to 2030: Retail, Office, Warehouse

Site EUI (kBtu/sf) targets to reach a zero energy code in 2029

2020: 5% Better than 90.1-2016

2020-2029: Constant percent savings

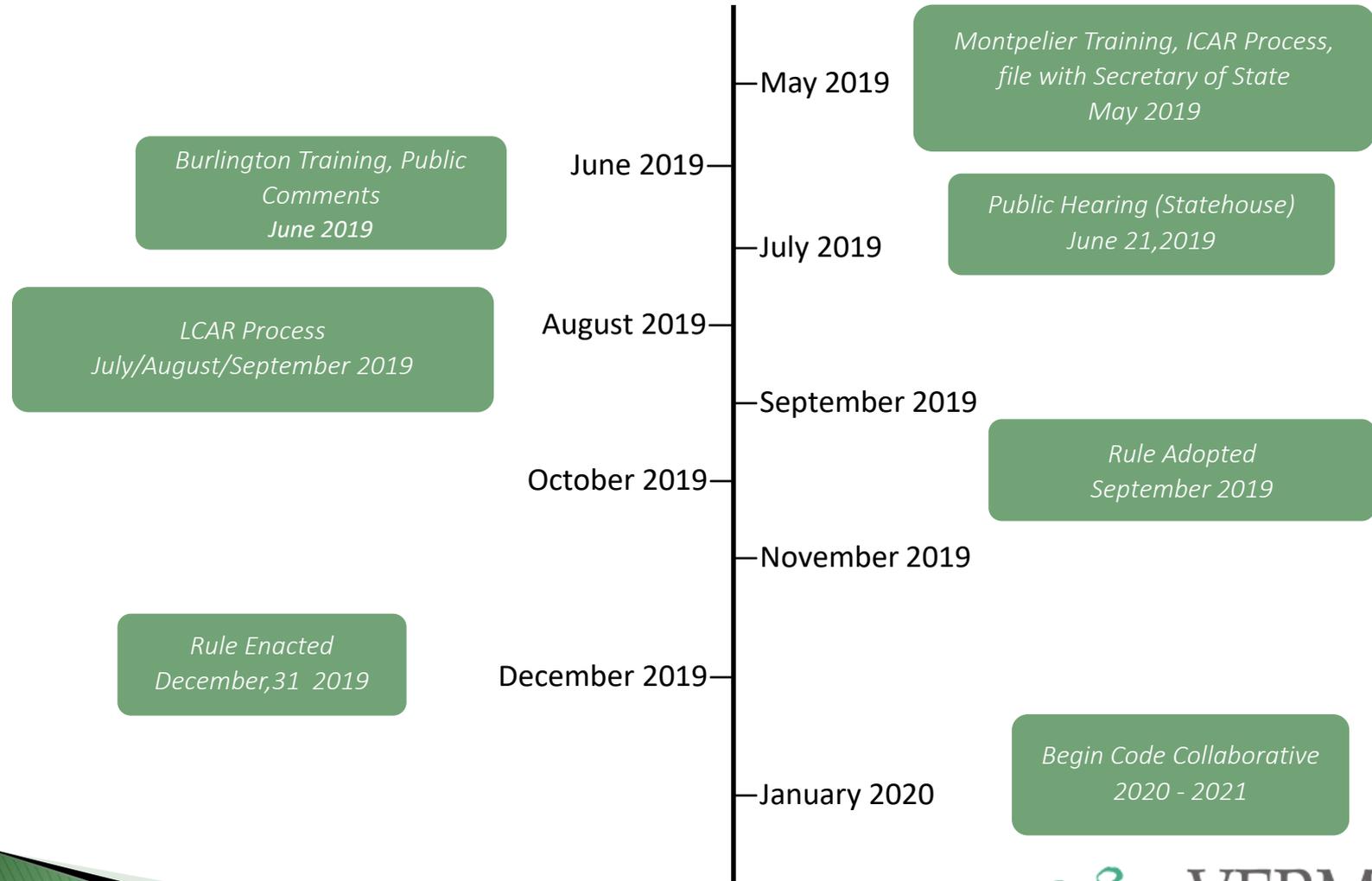


Schedule & Process

Code Update: Stakeholder Engagement Completed So Far

- ▶ Meetings/Calls Held So Far
 - Vermont stakeholder meetings
 - July 2018 in Hartford & Burlington
 - ▶ Advisory Committee meetings
 - August in Montpelier
 - ▶ Follow up stakeholder meetings
 - October conference call
 - Affordable housing stakeholders
 - ▶ Follow up Advisory Committee meetings
 - October in Montpelier
 - ▶ 2019 Better Buildings by Design Conference
 - ▶ May 1 VT BSA Training in Montpelier
- ▶ Representation from:
 - Energy efficiency utilities
 - Architects
 - Builders
 - ASHRAE
 - Log Home Representative
 - Affordable Housing Representative
 - Insulators
 - State officials
 - Regional energy advocates
 - Trade associations (renewables, fuel dealers, building performance professionals)
 - Etc.

Code Update: Schedule



Additional Opportunities for Input

- ▶ Revised code language has been filed with the State ICAR public review process
- ▶ Public hearing June 21 (Room 11, Statehouse)
 - Please send public comments by June 19th so they may be addressed at the hearing
- ▶ Opportunity for written comments through July 10
 - <http://publicservice.vermont.gov/content/building-energy-standards-update>
- ▶ LCAR Process
 - July 23 goal date for submission
 - August hearing

Code Compliance

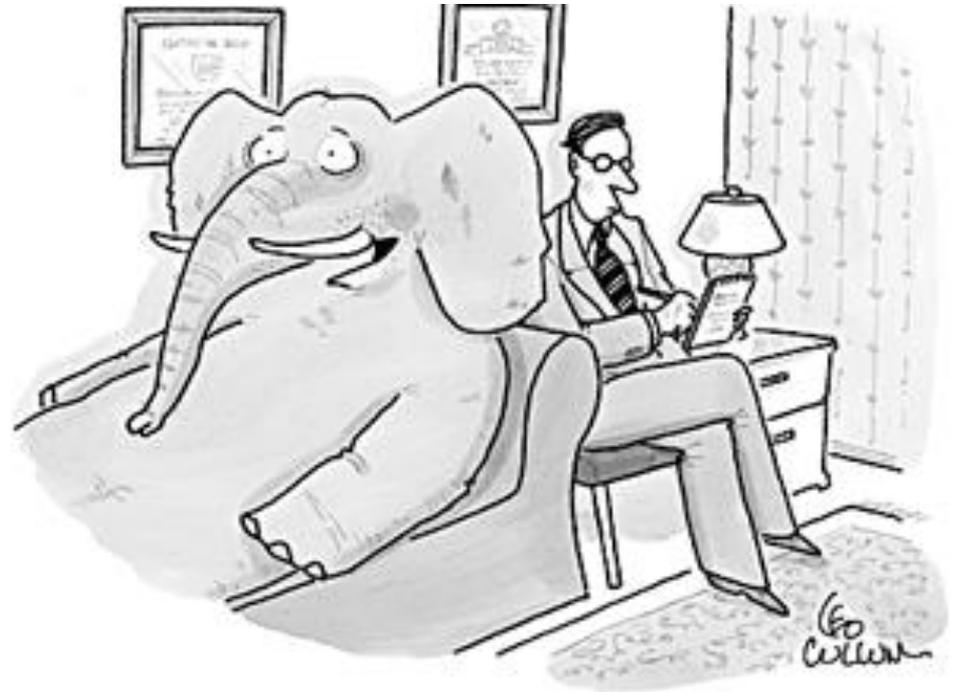


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Code Compliance & Enforcement

Issues not addressed in this scope of work:

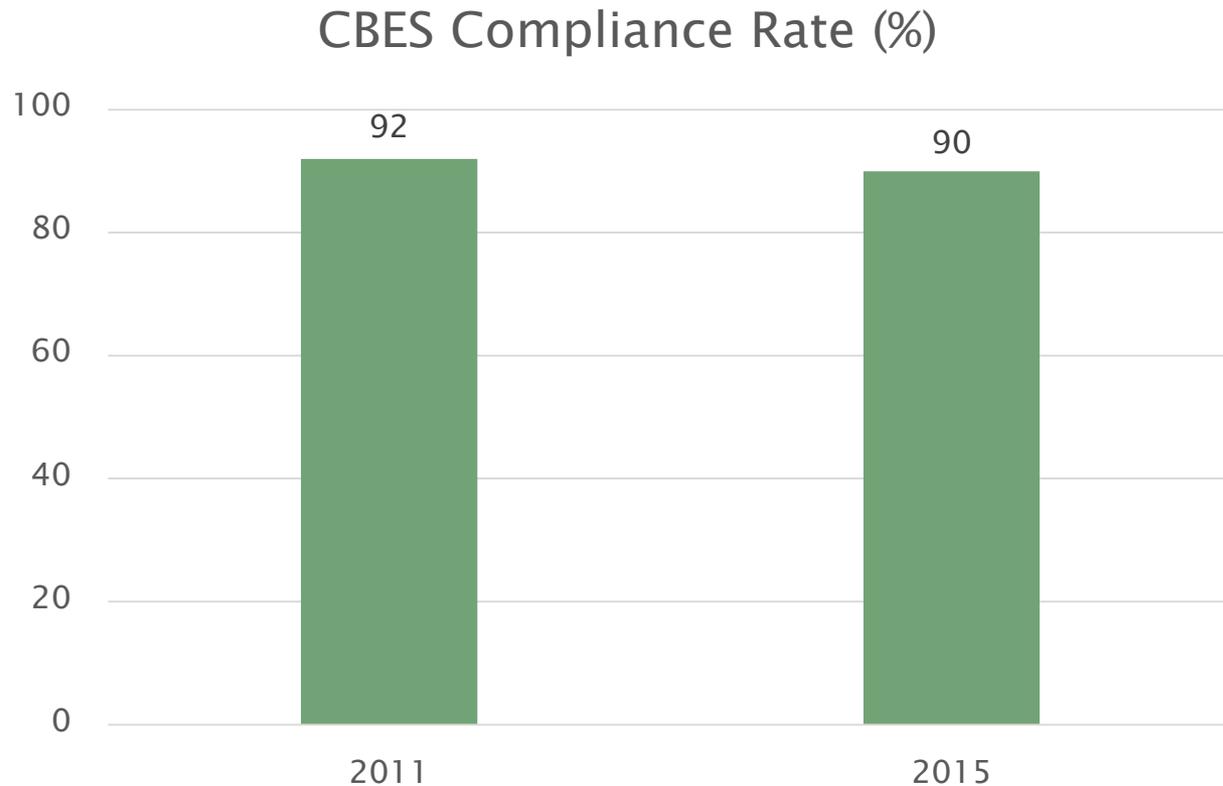
- Compliance
- Enforcement
- FYI: Department of Public Safety will no longer issue a Certificate of Occupancy without a completed CBES certificate
- Administration
- Definition of Net-Zero



"I'm right there in the room, and no one even acknowledges me."

2012 Study: “Vermont Energy Code Compliance Plan – Achieving 90% Compliance by 2017”

Respondents reported that 66% of projects undertaken exceed the minimum CBES requirement



Market
Baseline
Studies

Compliance Approach

Current Approach	Proposed Approach	Required Documents
2015 CBES	2019 CBES	CBES Certificate and COMcheck
ASHRAE 90.1 – 2013 with Amendments	ASHRAE 90.1 – 2016 Sections 5–10 with Amendments	CBES Certificate and COMcheck
ASHRAE 90.1 – 2013 Energy Cost Budget Method	ASHRAE 90.1 – 2016 Section 11 – Energy Cost Budget Method	CBES Certificate and all documentation as noted in Section 11.1.5 of ASHRAE 90.1–2016
	ASHRAE 90.1 – 2016 Appendix G – Performance Rating Method	CBES Certificate and all documentation as noted in Appendix G of ASHRAE 90.1–2016
Above-Code Program Prescriptive		Contact Vermont DPS for approval of above-code program

Proposed 2019 CBES Updates

Summary and Performance Cost Index

Summary of National Changes

- ▶ 2018 IECC commercial: Total of 129 approved proposals
 - Section 4 (mechanical) completely reorganized
 - 36 proposals increase energy efficiency, 3 major
 - 10 proposals reduce energy efficiency, 2 major
- ▶ ASHRAE 90.1–2016 : Total of 121 addenda
 - Major format changes for ease of use
 - New climate maps aligning with ASHRAE Standard 169
 - New performance–based compliance path
 - 49 of the 121 addenda have energy impact
- ▶ Vermont tied to mechanical efficiency levels of national code

Building Documentation – New Requirement

C103.6 Building documentation.

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.

Building Documentation – New Requirement

For projects complying with Item 1 of Section C401.2, the documentation shall include:

1. The envelope insulation compliance path.
2. All compliance calculations including those required by Sections C402.1.3, C403.8.1, C405.3 and C405.4.

C103.6.3 Systems operation control.

Training shall be provided to those responsible for maintaining and operating equipment included in the manuals required by Section C103.6.2.

The training shall include:

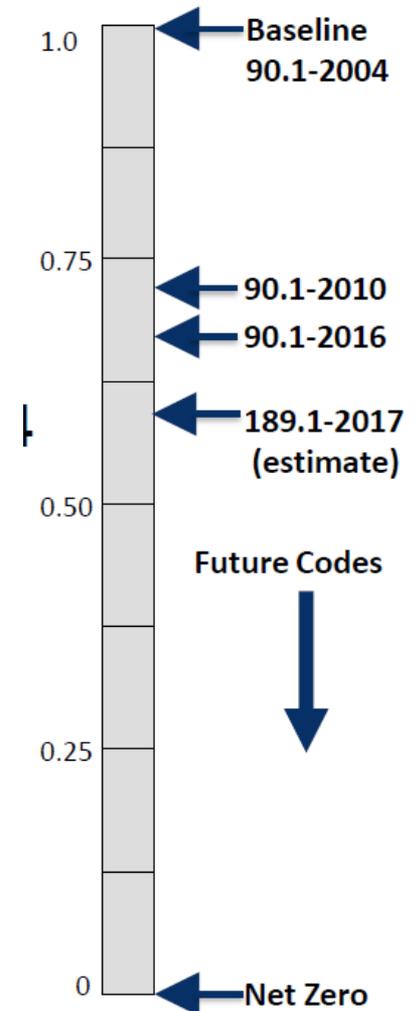
1. Review of manuals and permanent certificate.
2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and startup procedures.
3. Training completion report.

New Compliance Path

- ▶ 90.1–2016 Introduces a Third Path for Compliance
- ▶ Appendix G requires a Performance Cost Index (PCI) specific to building type and climate zone

$$\text{Performance Cost Index (PCI)} = \frac{\text{Proposed Building Performance}}{\text{Baseline Building Performance}}$$

- ▶ Stable and independent baseline set ~ 90.1–2004
- ▶ Intent is that the stringency of the baseline doesn't change (stable)
- ▶ Clear rules about what systems and other prescriptive choices are in baseline (independent)
- ▶ PCI target changes with each version of a code
- ▶ Each code edition has a required PCI for compliance
- ▶ Beyond code programs can choose a PCI to meet their needs
 - Vermont will base PCI on building modeling of the prescriptive CBES compliance path



Source: Pacific Northwest National Laboratory

Performance Cost Index

- ▶ PCI shall be fuel neutral
 - $PCI = BPF * (BBUEC + BBREC) / BBP$, where
 - BPF = Building Performance Factor
 - BBUEC = Baseline Building Unregulated Energy Cost
 - BBREC = Baseline Building Regulated Energy Cost
 - BBP = Baseline Building Performance

Building Area Type	Proposed Code BPF
Multifamily	0.62
Healthcare/hospital	0.46
Hotel/motel	0.48
Office	0.43
Restaurant	0.50
Retail	0.44
School	0.39
Warehouse	0.53
All Others	0.45

Code Changes

C402 Building Envelope



Summary of Major Changes: Building Envelope

- ▶ **New definitions for building envelope**
- ▶ **R-Values / U-factors updates**
- ▶ **Roof assemblies**
- ▶ **New assembly U-factor tables**
- ▶ **Increased fenestration requirements**
- ▶ **Building above-grade performance alternative**
- ▶ **Air leakage section reorganized**
- ▶ **Construction documents must include air barrier information**

Summary of Major Changes: Building Envelope (continued)

- ▶ **Air leakage compliance via testing reduced to 0.30 CFM/SF**
- ▶ **Air barrier commissioning**
- ▶ **Air leakage tests for dwelling units**
- ▶ **Vestibules**
- ▶ **Rooms with fuel-burning appliances that are not direct vented**

New Definitions for Building Envelope

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and is directly or indirectly heated ~~or cooled~~ **by a heating system whose output capacity is greater than 14 Btu/h-ft² of floor area or directly or indirectly cooled by a cooling system whose sensible output capacity is greater than or equal to 3.4 Btu/h-ft² of floor area.** Spaces are indirectly heated or cooled ...

SEMI-CONDITIONED SPACE. **An enclosed space within a building that is directly or indirectly heated by a heating system whose output capacity is less than or equal to 14 Btu/h-ft² of floor area; or if the space is directly or indirectly cooled and the cooling system's sensible output capacity is less than 3.4 Btu/h-ft² of floor area.**

MULTIFAMILY DWELLING. **A building containing three or more dwelling units where the occupants are primarily permanent in nature and which are adjacent vertically or horizontally. If built side-by-side, at least one of the following is true: (1) they do not have a wall that extends from ground to roof, (2) they share a heating system, or (3) they have interstructural public utilities such as water supply/sewage disposal.**

Building Envelope – *Table C402.1 – Roofs*

Component	2015 CBES	2018 IECC	2019 CBES
Roof – Above Deck	R-30ci	R-30ci	R-40ci
Roof – Metal Building	R-25 + R11 LS	R-25 + R11 LS	R-25 + R-11 + R11 LS
Roof – Attic and Other	R-49	R-49	R-49

Per stakeholder comment we now have requirements for semi-conditioned spaces.

Building Envelope – *Table C402.1 – Walls Above Grade*

Component	2015 CBES	2018 IECC	2019 CBES
Mass	R-13.3 ci	R-13.3ci	R-19ci
Metal Building	R-13 + R-13ci or R19.5ci	R-13 + R-13ci	R-13 + R-17ci or R22.1ci
Metal Framed	R-13 + R-7.5ci or R-13ci	R-13 + R-7.5ci	R-13 + R-15ci or R-20ci
Wood Framed and others	R-13 + R-7.5ci or R-20 + R3.8ci or R-23 or R-15ci	R-13 + R-7.5ci or R-20 + R3.8ci	R-13 + R-12ci or R-19 + R8ci or R-20ci

Per stakeholder comment we now have more U-factor reference tables available for more construction types.

Building Envelope – *Table C402.1 Floors*

Component	2015 CBES	2018 IECC	2019 CBES
Mass	12.5ci	R-12.5ci	R-16.7ci
Joist/Framing – Metal	R-38	R-30	R-38
Joist/Framing – Wood and Other	R-30	R-30	R-30
Unheated Slabs	R-10 for 48”	R-10 for 24”	R-10 entire slab
Heated Slabs	R-10 entire slab	R-15 for 36” + R-5 entire slab	R-20 entire slab

Roof Assemblies

Exceptions:

1. Continuously insulated roof assemblies where the R-value is at least R-12 over the entire roof assembly and where the average, area-weighted R-value is equivalent to the R-value specified in Table C402.1(1).
2. A minimum of 60% of the required R-value from Table C402.1(1) must be maintained in area where the roof insulation tapers, such as at roof drains.
3. Mechanical curbs shall be insulated to R-12.
4. Skylight curbs shall be insulated to the level of roofs with insulation entirely above the deck or R-10, whichever is less.

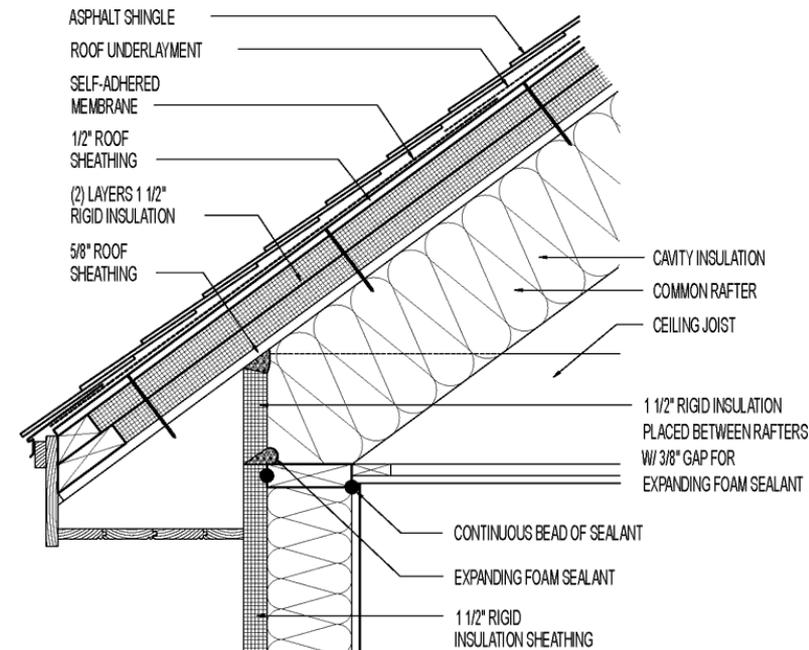


Image Source: Green Building Advisor

New Assembly U-Factor Tables

New tables for:

- Attic roofs with wood joists
- Metal framed walls
- Wood framed walls

ASSEMBLY U-FACTORS FOR METAL-FRAMED WALLS

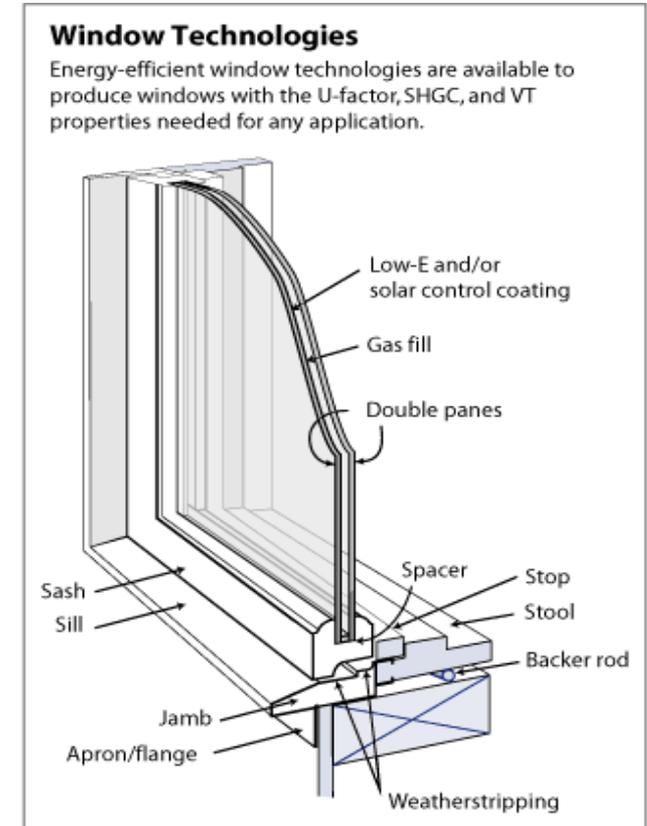
RATED R-VALUE OF CAVITY INSULATION (EFFECTIVE INSTALLED)	OVERALL U-FACTOR FOR BASE WALL ASSEMBLY	OVERALL U-FACTORS FOR ASSEMBLY OF BASE WALL PLUS CONTINUOUS INSULATION (UNINTERRUPTED BY FRAMING)								
		R-12	R-13	R-14	R-15	R-20	R-25	R-30	R-35	R-40
Steel Framing at 16 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.352		0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
R-11 (5.5)	0.132	0.051	0.049	0.046	0.044	0.036	0.031	0.027	0.024	0.021
R-13 (6.0)	0.124	0.050	0.048	0.045	0.043	0.036	0.030	0.026	0.023	0.021
R-15 (6.4)	0.118	0.049	0.047	0.045	0.043	0.035	0.030	0.026	0.023	0.021
Steel Framing at 16 in. on Center and 6.0 in. Depth										
R-19 (7.1)	0.109	0.047	0.045	0.043	0.041	0.034	0.029	0.026	0.023	0.020
R-21 (7.4)	0.106	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. on Center and 3.5 in. Depth										
R-0 (0.0)	0.338		0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
R-11 (6.6)	0.116	0.048	0.046	0.044	0.042	0.035	0.030	0.026	0.023	0.021
R-13 (7.2)	0.108	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
R-15 (7.8)	0.102	0.046	0.044	0.042	0.040	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. on Center and 6.0 in. Depth										
R-19 (8.6)	0.094	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.022	0.020
R-21 (9.0)	0.090	0.043	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020

Shaded areas comply with minimum requirements for semi-conditioned spaces but not conditioned spaces.



Fenestration – *Table C402.3*

Component	2015 CBES	2019 CBES
U-factor		
Fixed fenestration	0.36	0.29
Operable fenestration	0.43	0.37
Entrance doors	0.77	0.68
Skylights		
U-Factor	0.5	0.48
SHGC	0.4	0.38



Semi-conditioned spaces are exempt from fenestration requirements.

Image Source: Pacific Northwest National Laboratory, Heat, R.

Building Above-Grade Performance Alternative

This is an alternative to compliance with the *U*-factors in Tables C402.1(1) and C402.3 and the maximum allowable fenestration areas in Section C402.3.1. Below-grade walls, floors, and slabs shall meet the applicable requirements of Section C402.1.1 or C402.1.2. *Fenestration* shall meet the applicable SHGC requirements of Section C402.3.3.

$$UA\text{-Total} / \text{Area} < 0.035$$

UA-Total	=	Sum of the (UA) values for each distinct above-grade assembly type of the building thermal envelope including above-grade walls, roofs, doors, vertical fenestration, and skylights.
UA	=	Proposed U-value \times Area.
Area	=	Surface area in square feet of the above-grade thermal barrier (above-grade wall area plus roof area).

Air Leakage Section Reorganized

Must comply with sections C402.4.1 through C402.4.5

- Air barriers
- Dwelling unit air infiltration
- Air intakes, exhaust openings, stairways and shafts
- Loading dock weatherseals
- Vestibules

Air barriers is satisfied by C402.1.1 OR C402.1.2 through C402.1.8

- Air barrier performance testing
- Continuous air barrier commissioning
- Air barrier construction
- Air barrier compliance (either Materials or Assemblies)
- Air leakage of fenestration
- Rooms containing fuel-burning appliances that are not direct vented
- Doors and access opening to shafts, chutes, stairways and elevator lobbies
- Recessed lighting

Construction Documents Must Include Air Barrier

Construction documents shall contain a diagram showing the building's pressure boundary in plan(s) and section(s) and a calculation of the area of the pressure boundary to be considered in the test.

Air Leakage Compliance via Testing

Tested air leakage rate of the building thermal envelope is not greater than ~~0.50~~ **0.30** cfm/per square foot of shell area (excluding area of slab and below grade walls) at ~~50~~ **75** Pa, **six sided surface area**.

But there is an exemption if you fail to achieve 0.30 CFM/SF

Where the measured air leakage rate exceeds 0.30 cfm/ft² but does not exceed 0.40 cfm/ft², a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the building is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components.



Air Barrier Commissioning

Prior to the final inspection, the registered design professional shall provide evidence of commissioning of the continuous air barrier by an approved agency. A final commissioning report shall be delivered to the building owner, and shall include at a minimum:

1. A field inspection checklist showing the requirements necessary for proper installation of the continuous air barrier.
2. Reports from field inspections during project construction showing compliance with continuous air barrier requirements including but not limited to proper material handling and storage, use of approved materials and approved substitutes, proper material and surface preparation, air barrier continuity at building thermal envelope penetrations

Air Barrier Commissioning Checklist

RELATED SYSTEMS, EQUIPMENT, ASSEMBLIES AND COMPONENTS	TASKS/COMMENTS
Foundations subsoil drainage system	<p><u>Verify compliance with approved plans, specifications and construction documents.</u></p>
Foundation damp-proofing and waterproofing	
Flashing at: exterior doors, skylights, wall flashing and drainage systems	
Exterior wall coverings	
Moisture envelopes	
Exterior below-grade walls	<p>Where applicable meet owner’s project requirements (OPR), Basis of Design (BOD), Cx Specifications.</p> <p>Check for proper drainage system at exterior wall perimeter to keep water from entering building.</p>
External floor and soffits, slab-on grade	<p>Check for thermal resistance or insulation when required. Slabs: Check drainage for moisture penetration.</p>
Exterior walls	<p>Check drawings for wall assembly requirements.</p>
Exterior glazed window fenestration: windows, glazed doors and skylights	<p>Drawing reviews and contractor submittal reviews:</p> <ul style="list-style-type: none"> • Check that fenestration products are labeled with a U-factor (see NFRC 100) and a solar heat gain coefficient (SHGC) (see NFRC 200), and certification for the air infiltration requirement. • Check for proper flashing and caulking at walls and roof assemblies. <p>Glazed doors:</p> <ul style="list-style-type: none"> • Check for proper flashing, and seals and gaskets; and proper pull force, if provided with a closer. • Check for proper door swing.

Air Barrier Commissioning Checklist (continued)

Site-built fenestration: curtain walls and store-front systems, and atrium roof systems	Check for a label certificate issued by the National Fenestration Rating Council (NFRC) or a label certificate issued by the glazing fabricator that meets the default U-factor and SHGC; or an NFRC component modeling approach (CMA) label certificate or another approved standard. <ul style="list-style-type: none">• Check for proper door swing.
Field-fabricated fenestrations: fenestration made at the site, not preformed or cut	Check for compliance with the default U-factor and the default SHGC.
Exterior doors	Check for proper flashing installation at header, walls and floor. <ul style="list-style-type: none">• Check for U-factor requirements for swinging and nonswinging doors.• Check for appropriate manufacturer's referenced standard [American Architectural Manufacturer's Association (AAMA); Canadian Standards Association (CSA); and Window and Door Manufacturer's Association (WDMA) or other approved standard] product data sheets.
Sealants, control joints and flashing (stationary and moveable)	Check for proper installation in accordance with the manufacturer's written instructions
Shading devices	Check for proper anchoring to building with proper flashing at wall connections.
Structural systems	Check for proper anchoring in accordance with construction documents, including metal connectors and beam supports.

Air Leakage Tests for Dwelling Units

A sampling of dwelling units shall be tested and the air leakage rate of each tested dwelling unit's enclosure surface area shall not exceed 0.35 cfm/ft² at 75 Pa and six-sided surface area.

- Tested units will be randomly selected
- The sampling of dwelling units tested shall include at least 10 percent of the dwelling units in each building
- Including at least one corner unit.
- Approximately an equal number of units on each floor level.
- At least one unit on each floor level.



Image Source: The Energy Conservatory

Vestibules

New Requirements:

1. Interior and exterior doors shall have a minimum distance between them of not less than 7 feet.
2. The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space.
3. Either the interior or exterior envelope of unconditioned vestibules shall comply with the requirements for a conditioned space.

New Exemptions:

1. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
2. Elevator doors in parking garages provided that the elevators have an enclosed lobby at each level of the garage.
3. Doors opening directly from a semi-conditioned space.

Rooms Containing Fuel-Burning Appliances

2015 CBES:

Where open combustion air ducts provide combustion air to open combustion space conditioning fuel-burning appliances, the appliances and combustion air openings shall be located outside of the building thermal envelope or enclosed in a room isolated from inside the thermal envelope.

2019 CBES:

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:

C403

Building Mechanical Systems



Summary of Major Changes: Mechanical

- ▶ New definition for cold-climate heat pump
- ▶ New allowances for heat pump systems
- ▶ Equipment sizing – to reduce oversizing
- ▶ Air conditioner, furnace, boiler, cooling tower, VRF minimum efficiency increase
- ▶ ERV required for $> 3,000$ hours and lower CFMs
- ▶ Part-load control required on >2 HP pumps and fans
- ▶ Economizers required in more locations
- ▶ Fan efficiency increased
- ▶ Fractional HP fan motors require ECM or NEMA premium

C403.1 General

Added verbiage for clarity – no actual change to code

In addition to the mechanical requirements of Section C403, mechanical enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

Organization changed to match IECC

All mention of International Mechanical Code (IMC) has been removed

Definition: COLD-CLIMATE HEAT PUMP

- ▶ An air source heat pump with an inverter-driven, variable capacity compressor that is designed to provide full heating heat pump capacity and having a minimum COP of 1.75 or greater at maximum operating capacity at an outside air temperatures of 5°F. The indoor and outdoor units must be part of an AHRI matched system.

C403.2.3 Electric resistance space heating

Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, ~~domestic hot water heaters~~, outdoor air intake grids, and coils in terminal units and air systems, is prohibited.

Exceptions:

~~2. Replacement of existing electrical resistance unit—Moved to Existing Buildings – not deleted~~

4. Multifamily buildings with heating loads ≤ 6.0 Btu/hour/square foot at design temperature.

5. Cold-Climate Heat Pump where:

- a. the full heating demand can be met with the heat pump at an outside air temperature of 5°F; and
- b. the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) and deemed to comply with the provisions of Section C402.4.1 when the tested air leakage rate of the building thermal envelope is not greater than 0.20 cfm/ft² (including the areas of the slab and below grade walls).

C403.4.1.1 Heat pump supplementary heat (Mandatory)

Heat pumps having supplementary electric resistance heat **shall be certified *cold-climate heat pumps*** meeting the requirements of section C403.2.3.

C403.2.2 Ventilation (Mandatory)

Ventilation, ~~either natural or mechanical~~, shall be provided in accordance with ASHRAE Standard 62.1. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by ASHRAE Standard 62.1. The design professional shall utilize ventilation rates based on the expected occupancy level of the space. Life safety maximum allowable occupancy density shall not be used as a ventilation basis of design.

C403.2.4.2.1 Thermostatic setback capabilities.(Mandatory)

Thermostatic setback controls shall ~~have the capability be configured~~ to set back or temporarily operate the system to maintain zone temperatures down to ~~60~~55°F (13°C) or up to ~~80~~85°F (29°C).

- ▶ **Exemption:**
- ▶ 1. Zones served exclusively by cold-climate heat pumps.

C403.2.4.3.3.3 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 valve.

C403.3 Heating and cooling equipment efficiencies (Mandatory)

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

- ▶ C403.3.1 Equipment sizing (Mandatory).

The output capacity of heating and cooling equipment shall be not 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. Heating and cooling equipment sizing is permitted to be up to ten percent greater (to the next nearest available size) than the calculated peak heating and cooling loads to allow for building pickup and cool down after temperature setback conditions.

C403.3.2 HVAC equipment performance requirements (Mandatory)

Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through C403.3.2(11) when tested and rated in accordance with the applicable test procedure. **Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of Table C403.3.2(12) which lists the AHRI test procedure.**

EQUIPMENT TYPE	SUBCATEGORY	MINIMUM EFFICIENCY	TEST PROCEDURE ^a
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

TABLE C403.3.2(1) and C403.3.2(2) 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 cooled (heating mode)	< 65,000 Btu/hb	—	Split System	10.0 HSPF	AHRI 210/240
		—	Single Package	10.0 HSPF	
Through-the-wall, (air cooled, heating mode)	£ 30,000 Btu/hb (cooling capacity)	—	Split System	10.0 HSPF	
		—	Single Package	10.0 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/hb	—	Split System	10.0 HSPF	

TABLE C403.3.2.3(3)
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

Room air conditioners, with louvered sides	< 6,000 Btu/h	—	11.0 CEER
	³ 6,000 Btu/h and < 8,000 Btu/h	—	11.0 CEER
	³ 8,000 Btu/h and < 14,000 Btu/h	—	10.9 CEER
	³ 14,000 Btu/h and < 20,000 Btu/h	—	10.7 CEER
	³ 20,000 Btu/h and ≤ 25,000 Btu/h	—	9.4 CEER
	> 25,000 Btu/h	—	9.0 CEER
Room air conditioners, without louvered sides	< 6,000 Btu/h	—	10.0 CEER
	³ 6,000 Btu/h and < 8,000 Btu/h	—	10.0 CEER
	³ 8,000 Btu/h and < 11,000 Btu/h	—	9.6 CEER
	³ 11,000 Btu/h and < 14,000 Btu/h	—	9.5 CEER
	³ 14,000 Btu/h and < 20,000 Btu/h	—	9.3 CEER

TABLE C403.3.2.3(3)
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

Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	—	9.8 CEER
	≥ 20,000 Btu/h	—	9.3 CEER
Room air-conditioner heat pumps without louvered sides	< 14,000 Btu/h	—	9.3 CEER
	≥ 14,000 Btu/h	—	8.7 CEER
Room air conditioner casement only	All capacities	—	9.5 CEER
Room air conditioner casement-slider	All capacities	—	10.4 CEER

TABLE C403.3.2(4)
WARM-AIR FURNACES AND COMBINATION WARM-AIR
FURNACES/AIR-CONDITIONING UNITS,
WARM-AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM
EFFICIENCY REQUIREMENTS

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	—	80% AFUE or 80%Etc	DOE 10 CFR Part 430 or ANSI Z21.47
	³ 225,000 Btu/h	Maximum capacity ^c	80%E ^f	ANSI Z21.47
Warm-air furnaces, oil fired	< 225,000 Btu/h	—	83% AFUE or 80%Etc	DOE 10 CFR Part 430 or UL 727
	³ 225,000 Btu/h	Maximum capacity ^b	81%E ^g	UL 727

TABLE C403.3.2(5)
MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

EQUIPMENT TYPE ^a	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY ^{d, e}
Boilers, hot water	Gas-fired	< 300,000 Btu/hf, g	82% AFUE
		³ 300,000 Btu/h and £ 2,500,000 Btu/hb	80% Et
		> 2,500,000 Btu/ha	82% Ec
	Oil-fired ^c	< 300,000 Btu/hg	84% AFUE
		³ 300,000 Btu/h and £ 2,500,000 Btu/hb	82% Et
		> 2,500,000 Btu/ha	84% Ec
Boilers, steam	Gas-fired	< 300,000 Btu/hf	80% AFUE
	Gas-fired- all, except natural draft	³ 300,000 Btu/h and £ 2,500,000 Btu/hb	79% Et
		> 2,500,000 Btu/ha	79% Et
	Gas-fired-natural draft	³ 300,000 Btu/h and £ 2,500,000 Btu/hb	77% Et
		> 2,500,000 Btu/ha	77% Et
	Oil-fired ^c	< 300,000 Btu/h	82% AFUE
		³ 300,000 Btu/h and £ 2,500,000 Btu/hb	81% Et
		> 2,500,000 Btu/ha	81% Et

TABLE C403.3.2(5) MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILERS

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

TABLE C403.3.2.3(8)
MINIMUM EFFICIENCY REQUIREMENTS:
HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE ^a	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION ⁱ	PERFORMANCE REQUIRED ^{b, c, d, g, h}	TEST PROCEDURE ^{e, f}
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	³ 40.2 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	³ 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	³ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS

TABLE C403.3.2(10)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY
VRF air conditioners, air cooled	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER
	• 65,000 Btu/h and < 135,000 Btu/h	None	VRF multisplit system	11.2 EER 15.5 EER
	• 135,000 Btu/h and < 240,000 Btu/h	None	VRF multisplit system	11.0 EER 14.9 IEER
	• 240,000 Btu/h	None	VRF multisplit system	10.0 EER 13.9 IEER

TABLE C403.3.2(11)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY
VRF air cooled (cooling mode)	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER
	³ 65,000 Btu/h and < 135,000 Btu/h	None	VRF multisplit system	11.0 EER 14.6 IEER
	³ 65,000 Btu/h and < 135,000 Btu/h	None	VRF multisplit system with heat recovery	10.8 EER 14.4 IEER
	³ 135,000 Btu/h and < 240,000 Btu/h	None	VRF multisplit system	10.6 EER 13.9 IEER
	³ 135,000 Btu/h and < 240,000 Btu/h	None	VRF multisplit system with heat recovery	10.4 EER 13.7 IEER
	³ 240,000 Btu/h	None	VRF multisplit system	9.5 EER 12.7 IEER
	³ 240,000 Btu/h	None	VRF multisplit system with heat recovery	9.3 EER 12.5 IEER

TABLE C403.3.2(11)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

VRF water source (cooling mode)	< 65,000 Btu/h	All	VRF multisplit system 86°F entering water	12.0 EER 16.0 IEER
	< 65,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	11.8 EER 15.8 IEER
	³ 65,000 Btu/h and < 135,000 Btu/h	All	VRF multisplit system 86°F entering water	12.0 EER 16.0 IEER
	³ 65,000 Btu/h and < 135,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	11.8 EER 15.8 IEER
	³ 135,000 Btu/h and < 240,000 Btu/h	All	VRF multisplit system 86°F entering water	10.0 EER 14.0 IEER
	³ 135,000 Btu/h and < 240,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	9.8 EER 13.8 IEER
	³ 240,000 Btu/h	All	VRF multisplit system 86°F entering water	10.0 EER 12.0 IEER
	³ 240,000 Btu/h	All	VRF multisplit system with heat recovery 86°F entering water	9.8 EER 11.8 IEER

TABLE C403.3.2(11)

MINIMUM EFFICIENCY

ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS

VRF air cooled (heating mode)	< 65,000 Btu/h (cooling capacity)	—	VRF multisplit system	10.0 HSPF
	≥ 65,000 Btu/h and < 135,000 Btu/h	—	VRF multisplit system 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 system 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)	< 135,000 Btu/h	—	VRF multisplit system 68°F entering water	4.3 COP _H
	≥ 135,000 Btu/h	—	VRF multisplit system 68°F entering water	4.0 COP _H

C403.3 Hot Gas Bypass and Boiler Turndown

- ▶ C403.3.3 Hot gas bypass.
The use of hot gas bypass is prohibited in all systems.
- ▶ C403.3.4 Boiler turndown. – **not changing**
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
³ 1,000,000 and less than or equal to 5,000,000	3 to 1
> 5,000,000 and less than or equal to 10,000,000	4 to 1
> 10,000,000	5 to 1

C403.4.1.4 Heated vestibules (Mandatory)

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 55°F (16°C). Vestibule heating systems shall be controlled by a thermostat located in the vestibule configured to limit heating to a temperature not greater than 55°F (16°C). Cooling of the vestibule is prohibited.

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

C403.4.2.3 Automatic start (Mandatory)

Automatic start controls shall be provided for each HVAC system. The 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.

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 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.

C403.4.4 Part-load controls

Hydronic systems greater than or equal to **300,000 Btu/h (146.5 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.

C403.4.4 Part-load controls

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 1 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 nominal output motor power of 2 hp or more.

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. In systems where pump speed is controlled by a differential pressure setpoint, that setpoint shall be incrementally indexed down to maintain at least one valve nearly wide open. There shall be no lower limit to the differential pressure except to remain within the tolerances and accuracy of the controlling sensor.

C403.4.4 Part-load controls

Exceptions:

- ▶ 1. Supply-water temperature reset is not required for chilled-water systems supplied by off-site district 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. For renovations, variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by a pre-existing electric boiler.

C403.5 Economizers (Prescriptive)

Requirements remained the same except for the following deletion in Exceptions:

~~5. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.~~

~~6. Where the cooling efficiency meets or exceeds a 50% efficiency improvement in cooling equipment performance (EER or IPLV).~~

~~7. Chilled water cooling systems that are passive (without a fan) or use induction where the total chilled water system capacity less the capacity of fan units with air economizers is less than the minimum specified in Table C403.3(1).~~

~~8. Systems that include a heat recovery system in accordance with Section C403.4.5.~~

~~9. Systems serving primarily computer rooms~~

C403.5.5 Economizer fault detection and diagnostics (Mandatory)

Air-cooled unitary direct-expansion units listed in Tables C403.3.2(1) through C403.3.2(3) and Tables C403.3.2(10) through C403.3.2(11) that are **15 tons (180,000 Btu/h)** or greater and equipped with an economizer in accordance with Section C403.5 shall include a fault detection and diagnostics system complying with the following:

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 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.

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.

C403.7.3 Ventilation air heating control (Mandatory)

Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating 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.

C403.7.4 Energy recovery systems (Mandatory)

**TABLE C403.7.4
ENERGY RECOVERY REQUIREMENT
(Air systems operating not less than 3,000 hours per year)**

PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
³ 10% and < 20%	³ 20% and < 30%	³ 30% and < 40%	³ 40% and < 50%	³ 50% and < 60%	³ 60% and < 70%	³ 70% and < 80%	³ 80%
DESIGN SUPPLY FAN AIRFLOW RATE (cfm)							
³ 10,500	³ 6,500	³ 5,500	³ 4,500	³ 3,500	³ 2,000	³ 1,000	> 120

C403.7.6 Automatic control of HVAC systems serving guestrooms (Mandatory)

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.

C403.7.6.1 Temperature setpoint controls.

Controls shall be provided on each HVAC system that are capable of and configured to 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. The controls shall be capable of and configured to 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) when the guestroom is unrented or has not been continuously occupied for more than 16 hours or a networked guestroom control system indicates that the guestroom is unrented and the guestroom is unoccupied for more than 30 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.



C403.7.6 Automatic control of HVAC systems serving guestrooms (Mandatory)

C403.7.6.2 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 30 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.

C403.8.1 Allowable fan horsepower (Mandatory)

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.

C403.8.3 Fan efficiency (Mandatory)

Fans shall employ contamination-sensing devices and automatic controls configured to stage fans or modulate have a fan efficiency grade (FEG) of **not less than 70**, as determined in accordance with AMCA 205 by an approved, independent testing laboratory and labeled by the manufacturer. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

- ▶ Exception: The following fans are not required to have a fan efficiency grade:
 - ▶ 1. Fans of **1 hp (0.75 kW)** or less as follows:
 - ▶ 1.1. Individual fans with a motor nameplate horsepower of **1 hp (0.75 kW)** or less, unless Exception 1.2 applies.
 - ▶ 1.2. Multiple fans in series or parallel that have a combined motor nameplate horsepower of **2 hp (1.5 kW)** or less and are operated as the functional equivalent of a single fan

C403.8.4 Fractional hp fan motors (Mandatory)

Motors for fans that are not less than 1 / 12 hp (0.082 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors or **NEMA Premium efficiency motors 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 that are an integral part of specialized process equipment.**
2. **Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.**
3. Motors in the airstream within fan coils and terminal units that only provide heating to the space served.
4. Motors in space-conditioning equipment that comply with Section C403.3.2 or Sections C403.8.1. through C403.8.3.
5. Motors that comply with Section C405.7.

C403.8.5 Fan control

Each cooling system listed in Table C403.8.5.1 shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

**TABLE C403.8.5.1
COOLING SYSTEMS**

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	³ 24,000 Btu/h
Chilled water and evaporative cooling	³ 1/4 hp	Any

C403.9.1 Fan speed control

Each fan system ~~powered by an individual motor or array of motors with connected power, including the motor service factor, totaling 2 hp (1.5 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 or 50 percent of the design airflow.

C403.9.3 Limitation on centrifugal fan open-circuit cooling towers

Centrifugal fan open-circuit cooling towers with a combined rated capacity of **550gpm (2032L/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.

TABLE C403.10.1(4)

WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day) ^a
Display door, medium temperature	DD, M	$0.04 \times \text{Add} + 0.41$
Display door, low temperature	DD, L	$0.15 \times \text{Add} + 0.29$
Passage door, medium temperature	PD, M	$0.05 \times \text{And} + 1.7$
Passage door, low temperature	PD, L	$0.14 \times \text{And} + 4.8$
Freight door, medium temperature	FD, M	$0.04 \times \text{And} + 1.9$
Freight door, low temperature	FD, L	$0.12 \times \text{And} + 5.6$

TABLE C403.10.1(5) WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS

CLASS DESCRIPTOR	CLASS	MINIMUM ANNUAL WALK-IN ENERGY FACTOR AWEF (Btu/W-h)
Dedicated condensing, medium temperature, indoor system	DC.M.I	5.61
Dedicated condensing, medium temperature, indoor system, > 9,000 Btu/h capacity	DC.M.I, > 9,000	5.61
Dedicated condensing, medium temperature, outdoor system	DC.M.I	7.60
Dedicated condensing, medium temperature, outdoor system, > 9,000 Btu/h capacity	DC.M.I, > 9,000	7.60

C403.10.1 Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers (Mandatory)

11. Lights in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall be LED with an efficacy of **90 lpw or more** and have occupancy controls that turns off the lights within 15 minutes when the space is not occupied.

C403.11.1 Duct and plenum insulation and sealing (Mandatory)

Supply and return air ducts and plenums shall be insulated with not less than R-8 insulation where located in unconditioned spaces and where located outside the building with not less than R-12 insulation. 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. Buried ducts shall be insulated to a minimum of R-6.

C403.11.3 Piping insulation (Mandatory)

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 85°F (29°C)**.
4. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
5. Direct buried piping that conveys fluids at or below 60°F (15°C).

C403.11.3 Piping insulation (Mandatory)

**TABLE C403.11.3
MINIMUM PIPE INSULATION THICKNESS (in inches)**

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
> 350	0.32 - 0.34	250	4.5	5.0	5.0	5.0
251 - 350	0.29 - 0.32	200	3.0	4.0	4.5	4.5
201 - 250	0.27 - 0.30	150	2.5	2.5	2.5	3.0
141 - 200	0.25 - 0.29	125	1.5	1.5	2.0	2.0
85 - 140	0.21 - 0.28	100	1.0	1.0	1.5	1.5
40 - 60	0.21 - 0.27	75	0.5	0.5	1.0	1.0
< 40	0.20 - 0.26	50	0.5	1.0	1.0	1.0

C403.11.3.1 Protection of piping insulation (Mandatory)

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. Piping insulation shall comply with both of the following requirements:

1. Insulation exposed to weather shall be suitable for outdoor service and shall be protected by aluminum, sheet metal, painted canvas, plastic cover, or other similar materials approved by the building official. Cellular foam insulation shall be protected as above or painted with a coating that is water-retardant and provides shielding from solar radiation; and
2. Unless the insulation is vapor-retardant, insulation covering chilled-water piping or refrigerant suction piping located outside the conditioned space shall include a vapor retardant located outside the insulation. All penetrations and joints shall be sealed

C403.12.2 Snow- and ice-melt system controls

Snow- and ice-melting systems shall include automatic ~~or manual~~ controls configured to shut off the system when the outdoor temperature is above 40°F (4°C) ~~and no precipitation is falling~~ and the slab temperature ~~as measured not less than 2" below the surface~~ is 50°F (10°C).



C404

Service Water Heating

Summary of Major Changes: Service Water Heating

- ▶ **Electric water heating size limitation**
- ▶ **Electric heat pump**
- ▶ **Water heater efficiency increases**
- ▶ **Single-unit size change**
- ▶ **Circulation system control change**
- ▶ **Pipe length and volume method deleted**

C404.1 General

Added following verbiage for clarity – no actual change to section

In addition to the mechanical requirements of Section C404, service water heating enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

Organization changed to match IECC

C404.1.1 Electrical water heating limitation

- ▶ Individual electric service water heating units shall be limited to a maximum of **7.5 kW** total power input.
- ▶ Exceptions:
 - ▶ 1. Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.
 - ▶ 2. Hybrid heat pump service water heaters which utilize supplemental electric resistance elements and meeting the following requirements:
 - ▶ a. No less than 60% of maximum heating demand can be met with the heat pump alone.
 - ▶ b. For new buildings, if serving showers, the shower heads must have a maximum flow rate of no greater than 2.0 gpm.
 - ▶ c. For new buildings, if serving dishwashing equipment, this equipment must be ENERGY STAR labeled.

C404.2 Service water-heating equipment performance efficiency

**TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT**

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED ^{a, b}	TEST PROCEDURE
Water heaters, electric	< 7.5 kW	Tabletop Resistance	0.93 – 0.00132V, EF	DOE 10 CFR Part 430
		Grid-enabled > 75 gallons and < 120 gallons	0.960 – 0.0003V, EF 1.061 – 0.00168V, EF	
	> 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	³ 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	

Table C404.2 Minimum Performance of Water-Heating Equipment

d. 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.

e. 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.”

C404.2.1 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 92 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.

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. **Systems designed to maintain usage temperatures in hot-water pipes, such as recirculating hot-water systems or heat trace, shall be equipped with variable speed drive controlled on system pressure to reduce pump speed during hours of low water demand ~~automatic time switches or other controls that can be set to switch off the usage temperature maintenance system during periods when hot water is not required.~~**

Exception: in healthcare and other facilities with immunocompromised populations in accordance with ASHRAE Standard 188 – Legionellosis: Risk Management for Building Water Systems.

~~Maximum allowable pipe length method~~
~~Maximum allowable pipe volume method~~
~~Water volume determination~~

Sections deleted from CBES 2019,
refer to Plumbing Code for requirements

C404.9.3 Covers

- ▶ Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other approved vapor-retardant means. Hot tubs and spas capable of being heated to more than 90°F (32°C) shall be provided with a cover having a minimum insulation value of R-12.
- ▶ Exception:
- ▶ Where more than ~~70~~75 percent of the energy for heating, computed over an operating season of not fewer than 3 calendar months, is from site-recovered energy such as from a heat pump or solar-on-site renewable energy system, covers or other vapor-retardant means shall not be required.

C404.11 Service water–heating system commissioning and completion requirements

Service water–heating systems, swimming pool water–heating systems, spa water– heating systems and the controls for those systems shall be commissioned and completed in accordance with Section C407.2.

C405 Electrical Power and Lighting Systems



Summary of Major Changes: Electric & Lighting

- ▶ **New definitions for lighting**
- ▶ **Dwelling and Sleeping unit requirements**
- ▶ **Reduced interior lighting power allowance**
- ▶ **Reduction in allowance for additional interior lighting power**
- ▶ **Reduced exterior lighting power allowance**
- ▶ **Manual controls**
- ▶ **Amended control of occupancy sensors**
- ▶ **Open office area occupancy sensors**

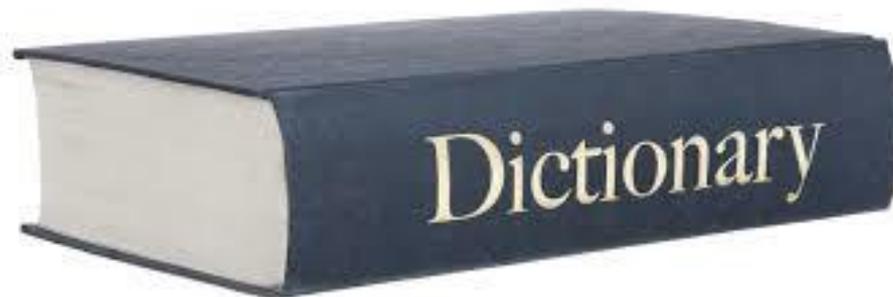
Summary of Major Changes: Electric & Lighting (continued)

- ▶ Egress lighting controls
- ▶ Requirements added to daylight control functions
- ▶ Daylight controlled dimming
- ▶ Exterior time switch control function
- ▶ Gas Lighting pilot control
- ▶ Amended 3-phase transformer requirements
- ▶ Amended general purpose motor efficiencies
- ▶ Voltage drop in feeders and branch circuits
- ▶ Electric vehicle charging stations

New Definitions for Lighting Systems

HIGH-EFFICACY LAMPS/LIGHTING. Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy of not less than 65 lumens per watt; or light fixtures of not less than 55 lumens per watt.

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



Dwelling and Sleeping Units

Dwelling units and *Sleeping Units* within Group R-2 buildings shall install lamps or fixtures where not less than 90 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 90 percent of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps.

- Changed from just multifamily to R-2 with also includes dormitories, fraternities, and sororities.
- *Dwelling units* within buildings other than Group R-2 with high-efficacy lighting are exempt from lighting controls.
- *Dwelling units* and *sleeping units* within buildings other than Group R-2 with high efficacy lighting are exempt for Lighting Power Density requirements.

HIGH-EFFICACY LAMPS/LIGHTING. Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy of not less than 65 lumens per watt; or light fixtures of not less than 55 lumens per watt.

Lighting Power Density – *Table C405.4.2(1)*

Area Type	2015 CBES	2018 IECC	2019 CBES
Automotive facility	0.80	0.71	0.60
Convention center	1.01	0.76	0.70
Courthouse	1.01	0.90	0.76
Dining: bar lounge/leisure	1.01	0.90	0.76
Dining: cafeteria/fast food	0.90	0.79	0.67
Dining: family	0.95	0.78	0.69
Dormitory	0.57	0.61	0.47
Exercise center	0.84	0.65	0.59
Fire station	0.67	0.53	0.48
Gymnasium	0.94	0.68	0.64
Health care clinic	0.90	0.82	0.69

In a facility for the elderly or visually impaired there are higher LPD allowances in the space-by-space method.

Lighting Power Density – *Table C405.4.2(1)*

Area Type	2015 CBES	2018 IECC	2019 CBES
Hospital	1.05	1.05	0.84
Hotel/Motel	0.87	0.75	0.65
Library	1.19	0.78	0.78
Manufacturing facility	1.17	0.90	0.82
Motion picture theater	0.76	0.83	0.64
Multifamily	0.51	0.68	0.48
Museum	1.02	1.06	0.83
Office	0.82	0.79	0.64
Parking garage	0.21	0.15	0.14
Penitentiary	0.81	0.75	0.62
Performing arts theater	1.39	1.18	1.02

Lighting Power Density – *Table C405.4.2(1)*

Area Type	2015 CBES	IECC 2018	2019 CBES
Police station	0.87	0.80	0.67
Post office	0.87	0.67	0.61
Religious building	1.00	0.94	0.77
Retail	1.26	1.06	0.92
School/university	0.87	0.81	0.67
Sports arena	0.91	0.87	0.71
Town hall	0.89	0.80	0.67
Transportation	0.70	0.61	0.52
Warehouse	0.60	0.48	0.43
Workshop	1.19	0.90	0.83

Additional Interior Lighting Power

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	=	500 250 W + (Retail Area 1 × 0.60 0.20 W/ft ²) + (Retail Area 2 × 0.60 0.20 W/ft ²) + (Retail Area 3 × 1.4 0.50 W/ft ²) + (Retail Area 4 × 2.5 0.90 W/ft ²)
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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.

Lighting Power Density for Zone 3 – *Table C405.4.2(2)*

Area Type	2015 CBES	2018 IECC	2019 CBES
Base Site Allowance	750 W	500 W	375 W
Parking Area and Drives	0.10 W/ft ²	0.06 W/ft ²	0.05 W/ft ²
Walkways less than 10 feet wide	0.8 W/linear foot	0.6 W/linear foot	0.40 W/linear foot
Walkways 10 feet wide or greater, plaza areas special feature areas	0.16 W/ft ²	0.11 W/ft ²	0.08 W/ft ²
Dining Areas	Not Specified	0.75 W/ft ²	0.60 W/ft ²
Stairways	1.0 W/ft ²	0.70 W/ft ²	0.50 W/ft ²
Pedestrian tunnels	0.2 W/ft ²	0.14 W/ft ²	0.10 W/ft ²
Landscaping	Not Specified	0.04 W/ft ²	0.03 W/ft ²

Zone 4 is removed from 2019 CBES

Lighting Power Density for Zone 3 – *Table C405.4.2(2)*

Area Type	2015 CBES	2018 IECC	2019 CBES
Main entries	30 W/linear foot of door width	21 W/linear foot of door width	15 W/linear foot of door width
Other doors	20 W/linear foot of door width	21 W/linear foot of door width	15 W/linear foot of door width
Entry canopies	0.40 W/ft ²	0.40 W/ft ²	0.20 W/ft ²
Loading Docks	Not Specified	0.35 W/ft ²	0.25 W/ft ²
Free-standing and attached	0.8 W/ft ²	0.60 W/ft ²	0.40 W/ft ²
Open areas (including vehicle sales lots)	0.5 W/ft ²	0.35 W/ft ²	0.25 W/ft ²
Street frontage for vehicle sales lots in addition to “open area” allowance	10 W/linear foot	7 W/linear foot	5 W/linear foot

Lighting Power Density for Zone 3 – *Table C405.4.2(2)*

Area Type	2015 CBES	2018 IECC	2019 CBES
Building facades	0.113 W/ft ² of gross above-grade wall area	0.113 W/ft ² of gross above-grade wall area	0.113 W/ft ² of gross above-grade wall area
Automated teller machines (ATM) and night depositories	270 W per location plus 90 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft ² of covered and uncovered area	0.5 W/ft ² of uncovered area	0.5 W/ft ² of covered and uncovered area

Lighting Power Density for Zone 3 – *Table C405.4.2(2)*

Area Type	2015 CBES	Proposed July	Proposed Oct.
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft ² of covered and uncovered area	0.35 W/ft ² of uncovered area	0.35 W/ft ² of covered and uncovered area
Drive-up windows/doors	400 W per drive-through	200 W per drive-through	200 W per drive-through
Parking near 24-hour retail entrances	800 W per main entry	400 W per main entry	400 W per main entry

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.



Occupancy Sensor Control Function

Occupant sensor controls for most spaces specified in Section C405.2.1 shall comply with the following:

1. They shall automatically turn off lights within ~~30~~ 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.

Exception: Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

3. They shall incorporate a manual control to allow occupants to turn off lights

Open Office Area Occupancy Sensors

Occupant sensor controls in open plan office spaces over 300 SF 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 m²) within the open plan office space.
- 2.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.
- 3.The controls shall be configured so that general lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone.
- 4.The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.

Egress Lighting Controls

Luminaires providing means of egress illumination where the means of egress shall be illuminated at all times the room or space is occupied shall be controlled by occupancy sensors, or a signal from another building control system, that automatically reduces the lighting power by at least 50% when unoccupied for a period longer than 15 minutes.

Exceptions:

1. Egress areas not exceeding 50% of the space-by-space interior lighting power allowance provided in Table C405.3.2(2).
2. Means of egress illumination that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.
3. Emergency lighting designated to meet National Fire Protection Association (NFPA) 1 or NFPA 101.

Requirements Added to Daylight Control Functions

6. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.

7. The maximum area a single daylight responsive control device serves shall not exceed 2,500 square feet (232 m²).

8. Occupant override capability of daylight dimming controls is not permitted, other than a reduction of light output from the level established by the daylighting controls.

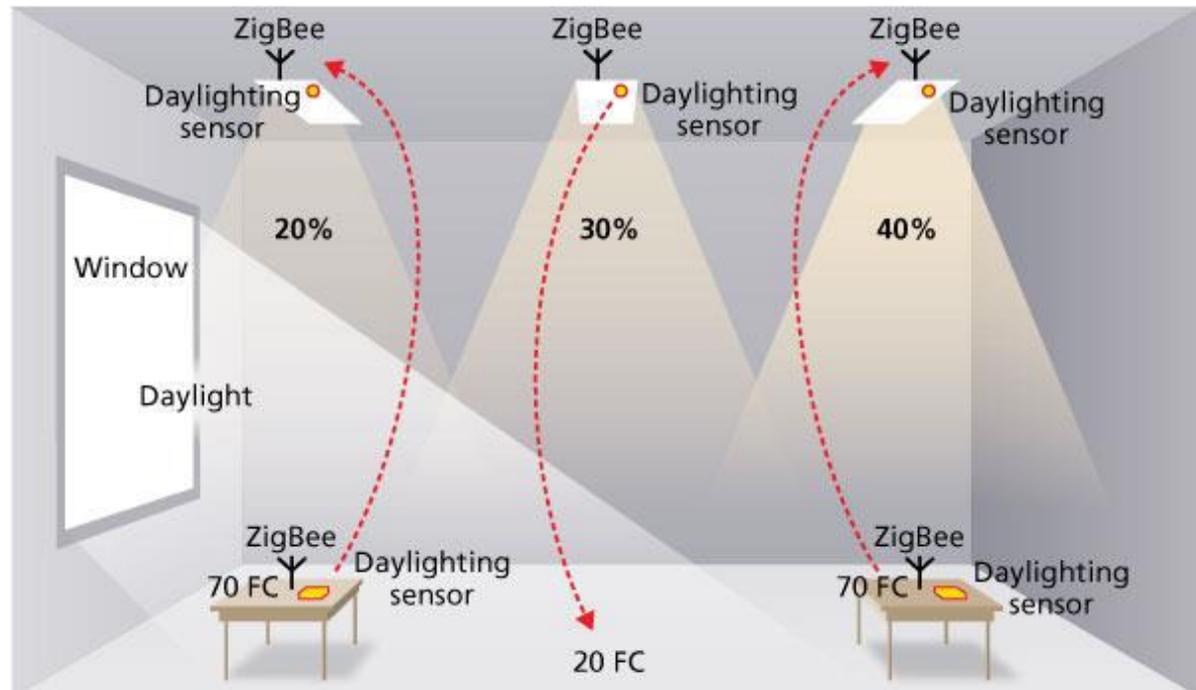


Image Source: Pacific Northwest National Laboratory, Heat, R.

Daylight Controlled Dimming

Daylight responsive controls shall be configured to automatically reduce the power of *general lighting* in the *daylight zone* in response to available daylight, while maintaining *uniform illumination* in the space through one of the following methods:

1. Continuous dimming using dimming ballasts/dimming drivers and daylight-sensing automatic controls. The system shall reduce lighting power continuously to less than 15 percent of rated power at maximum light output.
2. Stepped dimming using multi-level switching and daylight-sensing controls. The system shall provide a minimum of two steps of uniform illumination between 0 and 100 percent of rated power at maximum light output. Each step shall be in equal increments of power, plus or minus 10 percent. General lighting within daylight zones in offices, classrooms, laboratories and library reading rooms shall use the continuous dimming method. Stepped dimming is not allowed as a method of daylight zone control in these spaces.

Exterior Time-Switch Control Function

2015 CBES:

All time switches shall be able to retain programming and the time setting during loss of power for a period of at least 10 hours.

2019 CBES:

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.

Gas Lighting

Gas-fired lighting appliances shall not be equipped with continuously burning pilot ignition systems.



Electrical Transformers

Single-phase transformers unchanged, three-phase has been updated

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	97.0 97.89
25	98.00	30	97.5 98.23
37.5	98.20	45	97.7 98.40
50	98.30	75	98.0 98.60
75	98.50	112.5	98.2 98.74
100	98.60	150	98.3 98.83
167	98.70	225	98.5 98.94
250	98.80	300	98.6 99.02
333	98.90	500	98.7 99.14
—	—	750	98.8 99.23
—	—	1000	98.9 99.28

Electrical Transformers

**MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN A, NEMA DESIGN B,
AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP) ELECTRIC MOTORS AT 60 HZa, 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				

Voltage Drop in Feeders and Branch Circuits

The total *voltage drop* across the combination of feeders and branch circuits shall not exceed 5 percent.

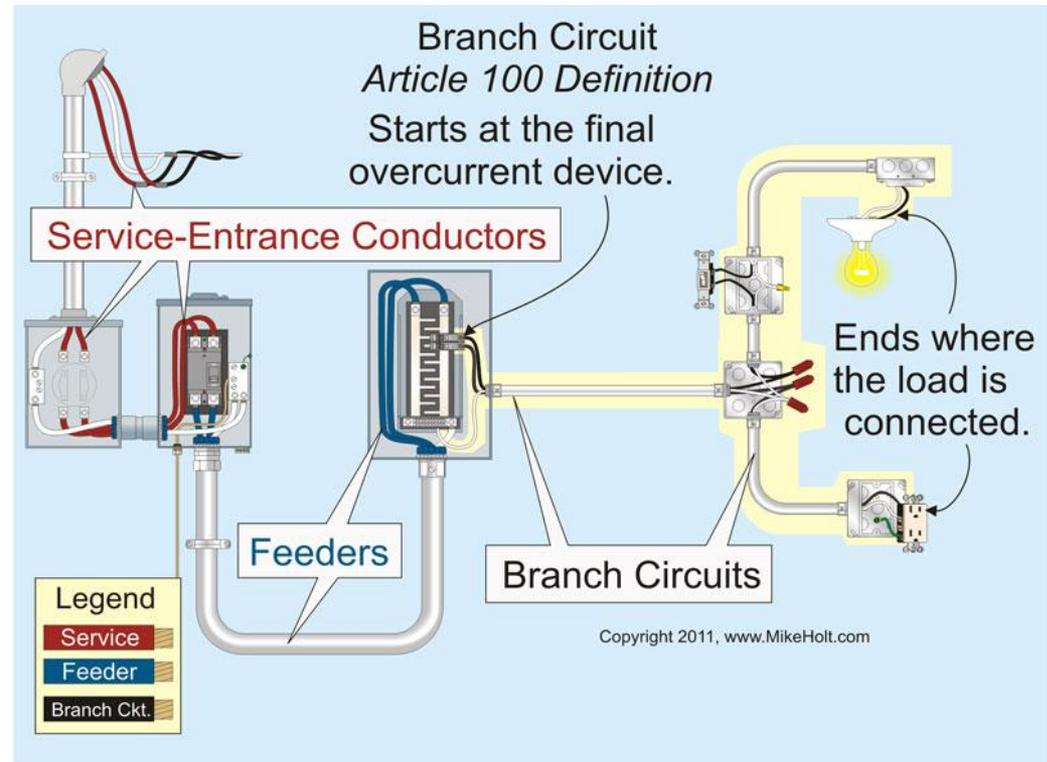


Image Source: www.MikeHolt.com

Electric Vehicle Charging Stations

Parking spots shall have a socket capable of providing the required level 1 or level 2 charge (see Table C405.11) within 5 feet of the centerline.

50% of the parking spaces, rounded up to the nearest whole number, shall have Electric Vehicle Supply Equipment (EVSE). The remainder shall be pre-wired to allow for installations at such time as they are needed.

Facility Type	Parking Spaces - EVSE plus EVSE-Ready (rounded up to nearest whole number)					
	<25		≥25 Option A		≥25 Option B	
	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
Groups A&M	0%	0%	0%	4%	0%	10
Groups B, E, F & H	1	1	3%	3%	2%	5
Groups I-1, I-2, I-3 & R-4	1	1	2%	4%	1%	10
Group R-1	0	1	0%	2%	1%	10
Group R-2	1	0	8%	0%	3%	5

Stand alone retail has no requirement for < 50 spaces

Parking for Electric Vehicle Charging Stations

Parking spaces with EVSE shall be marked for EV use only.

Exception:

1. In Group R-2 buildings the number of parking spaces with EVSE that are marked for “EV use only” need not exceed the number of EV cars driven by occupants of the building. This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.
2. In structured parking lots $\frac{1}{2}$ of parking spaces, rounded up, with EVSE shall be marked for “EV use only”, while the remainder need not be marked for “EV use only”. This exception does not reduce the number of EVSE spaces, just the number that are marked for EV use only.



Building Group Definitions

- A = Occupancy group used for buildings that are for the gathering of persons for purposes such as civic, social or religious functions; recreation, food or drink consumption or awaiting transportation.
- M = The use of a building for the display and sale of merchandise, and involves stocks of goods, wares or merchandise incidental to such purposed and accessible to the public, e.g. department stores, drug stores, markets, retail or wholesale stores, sales rooms
- B = The use of a building for office, professional or service-type transactions, including storage of records and accounts, e.g. banks, civic administration, clinic (outpatient), dry cleaning, electronic data processing
- E = The use of a building by six or more persons at any one time for educational purposes through the 12th grade
- F = Occupancy group used for disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operation that are not classified as Group H or Group S.
- H = Occupancy group used for manufacturing, processing, generation or storage of materials that constitute a physical or health hazard.

Building Group Definitions

- I = Occupancy group used for more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised environment and receive custodial care.
- R-4 = Occupancies for more than five but not more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised residential environment and receive custodial care.
- R-1 = Occupancies containing sleeping units where the occupants are primarily transient in nature, e.g. hotels/motels
- R-2 = Occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent in nature, e.g. apartment houses, dormitories, fraternities/sororities, vacation timeshare

C406 Additional Efficiency Package Options



Additional Efficiency Package

Concept is not new to code, but note in beginning of Sections 402 through 405 is a message like this:

C402.1 General (Prescriptive).

In addition to the envelope requirements of Section C402, envelope enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

Summary of Additional Efficiency Package Options

- ▶ **Must achieve 6 points**
- ▶ **Choose from the following options**
 - More efficient HVAC performance
 - Reduced lighting power density
 - Enhanced lighting controls
 - On-site renewable energy
 - Dedicated outdoor air system (DOAS)
 - High efficiency service water heating
 - Heat pump water heating
 - Enhanced envelope performance
 - Reduced air infiltration
 - Efficient kitchen appliances
 - Controlled receptacles

Points for Efficiency Package Options

Efficiency Package Option	Group R-1	Group R-2	Group B	Group E	Group M	All other groups
	Additional Efficiency Credits					
HVAC Performance	<u>2</u>	<u>2</u>	<u>5</u>	<u>2</u>	<u>6</u>	<u>3</u>
Lighting Power 1	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>
Lighting Power 2	<u>2</u>	<u>2</u>	<u>5</u>	<u>5</u>	<u>5</u>	<u>4</u>
Lighting Controls	<u>N/A</u>	<u>N/A</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>
Renewable Energy	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>3</u>
DOAS	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>3</u>
Water Heating 1	<u>5</u>	<u>6</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>3 (Group I only)</u>
Water Heating 2	<u>3</u>	<u>3</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>2 (Group I only)</u>
HP Water Heater	<u>5</u>	<u>5</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>2 (Group I only)</u>
Envelope	<u>3</u>	<u>4</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>
Air Infiltration	<u>3</u>	<u>5</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>3</u>
Kitchen Appliances	<u>5</u>	<u>N/A</u>	<u>N/A</u>	<u>N/A</u>	<u>5</u>	<u>5 (Group A-2 only)</u>
Controlled Receptacles	<u>N/A</u>	<u>N/A</u>	<u>6</u>	<u>2</u>	<u>N/A</u>	<u>N/A</u>

Building Group Definitions

- R-1 = Occupancies containing sleeping units where the occupants are primarily transient in nature, e.g. hotels/motels
- R-2 = Occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent in nature, e.g. apartment houses, dormitories, fraternities/sororities, vacation timeshare
- B = The use of a building for office, professional or service-type transactions, including storage of records and accounts, e.g. banks, civic administration, clinic (outpatient), dry cleaning, electronic data processing
- E = The use of a building by six or more persons at any one time for educational purposes through the 12th grade
- M = The use of a building for the display and sale of merchandise, and involves stocks of goods, wares or merchandise incidental to such purposed and accessible to the public, e.g. department stores, drug stores, markets, retail or wholesale stores, sales rooms

More Efficient HVAC Equipment and Fan Performance

2015 CBES required 10% improvement, 2019 CBES requires 15%.

Efficiency credits require all three of the following:

C406.2.1 HVAC system selection. No less than 90 percent of the total HVAC capacity serving the building shall be provided by equipment that is listed in Tables C403.3.2(1) through C403.3.2(12).

C406.2.2 Minimum equipment efficiency. Equipment shall exceed the minimum efficiency requirements listed in Tables C403.3.2(1) through C403.3.2(12) by 15 percent, in addition to the requirements of Section C403. Where multiple performance requirements are provided, the equipment shall exceed all requirements by 15 percent.

C406.2.3 Minimum fan efficiency. Stand-alone supply, return and exhaust fans designed for operating with motors over 750 watts (1 hp) shall have a fan efficiency grade of not less than FEG 71 as defined in AMCA 205. The total efficiency of the fan at the design point of operation shall be within 10 percentage points of either the maximum total efficiency of the fan or the static efficiency of the fan.

Reduced Lighting Power

2015 CBED required 10% improvement, 2019 CBES requires 10% for Option 1 and 20% for Option 2.

Buildings shall comply with Sections C406.3.1 or C406.3.2. Dwelling units and sleeping units within the building shall comply with C406.3.3.

C406.3.1 Reduced lighting power option 1. The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be 90 percent or less of the total interior lighting power value calculated in accordance with Section C405.3.2.1, or by using 90 percent of the total interior lighting power allowance calculated in accordance with Section C405.3.2.2.

C406.3.2 Reduced lighting power option 2. The total connected interior lighting power calculated in accordance with Section C405.3.1 shall be 80 percent or less of the total interior lighting power value calculated in accordance with Section C405.3.2.1, or by using 80 percent of the total interior lighting power allowance calculated in accordance with Section C405.3.2.2.

C406.3.3 Lamp fraction. Not less than 95 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 95 percent of the permanently installed lighting fixtures shall be high-efficacy fixtures or contain only high-efficacy lamps.

Enhanced Digital Lighting Controls

Besides some minor editing, this is largely unchanged from 2015 CBES

Interior lighting shall be located, scheduled and operated in accordance with Section C405.2 and no less than 90 percent of the total installed interior lighting power shall be configured with the following enhanced control functions.

1. Luminaires shall be configured for continuous dimming.
2. Luminaires shall be addressed individually.
3. Not more than eight luminaires within a *daylight zone* are permitted to be controlled by a *daylight* responsive control.
4. Luminaires shall be controlled through a digital control system configured with the following capabilities:
 1. Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.
 2. Load shedding.
 3. In open and enclosed offices, the illumination level of overhead general illumination luminaires are configured to be individually adjusted by occupants.
 4. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.
5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions required by this section.

On-Site Renewable Energy

2015 CBES did not distinguish between building type.

Buildings shall be provided with on-site renewable energy systems with a total system rating per square foot of conditioned floor area of the building of not less than the value specified in Table C406.5.

TABLE C406.5
ON-SITE RENEWABLE ENERGY SYSTEM RATING

<u>(PER SQUARE FOOT)</u> <u>Building Area Type</u>	<u>kBTU per year</u>	<u>kWh per year</u>
<u>Assembly</u>	<u>1.8</u>	<u>0.53</u>
<u>Dining</u>	<u>10.7</u>	<u>3.14</u>
<u>Hospital</u>	<u>3.6</u>	<u>1.06</u>
<u>Hotel/Motel</u>	<u>2.0</u>	<u>0.59</u>
<u>Multi-family residential</u>	<u>0.50</u>	<u>0.15</u>
<u>Office</u>	<u>0.82</u>	<u>0.24</u>
<u>Other</u>	<u>2.02</u>	<u>0.59</u>
<u>Retail</u>	<u>1.31</u>	<u>0.38</u>
<u>School/University</u>	<u>1.17</u>	<u>0.34</u>
<u>Supermarket</u>	<u>5.0</u>	<u>1.47</u>
<u>Warehouse</u>	<u>0.43</u>	<u>0.13</u>

Dedicated Outdoor Air System

2019 CBES added not less than 90% of conditioned space to qualify.

Not less than 90% of the building conditioned floor area, excluding floor area of unoccupied spaces that do not require ventilation per ASHRAE Standard 62.1, shall be served by DOAS. Buildings containing equipment or systems regulated by Section C403.3.4, C403.4.3, C403.4.4, C403.4.5, C403.6, C403.8.4, C403.8.5, C403.8.5.1, C403.9.1, C403.9.2, C403.9.3 or C403.9.4 shall be equipped with an independent ventilation system designed to provide not less than the minimum 100-percent outdoor air to each individual occupied space, as specified by ASHRAE Standard 62.1. The ventilation system shall be capable of total energy recovery. The HVAC system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall 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.

Reduced Energy Use in Service Water Heating

2015 CBES only had Load Fraction option. For 2019 CBES choose one of the three options for achieving energy credits.

To qualify for this credit, not less than 90 percent of the building conditioned floor area shall be of the following types: R-1, I-2, A-2, F, R-2, A-3

C406.7.2 Load fraction. Not less than 60 percent of the annual building service hot water energy use, or not less than 100 percent of the annual building service hot water heating energy use in buildings subject to the requirements of Section C403.9.5, shall be provided by waste heat recovery or on-site renewable energy water-heating systems.

C406.7.3 High Performance Water Heating Equipment. The combined input-capacity-weighted-average equipment rating of all water heating equipment in the building shall be not less than 95% Et or 0.95 EF.

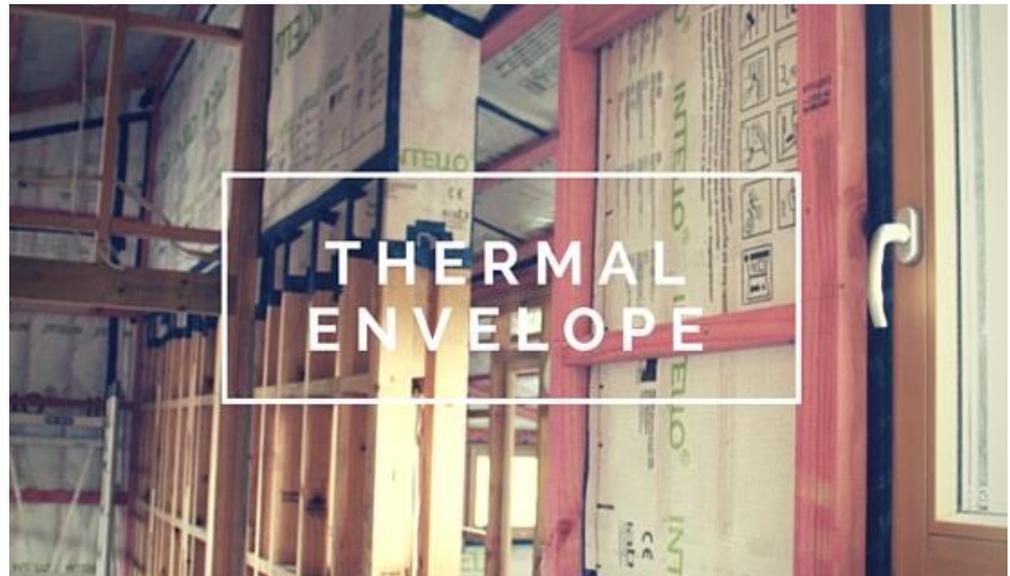
C406.7.4 Heat pump water heater. All Service hot water system ~~delivering~~ heating requirements shall be met using heat pump technology with a minimum COP of 3.0. Air-source heat pump water heaters shall not draw conditioned air from within the building, except exhaust air that would otherwise be exhausted to the exterior.

Enhanced Envelope Performance

This is a new option in 2019 CBES that was not provided in 2015 CBES

The total UA of the building thermal envelope as designed shall be not less than 15 percent below the total UA of the building thermal envelope for a building of identical configuration and fenestration area in accordance with Section C402.1.3.

If using Section C402.1.4 Building above-grade performance alternative for compliance, $UA_{\text{Total}} / \text{Area} \leq 0.030$ needs to be met as well as total UA of below-grade walls shall be not less than 15 percent below the total UA of the below-grade thermal envelope in accordance with Section C402.1.3.



Reduced Air Infiltration

This is a new option in 2019 CBES that was not provided in 2015 CBES

Air infiltration shall be verified by whole-building pressurization testing conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air-leakage rate of the building envelope shall not exceed 0.25 cfm/ft² (2.0 L/s × m²) under a pressure differential of 0.3 inches water column (75 Pa), with the calculated surface area being the sum of the above- and below-grade building envelope. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner.

Exception: For buildings having over 250,000 square feet (25 000 m²) of conditioned floor area, air leakage testing need not be conducted on the whole building where testing is conducted on representative above-grade sections of the building. Tested areas shall total not less than 25 percent of the conditioned floor area and shall be tested in accordance with this section.

Efficient Kitchen Appliances

This is a new option in 2019 CBES that was not provided in 2015 CBES

The following pieces of equipment that fall within the scope of the applicable Energy Star program shall comply with the equivalent criteria required to achieve the Energy Star label if installed prior to the issuance of the Certificate of Occupancy:

- Commercial Fryers
- Commercial Hot Food Holding Cabinets
- Commercial Steam Cookers
- Commercial Dishwashers
- Commercial Griddles
- Commercial Ovens



Controlled Receptacles

This is a new option in 2019 CBES that was not provided in 2015 CBES

At least 50 percent of receptacles installed in private offices, open offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, individual workstations and classrooms, including those installed in modular partitions and modular office workstation systems, shall be controlled as required by this section. Either split receptacles shall be provided, with the top receptacle(s) controlled, or a controlled receptacle shall be located within 12 inches (0.30 m) of each uncontrolled receptacle. Controlled receptacles shall be visibly differentiated from standard receptacles and shall be controlled by one of the following automatic control devices:

An occupant sensor that turns receptacle power off when no occupants have been detected for a maximum of 20 minutes.

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 not to exceed 5,000 square feet (465 m²) and not to exceed one full floor. The device shall be capable of being overridden for periods of up to two hours by a timer accessible to occupants.

A worker wearing a white hard hat and safety glasses, dressed in a red shirt, is shown in profile from the waist up. He is holding a large roll of white paper, likely blueprints, and looking upwards and to the left. The background is a complex industrial environment with numerous white pipes, valves, and machinery. The lighting is bright, typical of an indoor industrial facility.

C407 System Commissioning

System Commissioning: *Section C407*

- ▶ Requirements are described in more detail:
 - Cx Plan
 - Test and Balance
 - Functional HVAC Performance Testing
 - Functional Lighting Testing
 - Commissioning Report
 - Documentation (Construction drawings and O&M manual)

- ▶ **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 C403.5 that serve individual dwelling units and sleeping units.**

Code Changes C501 Existing Buildings

Adopting language from 2018 IECC
No Major Changes

Q&A

➤ Materials posted at
<http://publicservice.vermont.gov/content/building-energy-standards-update>

➤ Send questions/comments to:

- PSD.CodeUpdateCom@vermont.gov
- Logistical comments/questions:
info@energyfuturesgroup.com or Gabrielle Stebbins at 802-482-4014

