Modification

CEPI-80-21

IECC®: C403.12.3.1

Proponents: Howard Ahern, representing Airex Manufacturing (howard.ahern@airexmfg.com)

This would be the modification from my proposal.

C403.12.3.1Protection of piping insulation. Piping insulation exposed to the weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind. Protection, and shall provide shielding from solar radiation that can cause degradation of the material. ~~and~~ Protection shall be removable for no less than the first 6 feet (4876 mm) from the equipment for maintenance. Adhesive tape shall not be permitted.

This would be the edit from the current code.

R403.4.1Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, ~~equipment maintenance~~ physical damage, and wind . ~~and~~ The protection shall provide shielding from solar radiation that can cause degradation of the material and shall be removable for no less than 6 feet (1828 mm) from the equipment for maintenance. Adhesive tape shall be prohibited

CEPI-130-21

# IECC®: C404.4, C404.4.1 (New), TABLE C404.4.1 (New)

**Proponents:**

Gary Klein, Gary Klein and Associates, Inc., representing Self (gary@garykleinassociates.com); Emily Toto, representing ASHRAE (etoto@ashrae.org); John Bade, representing California Investor Owned Utilities (johnbade@2050partners.com)

**2021 International Energy Conservation Code**

# Revise as follows:

C404.4 ~~Insulation of piping~~ Service water heating system piping insulation.

~~Piping from a water heater to the termination of the heated water fixture supply pipe shall be insulated in accordance with Table~~ ~~C403.12.3. On both the inlet and outlet piping of a storage water heater or heated water storage tank, the piping to a heat trap or the~~ ~~first 8 feet (2438 mm) of piping, whichever is less, shall be insulated. Piping that is heat traced shall be insulated in accordance with~~ ~~Table C403.12.3 or the heat trace manufacturer's instructions. Tubular pipe insulation shall be installed in accordance with the~~ ~~insulation manufacturer's instructions. Pipe insulation shall be continuous except where the piping passes through a framing member.~~ ~~The minimum insulation thickness requirements of this section shall not supersede any greater insulation thickness requirements~~ ~~necessary for the protection of piping from freezing temperatures or the protection of personnel against external surface temperatures~~ ~~on the insulation.~~

Service water heating system piping shall be surrounded by uncompressed insulation. The wall thickness of the insulation shall be ~~greater than or equal to~~ not less than the thickness shown in Table C404.4.1. Where the insulation thermal conductivity is not within the range in the table, the following equation shall be used to calculate the minimum insulation thickness:

talt = r·[(1 + ttable/r)kalt/kupper - 1]

Where:

talt = minimum insulation thickness of the alternate material (in.) (mm)

r = actual outside radius of pipe (in.) (mm)

ttable = insulation thickness listed in this table for applicable fluid temperature and pipesize

kalt = thermal conductivity of the alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft2·°F] [W (m·°C)]

kupper = the upper value of the thermal conductivity range listed in this table for the applicable fluid temperature [Btu·in/h·ft2·°F] [W (m·°C)]

For nonmetallic piping thicker than Schedule 80 and having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot (meter) than a steel pipe of the same size with the insulation thickness shown in the table.

**Exception:** Tubular pipe insulation shall not be required on the following:

1. ~~The tubing from the connection at the termination of the fixture supply piping to a plumbing fixture or plumbing appliance.~~ Factory-installed piping within water heaters and hot water storage tanks
2. Valves, pumps, and strainers ~~and threaded unions~~ in piping that is not more than 1 inch (25 mm) ~~or less~~ in nominal diameter. ~~Piping that conveys hot water that has not been heated through the use of fossil fuels or electricity~~
3. Piping that conveys hot water that has not been heated through the use of fossil fuels or electricity
4. Piping from user-controlled shower and bath mixing valves to the water outlets~~.~~ ~~For piping 1 in. (25 mm) or less, insulation is not required for valves or strainers.~~
5. Cold-water piping of a demand recirculation water system. ~~Piping in existing buildings where alterations are made to existing service water heating systems where there is insufficient space or access to meet the requirements.~~
6. Piping in existing buildings where alterations are made to existing service water heating systems where there is insufficient space or access to meet the requirements.
7. Piping at locations where a vertical support of the piping is installed.
8. Insulation is not required at the point where piping passes through a framing member if it requires increasing the size of the framing member.

~~Tubing from a hot drinking-water heating unit to the water outlet.~~

~~Piping surrounded by building insulation with a thermal resistance (R-value) of not less than R-3.~~

# Add new text as follows:

C404.4.1 Installation Requirements.

The following piping shall be insulated per the requirements of this section:

1. Recirculating system piping, including the supply and return piping.
2. The first 8 ft (2.4m) of outlet piping from:
   1. Storage *water heaters*
   2. Hot water storage tanks
   3. Any *water heater* and hot water supply boiler containing 10 or more gallons (37.9 L) of water heated by a direct heat source, an indirect heat source, or both a direct heat source and an indirect heat source.
3. The first 8 ft (2.4m) of branch piping connecting to recirculated, heat traced, or impedance heated piping.
4. The make-up water inlet piping between heat traps and the storage water heaters and the storage tanks they are serving,
5. Nonrecirculating service water heating storage-system.
6. Hot water piping between multiple water heaters, between multiple hot water storage tanks, and between water heaters and hot water storage tanks.
7. Piping that is externally heated (such as heat trace or impedance heating).
8. For direct-buried service water heating system piping, reduction of these thicknesses by 1.5 in (38.1 mm) shall be permitted (before thickness adjustment required in ~~Table~~ C404.4~~.~~1 ~~(footnote a)~~) but not to thicknesses less than 1 in (25.4 mm).

TABLE C404.4.1 MINIMUM PIPING INSULATION THICKNESS FOR SERVICE WATER HEAING SYSTEMSa

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Service Hot-Water Temperature Range** | **Insulation Thermal Conductivity** | | **Nominal Pipe or Tube Size, in.** | | | | | | | | | |
| **Conductivity, Btu in h ft2** ° | **Mean Rating Temperature, ⁰F** | **<1** | | **1 to <1- 1 2** | | **1-1 2 to**  **<4** | | **4 to**  **<8** | | **:> 8** | | |
| **Insulation Thickness, in.** | | | | | | | | | |
| 105°F to 140°F | 0.22 to 0.28 | 100 | 1.0 | 1.0 | | 1.5 | | 1.5 | | 1.5 | |
| >140°F to 200°F | 0.25 to 0.29 | 125 | 1.0 | 1.0 | | 2.0 | | 2.0 | | 2.0 | |
| >200°F | 0.27 to 0.30 | 150 | 1.5 | 1.5 | | 2.5 | | 3.0 | | 3.0 | |

1. These thicknesses are based on energy efficiency considerations only. Additional insulation may be necessary for safety.

# Reason Statement:

This proposal has been submitted to create a placeholder for the IECC to incorporate changes that are being considered for inclusion in the 2022 update to ASHRAE Standard 90.1.

The existing pipe insulation thickness requirements for service water heating piping come from Table C403.12.3, which was developed primarily for space heating. The major change in this proposal is to include a pipe insulation wall thickness table in the service water heating section of the IECC. Having a separate table will allow requirements for service water heating piping insulation to be based on typical service water heating operation and operating temperatures, which may be very different from those for mechanical systems.

# Cost Impact:

The code change proposal will neither increase nor decrease the cost of construction. The revisions proposed to this section will not change construction costs.

CEPI-130-21

CEPI-125-21

# IECC®: SECTION 202 (New), C404.11 (New), ANSI Chapter 06 (New)

**Proponents:**

Kimberly Cheslak, NBI, representing NBI (kim@newbuildings.org); Josh Keeling, representing Cadeo Group (jkeeling@cadeogroup.com); Ben Rabe, representing Fresh Energy (rabe@fresh-energy.org); Bryan Bomer, representing Department of Permitting Services (bryan.bomer@montgomerycountymd.gov); Lauren Urbanek, representing Natural Resources Defense Council (lurbanek@nrdc.org); Howard Wiig, representing Hawaii State Energy Office (howard.c.wiig@hawaii.gov); Kim Burke, representing Colorado Energy Office (kim.burke@state.co.us); Matt Tidwell, representing Portland General Electric (matthew.tidwell@pgn.com); Chris Castro, representing City of Orlando (chris.castro@orlando.gov); Brad Smith, representing City of Fort Collins (brsmith@fcgov.com); Amber Wood, representing ACEEE (awood@aceee.org)

**2021 International Energy Conservation Code**

# Add new definition as follows:

~~C202 GRID-INTEGRATED CONTROL.~~

~~An automatic control that can receive, automatically respond to demand response requests from and send information back to a utility, electrical system operator, or third-party demand response program provider.~~

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a demand response signal.

# Add new text as follows:

C404.11 ~~Grid-integrated~~ Demand responsive water heating.

Electric storage water heaters with a ~~storage tank capacity between 37 and 120 gallons~~ rated water storage volume of 40 gallons (150L) to 120 gallons (450L) and a nameplate input rating equal to or less than 12kW shall be provided with *~~grid-integrated~~ demand responsive controls* ~~that comply with ANSI/CTA-2045-B Level 2~~ in accordance with Table C404.11 or another equivalent *approved* standard.

**Exceptions:**

# Water heaters that provide a hot water delivery temperature of 180°F (82°C) or greater

1. ~~Water heaters serving health care occupancies.~~

# Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code

# Water heaters that use 3-phase electric power

**Table C404.11**

**Demand Responsive CONTROLS for Water Heating**

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Controls** | |
| Before 7/1/2025 | On or after 7/1/2025 |
| Electric Storage Water heaters | ANSI/CTA-2045-B Level 1 and also capable of initiating water heating to meet the temperature set point in response to a *demand response signal*. | ANSI/CTA-2045-B Level 2, except “Price Stream Communication” functionality as defined in the standard. |

# Add new standard(s) as follows:

# *Add new standard(s) as follows:*

|  |  |  |
| --- | --- | --- |
| **ASME** | ASME  Two Park Avenue  New York, NY 10016-5990  (800) 843-2763; <https://www.asme.org> |  |
| **CTA** | Consumer Technology Association  1919 S. Eads Street  Arlington, VA 22202 |  |
| Standard  reference  number | Title | Referenced  in code  section number |
| ANSI/CTA-2045-B | Modular Communications Interface for Energy Management . . . . . . . | . . . . . . . R403.5.4 |
| ASME BPVC | Boiler and Pressure Vessel Code | . . . . . . . R403.5.4 |

# Reason for revision

# This revision is the result of a collaboration/negotiation between AHRI and NBI. It makes a couple of key revisions:

# It replaces definitions for “grid integrated control” with “demand responsive control.” The market is moving to a more robust implementation of demand response, but has not yet settled on a terminology. This change utilizes a known term, “demand response,” until such time as the market settles on a new term that can be defined in code. These definitions are used in Title 24, which is leading the market for demand responsive control requirements.

# The range of storage tank sizes subject to the requirement been aligned with water heaters on which manufacturers are installing controls that comply with these requirements.

# The exception for health care facilities was removed since the relevant water heating loads in those settings is covered by the other exceptions.

# An effective date of 7/1/2025 has been added based on the availability of these controls on the market. Before that date, water heaters will be required to meet requirements that can be met by equipment on the market today. After that date, water heaters will be required to meet requirements that can be met by equipment that manufacturers have committed to having available on the market by that date.

# The proposal uses a table format as that is the precedent for having “on or after” requirements in the IECC. It also enables the addition of DR controls for additional water heating equipment types as they become sufficiently available to require in code.

# Reason Statement:

With increasing penetrations of intermittent renewable energy, volatile wholesale power prices, and subsequent growth in dynamic rates/demand response programs, grid-interactive end uses present an opportunity to help homes manage their bills, participate in programs, and support efficient grid operations. Water heaters can provide many services to the grid, including generation, transmission, and distribution capacity, energy arbitrage, and ancillary services. In their assessment of the National Potential for Load Flexibility, Brattle estimated that across all measures these services could provide as much as $15 billion per year in value to the electric system.

As electricity systems transform to include more variable wind and solar energy, demand flexibility becomes increasingly critical to both grid operation and further transformation. Building systems that can use energy when it is abundant, clean, and low-cost not only help decarbonize the entire energy system, they also insulate their owners from future increases in demand charges and peak hour energy rates - a current and accelerating trend. Water heaters offer an unparalleled opportunity for load shifting: tanks full of hot water are inherently energy storage devices. Including the controls necessary to take advantage of this opportunity is relatively simple and affordable in new construction. Compared to other energy storage technologies such as batteries, smart, grid-integrated water heater controls can deliver substantial dispatchable (that is, reliable to the grid operator) energy flexibility. The controls specified by ANSI/CTA-2045-B ensure negligible risk of occupant disruption (that is, the hot water will not run out). Water heaters provide a particularly attractive option as they have inherent thermal storage that allows energy consumption to be shifted with little to no impact to the end user. This capability has been demonstrated in several contexts, most recently through regional demonstrations conducted by EPRI and BPA.

In their Grid-interactive and Efficient Buildings (GEBs) Roadmap, the US Department of Energy estimates that approximately 15 GW of additional load flexibility is expected to be added to the system under reference case assumptions. Combined with energy efficiency, this is expected to provide $13 billion/year of peak demand savings to the power system and its customers. Through a comprehensive literature review and interviewing dozens of national experts, the USDOE team found that one of the biggest barriers was the lack of interoperability. A key tool to solve this problem is building codes, which can help to ensure that interoperable devices and controls are installed at the time of construction. USDOE cited explicitly the use of codes and standards as one of its recommended pathways to enable greater adoption of GEBs technologies.

It is important to include the requirement for two-way communication (specifically, communication from the behind-the-meter control module back to the utility, grid operator, or other third party entity) because this communication ensures that the controls capability can be fully deployed when needed. With legacy demand response systems, a signal is sent out but the ability to track and quantify the impacts of that signal is effectively nonexistent. This one-way communication paradigm is a key reason that the "firmness" or reliability of many flexibility-related demand side management strategies, particularly demand response, is often considered to be very low.

However, a two-way communication paradigm enables much more reliable impact tracking. Buildings whose controls include two-way communication capability, that is, those with grid-interactive controls as defined here, will be better able to participate in the demand response programs of the future, and their owners will have improved financial prospects through enhanced ability to participate in potentially lucrative utility demand response programs.

ANSI/CTA-2045-B standardizes the socket, and communications protocol, for electric water heaters so they can communicate with the grid, and with demand response signal providers. In addition, 2045-B adds control and communications requirements for mixing valves in water heaters, which enable them to provide greater storage capacity to support increased load shifting while eliminating scalding risk.

Versions of this standard are included in codes or other requirements in California, Oregon, and Washington and are referenced explicitly by ENERGY STAR.

# Bibliography:

Brattle, The National Potential for Load Flexibility (2019) https://brattlefiles.blob.core.windows.net/files/16639\_national\_potential\_for\_load\_flexibility\_-\_final.pdf

BPA, CTA-2045 Water Heater Demonstration Report (2018) https://[www.bpa.gov/EE/Technology/demand-](http://www.bpa.gov/EE/Technology/demand-) response/Documents/Demand%20Response%20-%20FINAL%20REPORT%20110918.pdf

EPRI, CEA-2045 Field Demonstrations Project Description (2014) https://[www.epri.com/research/products/000000003002004009](http://www.epri.com/research/products/000000003002004009)

USDOE, A National Roadmap for Grid-Interactive Efficient Buildings (2021) https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf

Washington State Revised Code of Washington, Title 19, Chapter 19.260, Section 19.260.080, available at https://app.leg.wa.gov/RCW/default.aspx?cite=19.260.080

Oregon Department of Energy, Energy Efficiency Standards Rulemaking https://[www.oregon.gov/energy/Get-Involved/Pages/EE-](http://www.oregon.gov/energy/Get-Involved/Pages/EE-) Standards-Rulemaking.aspx

U.S. EPA Energy Star Program, Connected Criteria for ENERGY STAR Products, https://[www.energystar.gov/products/spec/connected\_criteria\_energy\_star\_products\_pd](http://www.energystar.gov/products/spec/connected_criteria_energy_star_products_pd)

# Cost Impact:

The code change proposal will increase the cost of construction.

To enable grid-interactive controls, there are two sources of costs: the incremental cost to ensure that equipment is interoperable with CTA-2045-B and the cost of the control module installed in that device. The incremental manufacturing cost is in the range of a few dollars, and negligible at higher volumes. The current incremental cost to include a CTA-2045-B compliant control module ranges from about $60 (direct current, hard-wired connection) to $160 (alternating current, wireless cellular connection); this is expected to decline as manufacturing lines are brought up to larger scale (source: Advanced Water Heating Initiative). The major determinant of cost if the chosen radio pathway as chipset costs vary considerably between different frequencies/standards.

In the BPA report, manufacturers stated a range of $2-$30 for regional deployment, but noted that there would be economies of scale for a national rollout. The main cost was development of firmware/hardware to accommodate the standard, but these costs have

already been incurred to meet codes/standards in OR, WA, and CA. CEPI-125-21

CEPI-119-21

# IECC®: SECTION 202, SECTION 202 (New), C202, C403.8.1, TABLE C403.8.1(1), TABLE C403.8.1(1) (New), TABLE C403.8.1(2), TABLE C403.8.1(2) (New), TABLE C403.8.1(3) (New), C403.8.1.1 (New), C403.8.1.2 (New), C503.3, TABLE C503.3 (New), C503.3.1

**(New), AHRI Chapter 06 (New) Proponents:**

John Bade, representing California Investor Owned Utilities (johnbade@2050partners.com)

**2021 International Energy Conservation Code**

# Revise definitions as follows:

**C202 ENTHALPY RECOVERY RATIO (ERR).** Change in the enthalpy of the *outdoor air* supply divided by the difference between the *outdoor air* and entering exhaust air enthalpy, expressed as a percentage.

**C202 FAN SYSTEM ELECTRICAL INPUT POWER**. The sum of the fan electrical input power of all fans that are required to operate at *fan system design conditions* ~~to supply air~~ ~~from the heating or cooling source to the conditioned spaces and/or return it to the source or exhaust it to the outdoors~~.

**C202 FAN SYSTEM DESIGN CONDITIONS.** Operating conditions that can be expected to occur during normal system operation that result in the highest supply fan airflow rate of ~~to~~ ~~conditioned spaces served by~~ the *fan system* ~~system~~, other than during air economizer operation.

# Add new definitions as follows:

**C202 FAN ELECTRICAL INPUT POWER**. The electrical input power in kilowatts required to operate an individual fan or *fan array* at design conditions. It includes the power consumption of motor controllers, if present.

**C202 FAN NAMEPLATE ELECTRICAL INPUT POWER.** Is the nominal electrical input power rating stamped on a fan assembly nameplate.

**C202 FAN SYSTEM.** All the fans that contribute to the movement of air serving *spaces* that pass through a point of a common duct, plenum, or cabinet.

**C202 FAN SYSTEM, COMPLEX**. a *fan system* that combines a *single-cabinet fan system* with other supply fans, exhaust fans, or both.

**C202 FAN SYSTEM, EXHAUST/RELIEF**. A *fan system* dedicated to the removal of air from interior spaces to the outdoors.

**C202 FAN SYSTEM, RETURN**. A *fan system* dedicated to removing air from the interior where some or all the air is to be recirculated except during economizer operation.

**C202 FAN SYSTEM, SINGLE-CABINET**. A *fan system* where a single fan, single fan array, a single set of fans operating in parallel, or fans or fan arrays in series and embedded in the same cabinet that both supply air to a space and recirculate the air.

**C202 FAN SYSTEM, TRANSFER**. A *fan system* that exclusively moves air from one occupied space to another.

**C202 FAN SYSTEM AIRFLOW.** The sum of the airflow of all fans with *fan electrical input power* greater than 1 kW at *fan system design conditions*, excluding the airflow that passes through downstream fans with *fan electrical input power*~~less~~not greater than 1 kW.

# Delete and substitute as follows:

~~C403.8.1 Allowable fan horsepower~~.

~~Each HVAC system having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW) at fan system design conditions~~

~~shall not exceed the allowable~~ *~~fan system motor nameplate hp~~* ~~(Option 1) or~~ *~~fan system bhp~~* ~~(Option 2) shown in Table C403.8.1(1).~~ ~~This includes supply fans, exhaust fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or~~ ~~cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation.~~

# ~~Exceptions:~~

1. ~~Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.~~
2. ~~Individual exhaust fans with motor nameplate horsepower of 1 hp (0.746 kW) or less are exempt from the allowable fan horsepower requirement.~~

# Delete without substitution:

~~TABLE C403.8.1(1) FAN POWER LIMITATION~~

|  |  |  |  |
| --- | --- | --- | --- |
|  | **~~LIMIT~~** | **~~CONSTANT VOLUME~~** | **~~VARIABLE VOLUME~~** |
| ~~Option 1: Fan system motor nameplate hp~~ | ~~Allowable nameplate motor hp~~ | ~~hp :5 CFMS x 0.0011~~ | ~~hp :5 CFMS x 0.0015~~ |
| ~~Option 2: Fan system bhp~~ | ~~Allowable fan system bhp~~ | ~~bhp :5 CFMS x 0.00094 +~~  *~~A~~* | ~~bhp :5 CFMS x 0.0013 +~~  *~~A~~* |

~~For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.~~

~~where:~~

~~CFMS = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.~~

~~hp = The maximum combined motor nameplate horsepower.~~

~~bhp = The maximum combined fan brake horsepower.~~

*~~A~~* ~~= Sum of [~~*~~PD~~* ~~x CFMD~~ ~~/ 4131].~~

~~where:~~

*~~PD~~* ~~= Each applicable pressure drop adjustment from Table C403.8.1(2) in. w.c.~~

~~CFMD = The design airflow through each applicable device from Table C403.8.1(2) in cubic feet per minute.~~

~~TABLE C403.8.1(2) FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT~~

|  |  |
| --- | --- |
| **~~DEVICE~~** | **~~ADJUSTMENT~~** |
| **~~Credits~~** | |
| ~~Return air or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms~~ | ~~0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)~~ |
| ~~Return and exhaust airflow control devices~~ | ~~0.5 inch w.c.~~ |
| ~~Exhaust filters, scrubbers or other exhaust treatment~~ | ~~The pressure drop of device calculated at fan system design condition~~ |
| ~~Particulate filtration credit: MERV 9 thru 12~~ | ~~0.5 inch w.c.~~ |
| ~~Particulate filtration credit: MERV 13 thru 15~~ | ~~0.9 inch w.c.~~ |
| ~~Particulate filtration credit: MERV 16 and greater and electronically enhanced filters~~ | ~~Pressure drop calculated at 2 times the clean filter pressure drop at fan system design condition.~~ |
| ~~Carbon and other gas-phase air cleaners~~ | ~~Clean filter pressure drop at fan system design condition.~~ |
| ~~Biosafety cabinet~~ | ~~Pressure drop of device at fan system design condition.~~ |
| ~~Energy recovery device, other than coil runaround loop~~ | ~~For each airstream, (2.2 x energy recovery effectiveness - 0.5) inch w.c.~~ |
| ~~Coil runaround loop~~ | ~~0.6 inch w.c. for each airstream.~~ |
| ~~Evaporative humidifier/cooler in series with another cooling coil~~ | ~~Pressure drop of device at fan system design conditions.~~ |
| ~~Sound attenuation section (fans serving spaces with design background noise goals below NC35)~~ | ~~0.15 inch w.c.~~ |
| ~~Exhaust system serving fume hoods~~ | ~~0.35 inch w.c.~~ |
| ~~Laboratory and vivarium exhaust systems in high-rise buildings~~ | ~~0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.~~ |
| **~~Deductions~~** | |
| ~~Systems without central cooling device~~ | ~~- 0.6 inch w.c.~~ |
| ~~Systems without central heating~~ | ~~- 0.3 inch w.c.~~ |
| ~~Systems with central electric resistance heat~~ | ~~- 0.2 inch w.c.~~ |

~~For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm, 1 foot = 304.8 mm.~~

~~w.c. = Water Column, NC = Noise Criterion.~~

# Add new text as follows:

C403.8.1 Fan power.

For each *fan system* serving an occupied space or other *enclosed space* that includes at least one fan or *fan array* with *fan electrical input power* greater than 1 kW, *fan system electrical input power* determined per Section C403.8.1.2 at the *fan system design airflow* shall not exceed the limit as calculated per Section C403.8.1.1. This section does not apply to fans serving heat rejection equipment.

C403.8.1.1 Determining Fan Power Limit.

To determine the maximum *fan system electrical input power* allowed for a *fan system*, complete steps 1 through 5:

1. Determine the *fan system’s* classification. A *fan system* is considered to be multizone VAV if it meets the following requirements. *fan systems* that do not meet the requirements shall be classified as other fans:
2. The fan system must serve three or more HVAC zones and airflow to each must be individually controlled based on heating, cooling and/or ventilation requirements.
3. The sum of the minimum airflows for each HVAC zone must be not greater than 40~~%~~percent ~~or less~~ of the *fan system design conditions*.

**Exception to C403.8.1.1(1)**

Hospital, vivarium, and laboratory systems that use flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall use the multizone VAV fan power allowances.

1. Determine the *fan system airflow* and choose the appropriate table(s) for fan power allowance.
2. For *single-cabinet fan systems*, use the *fan system airflow* and the power allowances in both Table C403.8.1(1) and Table 1.1. C403.8.1(2).
3. For *supply-only fan systems*, use the *fan system airflow* and power allowances in Table C403.8.1(1).
4. For *relief fan systems*, use the design relief airflow and the power allowances in Table C403.8.1(2).
5. For exhaust, return and transfer *fan systems*, use the *fan system airflow* and the power allowances in Table C403.8.1(2).
6. For *complex fan systems* and DOAS with energy recovery *fan systems*, separately calculate the fan power allowance for the supply and return/exhaust systems and sum them. For the supply airflow, use supply airflow at the *fan system* design conditions, and the power allowances in Table C403.8.1(1). For the return /exhaust airflow, use return /exhaust airflow at the *fan system* *design conditions*, and the power allowances in Table C403.8.1(2).
7. For each *fan system* determine the components included in the *fan system* and sum the fan power allowances of those components. All *fan systems* shall include the System Base Allowance. If, for a given component, only a portion of the *fan system airflow* passes through the component, calculate the fan power allowance for that component per equation 4-9:

Where:

*FPAadj =* The corrected fan power allowance for the component in w/cfm

*Qcomp =* The airflow through component in cfm

*Qsys =* The *fan system airflow* in cfm

*FPAcomp =* The fan power allowance of the component from Table C403.8.1(1) or Table C403.8.1(2)

1. Multiply the *fan system* airflow by the sum of the fan power allowances for the *fan system*, then divide by 1000 to convert to kW.

Where:

*FPL is the fan power limit in kW*

*Qsys is the fan system airflow in cfm (L/s)*

*FPAsum is the sum of the fan power allowances for the system in W/cfm.*

*1000 is the conversion from W to kW*

1. For building sites at elevations greater than 3,000 ft (900m), multiply the fan power limit by the correction factor from Table C408.3.1(3).

Where:

FPLalt is the adjusted fan power limit in kW.

FPL is the fan power limit in kW calculated in step 4.

Calt is the altitude correction factor from Table C408.3.1(3)

C403.8.1.2 Determining *Fan System Electrical Input Power*

The *fan system electrical input power* is the sum of the *fan electrical input power* of each fan or *fan array* included in the *fan system* other than fans with *fan electrical input power* ≤ 1 *kW*. If variable speed drives are used their efficiency losses shall be included. *Fan system input power* shall be calculated with mid-life filter pressure drop, which is the mean of the clean filter pressure drop and design final filter pressure drop. The *fan electrical input power* for each fan or *fan array* shall be determined using one of the following methods. There is no requirement to use the same method for all fans in a *fan system*:

1. Use the default *fan electrical input power* in Table C408.3.1(4) for one or more of the fans. This method cannot be used for complex *fan system*s.
2. Use the *fan electrical input power* at *fan system design conditions* provided by the manufacturer of the fan, *fan array*, or *equipment* that includes the fan or *fan array*, calculated per a test procedure included in 10 CFR Part 430, 10 CFR Part 431, ANSI/AMCA Standard 210, ASHRAE 51 AHRI Standard 430, AHRI Standard 440, or ISO 5801.
3. Use the *fan electrical input power* provided by the manufacturer, calculated at *fan system design conditions* per one of the methods listed in section 5.3 of ANSI/AMCA 208.
4. Use the *fan nameplate electrical input power*.

TABLE C403.8.1(1)

SUPPLY FAN POWER ALLOWANCES (W/CFM)

|  | **Multi-Zone VAV *Fan System*1 Airflow (cfm)** | | | | **All Other *Fan Systems* Airflow (cfm)** | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Air *System* Component** | **<5,000** | **5,000 to <10,000** | **≥ 10,000** | **<5,000** | | **5,000 to <10,000** | **≥ 10,000** |
|  | **W/cfm** | | | | | | |
| Supply System Base Allowance for each *fan* *system* | 0.413 | 0.472 | 0.480 | 0.243 | | 0.267 | 0.248 |
| **Particle filtration (select all that apply)** | | | | | | | |
| Filter not higher than MERV 12 ~~or less~~ | 0.094 | 0.079 | 0.073 | 0.097 | | 0.084 | 0.075 |
| MERV 13 to MERV 16 Filter | 0.210 | 0.177 | 0.165 | 0.217 | | 0.185 | 0.168 |
| HEPA Filter | 0.347 | 0.292 | 0.277 | 0.357 | | 0.304 | 0.278 |
|  | | | | | | | |
| **Heating (select all that apply)** | | | | | | | |
| Hydronic heating coil (central) | 0.047 | 0.050 | 0.055 | 0.049 | | 0.053 | 0.057 |
| Electric heat | 0.047 | 0.040 | 0.037 | 0.049 | | 0.042 | 0.038 |
| Gas or oil furnace <90% Et or <90% AFUE | 0.071 | 0.060 | 0.073 | 0.061 | | 0.063 | 0.075 |
| Gas or oil furnace ≥90% Et or ≥90% AFUE | 0.117 | 0.099 | 0.092 | 0.122 | | 0.104 | 0.094 |
| **Cooling and dehumidification (select all that apply)** | | | | | | | |
| Hydronic/DX cooling coil, or heat pump coil (wet) [Healthcare facilities can select twice] | 0.141 | 0.118 | 0.110 | 0.146 | | 0.125 | 0.112 |
| *Fluid economizer* coil | 0.141 | 0.118 | 0.110 | 0.146 | | 0.125 | 0.112 |
| Desiccant *system* – solid or liquid | 0.164 | 0.138 | 0.128 | 0.170 | | 0.145 | 0.131 |
| Hot gas reheat coil | 0.047 | 0.040 | 0.037 | 0.049 | | 0.042 | 0.038 |
| *Series energy recovery* | 0.141 | 0.118 | 0.110 | 0.146 | | 0.125 | 0.112 |
| Evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed W/cfm per 1.0 in. wg. Determine pressure loss (in. wg) at the lesser of 400 fpm or maximum velocity allowed by the manufacturer~~, whichever is less,~~ [Calculation required, see note 2] | 0.233 | 0.196 | 0.184 | 0.241 | | 0.205 | 0.186 |
| **Energy recovery** | | | | | | | |
| Enthalpy Recovery Ratio ≥ 0.50 and <0.55) | 0.141 | 0.118 | 0.110 | 0.146 | | 0.125 | 0.112 |
| Enthalpy Recovery Ratio ≥ 0.55 and <0.60) | 0.166 | 0.140 | 0.130 | 0.172 | | 0.147 | 0.133 |
| Enthalpy Recovery Ratio ≥ 0.60 and <0.65) | 0.191 | 0.161 | 0.151 | 0.198 | | 0.169 | 0.153 |
| Enthalpy Recovery Ratio ≥ 0.65 and <0.70) | 0.217 | 0.182 | 0.171 | 0.224 | | 0.191 | 0.173 |
| Enthalpy Recovery Ratio ≥ 0.70 and <0.75) | 0.242 | 0.204 | 0.191 | 0.250 | | 0.213 | 0.193 |
| Enthalpy Recovery Ratio ≥ 0.75 and <0.80) | 0.267 | 0.225 | 0.212 | 0.276 | | 0.235 | 0.213 |
| Enthalpy Recovery Ratio ≥ 0.8) | 0.292 | 0.246 | 0.232 | 0.301 | | 0.257 | 0.234 |
| Run-around liquid or refrigerant coils | 0.141 | 0.118 | 0.110 | 0.146 | | 0.125 | 0.112 |
| **Gas-phase filtration** | | | | | | | |
| Gas phase filtration | 0.233 | 0.196 | 0.184 | 0.241 | | 0.205 | 0.186 |
| **Other** | | | | | | | |
| *Economizer* return damper | 0.049 | 0.042 | 0.038 | 0.049 | | 0.043 | 0.039 |
| 100% *Outdoor air* *system* meeting the requirements of Note 3. | 0.000 | 0.000 | 0.000 | 0.073 | | 0.104 | 0.112 |
| Low-turndown single-zone VAV *fan systems* meeting the requirements in note 4. | 0.000 | 0.000 | 0.000 | 0.073 | | 0.104 | 0.094 |
| Air blender | 0.047 | 0.040 | 0.037 | 0.049 | | 0.042 | 0.038 |
| Sound attenuation section [fans serving spaces with design background noise goals below NC35] | 0.035 | 0.030 | 0.027 | 0.036 | | 0.032 | 0.029 |
| Deduction for *system*s that feed a terminal unit or fan coil with a fan with electrical input power < 1*kW* | -0.500 | -0.500 | -0.500 | -0.100 | | -0.100 | -0.100 |
| 1. See section 6.5.3.1.1.1 (1) for requirements a for a Multizone VAV *System* | | | | | | | |
| 1. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table 6.5.3-1. | | | | | | | |
| 1. The 100~~%~~percent outdoor air *system* must serve 3 or more *HVAC zones*. | | | | | | | |
| 1. A low-turndown single-zone VAV *fan system* must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30~~%~~percent of the design wattage at that airflow. No more than 10 percent of the design load served by the *equipment* shall have fixed loads. | | | | | | | |
| 1. The deduction of 0.500 W/cfm is a default value for multizone VAV *fan system*s. If the terminal unit or fan coil manufacturer can demonstrate that the share of the unit's fan power required to move the *fan system*'s air is less than 0.500 W/cfm, that value may be used. The W/cfm shall be calculated by dividing the power required to operate the terminal unit’s fan at *fan system* design conditions by the airflow of the terminal unit at those conditions. | | | | | | | |

TABLE C403.8.1(2)

EXHAUST, RETURN, RELIEF, TRANSFER FAN SYSTEM POWER ALLOWANCES (W/CFM)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Multi-Zone VAV *Fan System*1 airflow (cfm)** | | | **All Other *Fan Systems* Airflow (cfm)** | | |
| **Air *System* Component** | **<5,000** | **5,000 to <10,000** | **≥ 10,000** | **<5,000** | **5,000 to <10,000** | **≥ 10,000** |
|  | W/cfm | | | | | |
| Exhaust, Return, Relief, and Transfer *System* Base Allowance for each *fan system* | 0.231 | 0.256 | 0.248 | 0.194 | 0.192 | 0.200 |
| **Particle filtration** | | | | | | |
| Filter (any MERV value)2 | 0.049 | 0.042 | 0.038 | 0.049 | 0.043 | 0.039 |
| **Energy recovery** | | | | | | |
| Enthalpy Recovery Ratio ≥ 0.50 and <0.55) | 0.146 | 0.125 | 0.112 | 0.146 | 0.128 | 0.114 |
| Enthalpy Recovery Ratio ≥ 0.55 and <0.60) | 0.173 | 0.148 | 0.133 | 0.173 | 0.150 | 0.135 |
| Enthalpy Recovery Ratio ≥ 0.60 and <0.65) | 0.199 | 0.170 | 0.153 | 0.199 | 0.173 | 0.155 |
| Enthalpy Recovery Ratio ≥ 0.65 and <0.70) | 0.225 | 0.192 | 0.173 | 0.226 | 0.196 | 0.176 |
| Enthalpy Recovery Ratio ≥ 0.70 and <0.75) | 0.250 | 0.214 | 0.193 | 0.252 | 0.218 | 0.196 |
| Enthalpy Recovery Ratio ≥ 0.75 and <0.80) | 0.276 | 0.236 | 0.213 | 0.277 | 0.240 | 0.216 |
| Enthalpy Recovery Ratio ≥ 0.8) | 0.302 | 0.258 | 0.234 | 0.303 | 0.263 | 0.236 |
| Run-around liquid or refrigerant coils | 0.146 | 0.125 | 0.112 | 0.146 | 0.128 | 0.114 |
| **Special exhaust and return *system* requirements (select all that apply)** | | | | | | |
| Return or exhaust *systems* required to be fully ducted by code or accreditation standards | 0.122 | 0.105 | 0.094 | 0.122 | 0.107 | 0.096 |
| Return and/or exhaust airflow control devices required by code or accreditation standards to maintain pressure relationships between *spaces* | 0.122 | 0.105 | 0.094 | 0.122 | 0.107 | 0.096 |
| Laboratory and vivarium exhaust *system*s in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed W/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet. [Calculation required, see note 3] | 0.061 | 0.053 | 0.047 | 0.061 | 0.054 | 0.048 |
| Exhaust system serving fume hoods | 0.085 | 0.074 | 0.066 | 0.085 | 0.075 | 0.067 |
| Biosafety cabinet. Value shown is allowed W/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3] | 0.241 | 0.206 | 0.186 | 0.242 | 0.210 | 0.188 |
| Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed W/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 3] | 0.241 | 0.206 | 0.186 | 0.242 | 0.210 | 0.188 |
| **Other** | | | | | | |
| Sound attenuation section (fans serving *spaces* with design background noise goals below NC35) | 0.036 | 0.032 | 0.029 | 0.036 | 0.032 | 0.029 |

1. See Section C408.3.1.1 for requirements for a Multi-Zone VAV System.

2. Particle filter pressure loss can only be counted once per *fan system*.

3. Power allowances require further calculation. Multiply the actual pressure drop of the device or component by the fan power allowance in Table C403.8.1(2)

TABLE C403.8.1(3): FAN POWER LIMIT ALTITUDE CORRECTION FACTOR

|  |  |
| --- | --- |
| Altitude (ft) | Correction factor |
| <3,000 | 1.000 |
| ≥3,000 and <4,000 | 0.896 |
| ≥4,000 and <5,000 | 0.864 |
| ≥5,000 and <6,000 | 0.832 |
| ≥6,000 | 0.801 |

TABLE C403.8.1(4)

DEFAULT VALUES FOR FAN ELECTRICAL INPUT POWER BASED ON MOTOR NAMEPLATE HP

|  |  |  |
| --- | --- | --- |
| *Motor Nameplate Horsepower* | Variable-Speed Drive (*kW*) | Without Variable-Speed Drive (*kW*) |
| <1 | 0.96 | 0.89 |
| >1 and ≤1.5 | 1.38 | 1.29 |
| >1.5 and ≤2 | 1.84 | 1.72 |
| >2 and ≤3 | 2.73 | 2.57 |
| >3 and ≤5 | 4.38 | 4.17 |
| >5 and ≤7.5 | 6.43 | 6.15 |
| >7.5 and ≤10 | 8.46 | 8.13 |
| >10 and ≤15 | 12.47 | 12.03 |
| >15 and ≤20 | 16.55 | 16.04 |
| >20 and ≤25 | 20.58 | 19.92 |
| >25 and ≤30 | 24.59 | 23.77 |
| >30 and ≤40 | 32.74 | 31.70 |
| >40 and ≤50 | 40.71 | 39.46 |
| >50 and ≤60 | 48.50 | 47.10 |
| >60 and ≤75 | 60.45 | 58.87 |
| >75 and ≤100 | 80.4 | 78.17 |
| 1. This table cannot be used for Motor Nameplate Horsepower values greater than 100. | | | | |
| 2. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used. | | | | |

# Add new text as follows:

C503.3 Heating and cooling systems.

New heating, cooling and duct systems that are part of the *alteration* shall comply with Sections C403 and C408.

# C503.3.1 Economizers.

New cooling systems that are part of *alteration* shall comply with [Section C403.5](https://codes.iccsafe.org/lookup/IECC2021P2_CE_Ch04_SecC403.5/2218).

# C503.3.2 Fan Power Limit

# If a new *fan system* is installed and the existing duct system is not replaced, a fan power allowance as shown in Table C503.3 shall be added to that allowed in Section C403.8.

TABLE C503.3

ADDITIONAL FAN POWER ALLOWANCES (W/CFM)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Multi-Zone VAV *Fan System*1 airflow (cfm)** | | | **All Other *Fan Systems* Airflow (cfm)** | | |
| **Air *System* Component** | **<5,000** | **5,000 to <10,000** | **≥ 10,000** | **<5,000** | **5,000 to <10,000** | **≥ 10,000** |
|  | W/cfm | | | | | |
| Supply f*an system* | 0.313 | 0.320 | 0.306 | 0.334 | 0.334 | 0.305 |
| Exhaust, return, relief, transfer *fan system* | 0.106 | 0.119 | 0.110 | 0.109 | 0.126 | 0.113 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 0.070 | 0.061 | 0.054 | 0.070 | 0.062 | 0.055 |
| 0.016 | 0.017 | 0.220 | 0.000 | 0.000 | 0.000 |

a. See definition of *FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV)*

unit with adapter curb

Exhaust/ Relief/ Return/ Transfer *Fan system*

Additional Allowance

Exhaust/ Relief/ Return/ Transfer *Fan system*

Additional Allowance with adapter curb

C503.3.1 Additional fan power allowances.

Additional Fan Power Allowances are available when determining the Fan Power Budget (Fan kWbudget) as specified in Table C503.4. These values can be added to the Fan Power Allowance values in Table C403.8.1(1) and Table C403.8.1(2) when calculating a new Fan kWbudget for the *fan system* being altered.

# Add new standard(s) as follows:

AHRI Air-Conditioning, Heating, & Refrigeration Institute 2111 Wilson Blvd, Suite 500 Arlington VA 22201

AHRI 1060-2018 Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment

AHRI Standard 430-2020 Performance Rating of Central Station Air-Handling Units

# Reason Statement:

The fan power limits were one of the most successful energy savings addenda in the IECC. However, they have not been updated in a decade. This proposal provides some increase in stringency, but more importantly, it addresses flaws in the original to improve both enforceability and clarity.

The improvements include:

The requirements are based on actual energy input rather than brake horsepower. Designs now get credit for using direct-drive transmissions vs. belt-drive.

The scope has been expanded to include fan systems down to 1 kW of input power from the previous lower threshold of 5 brake horsepower.

Fan systems to which the requirements apply have been clearly defined.

Fan system components that were not included previously have been added (e.g., hot gas reheat coils) Equipment that does not include mechanical heating or cooling have been brought into scope.

A similar proposal was approved by the California Energy Commission for Title 24-2022. The measure was reviewed with stakeholders in several meetings and went through three stages of public review. The Codes and Standards Enhancement Report that includes an in=depth discussion of the proposal and energy savings analysis is available at this

link: https://title24stakeholders.com/wp-content/uploads/2020/09/2022\_T24-Final-CASE-Report\_Air-Distribution.pdf.

This proposal is also soon to be voted on by SSPC 90.1. The draft of that addendum has been reviewed in two rounds of stakeholder meetings.

# Cost Impact:

The code change proposal will increase the cost of construction.

# Cost-effectiveness for Proposal 510 - Fan Power Limits

The proposed values reduce the allowed fan system electrical input power by about 10% on average, the amount varies by system. A large multi-zone VAV system will see a reduction of about 13% if it includes MERV-13 filters. On the other hand with the new credit for single-zone VAV systems that are configured to turn down to 50% of airflow, there is no increase in stringency at all.

There are many ways to improve a system to achieve the goal. Though the improvements here are based on the cost difference between a belt-drive centrifugal fan and a direct-drive plenum fan, there are many options to reduce pressure drop in the fan system that will yield the same results for less money. In fact, the California Title 24 cost-effectiveness was based entirely on improving the design of the duct system while leaving the current minimum-efficiency air handler systems unchanged. Some of the options for improving fan system performance include:

Reducing duct pressure drop through the selection of high-performance fittings.

Using angle filters in place of flat filters.

Locating equipment so that duct runs, and in particular vertical shafts, are straight.

Careful consideration of design and the placement of the first turn in the duct system after leaving the air handler (this is often the highest pressure drop in the system).

However, for the purpose of this exercise, the cost of a belt-driven centrifugal fan with a variable-frequency drive was compared to a direct-drive plenum fan. The reduction in transmission losses alone make up for most of the required improvement in electrical input power. The two systems were run in the prototype buildings used by ASHRAE 90.1 in all climate zones. The majority of fans in the prototype buildings that are large enough to meet the threshold of 1 kW of input power in the proposal are variable-speed fans.

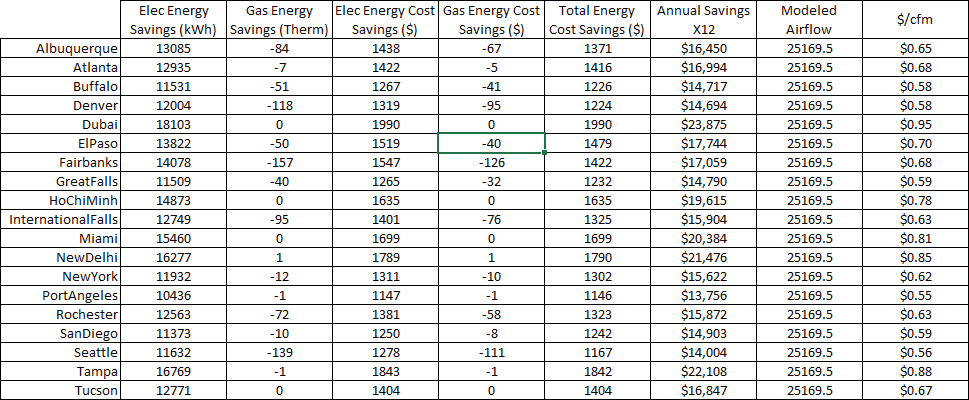
Manufacture cost data was used to compare the cost per design cfm of the two different fans at two different sizes:

3,000 cfm - $0.346 per cfm

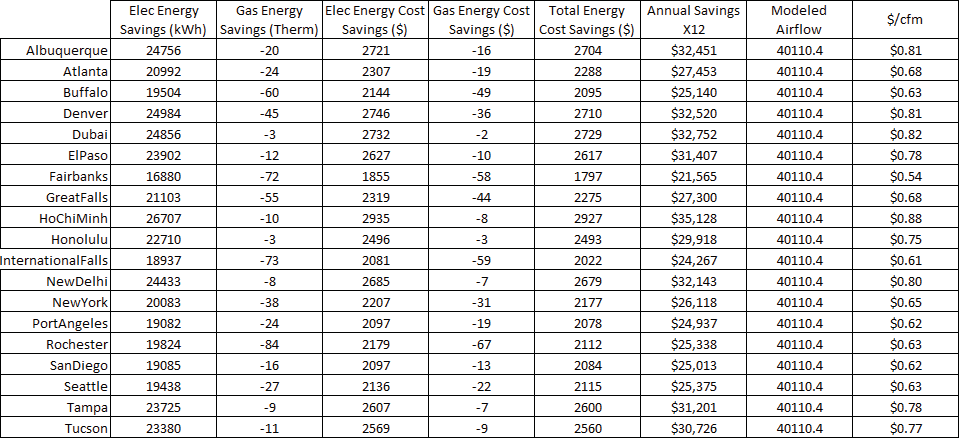
10,000 cfm - $0.192 per cfm

The following tables show the annual energy cost savings for various buildings. The savings vary by climate, with warmer and wetter climates generally showing higher savings. The annual savings were multiplied by 12, which is the ASHRAE scalar limit for equipment with a 15-year lifespan. In nearly all cases, the cost per cfm of an improved fan is less than the scalar limit.

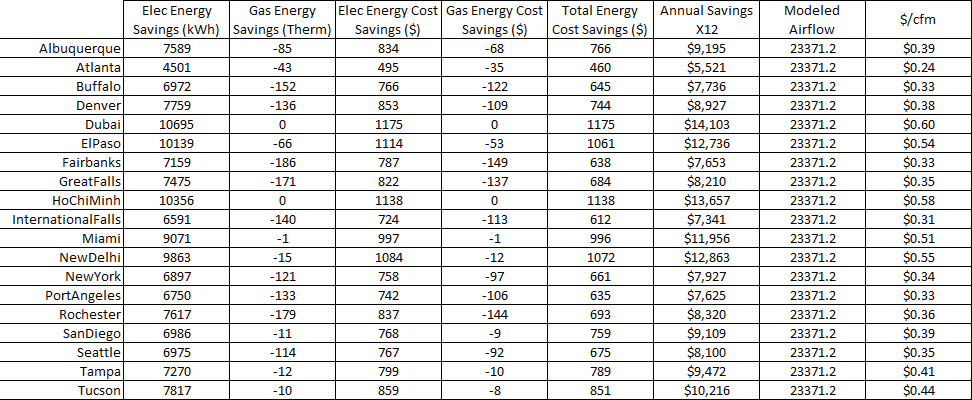
Primary school - these typically have fans that are about 3,000 cfm or a little more. In all cases, the savings are greater than the $0.346 additional cost:



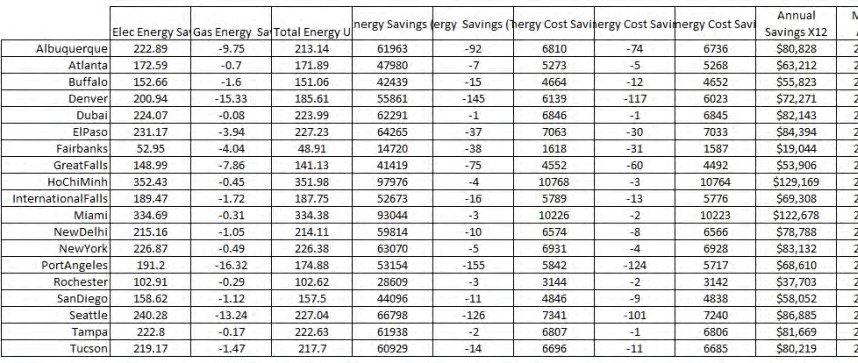
Large Hotel - These typically use large VAV fans. Again, in all cases, the additional cost of $0.192 per cfm is much less than the projected savings:



Standalone Retail - These prototypes use a mix of small and large fans. However, the 12-year savings are much higher than the per cfm cost of both sizes.



Large Office - These prototypes use large VAV fans. In this case, the additional cost of $0.192 per cfm meets the scalar for most climate zones. It does not meet the scalar for Climate Zone 8.



CEPI-119-21

CEPI-99-21

# IECC®: SECTION 202 (New), C403.4.1.6 (New)

**Proponents:**

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representing ACEEE (awood@aceee.org)

**2021 International Energy Conservation Code**

# Add new definition as follows:

~~C202 GRID-INTEGRATED CONTROL.~~

~~An automatic control that can receive, automatically respond to demand response requests from and send information back to a utility, electrical system operator, or third-party demand response program provider.~~

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a demand response signal.

# Add new text as follows:

# Add new text as follows: C403.4.1.6 Demand Responsive~~Grid-Integrated~~ Controls. All thermostatic controls shall be provided with demand responsive~~grid-integrated~~ controls capable of the following:

# Automatically increasing the zone operating cooling set point by a minimum of 4°F (2.2°C)

# Automatically decreasing the zone operating heating set point by a minimum of 4°F (2.2°C)

# Automatically decreasing the zone operating cooling set point by a minimum of 2°F (1.1°C)

# Automatically increasing the zone operation heating set point by a minimum of 2°F (1.1°C)

# ~~Both ramp-up and ramp-down logic to prevent the building peak demand from exceeding that expected without the DR implementation.~~

# ~~The thermostatic controls shall be capable of performing all other functions provided by the control when the grid- integrated controls are not available. Systems with direct digital control of individual zones reporting to a central control panel shall be capable of remotely complying.~~

Demand responsive controls shall comply with the following:

1. All demand responsive controls shall comply with no less than one of the following:
   1. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification, or
   2. Certified by the manufacturer as being capable of responding to a demand response signal from a certified OpenADR 2.0b Virtual End Node by automatically implementing the control functions requested by the Virtual End Node for the equipment it controls, or
   3. Comply with IEC 62726-10-1, an international standard for the open automated demand response system interface between the smart appliance, system, or energy management system and the controlling entity, such as a utility or service provider, or
   4. Comply with the communication protocol required by a controlling entity, such as a utility or service provider, to participate in an automated demand response program.
   5. Comply with the physical configuration and communication protocol required by CTA 2045-A.
2. All demand responsive controls shall be capable of communicating to the VEN using one or more of the following: Wi-Fi, ZigBee, BACnet, Ethernet, or hard-wiring any other bi-directional communication pathway.
3. When communications are disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control.

**Exception:** Health care and assisted living facilities.

**Add new standard(s) as follows:**

Chapter 6 Referenced Standards New

CTA

Consumer Technology Association Technology & Standards Department

1919 S Eads Street

Arlington, VA 22202

ANSI/CTA-2045-B – 2018: Modular Communications Interface for Energy Management

IEC

IEC Regional Centre for North America

446 Main Street 16th Floor

Worcester, MA 01608

IEC 62746-10-1 - 2018 Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response

OpenADR

OpenADR Alliance

111 Deerwood Road

Suite 200

San Ramon, CA 94583

OpenADR 2.0a and 2.0b – 2019: Profile Specification Distributed Energy Resources

# Reason for revision

# This revision is the result of a collaboration/negotiation between NBI, DOE, and AHRI. This proposal is being revised to align closely with REPI-70, which defines requirements for demand responsive thermostats in residential applications.

# It makes these key revisions:

# It replaces definitions for “grid integrated control” with “demand responsive control.” The market is moving to a more robust implementation of demand response, but has not yet settled on a terminology. This change utilizes a known term, “demand response,” until such time as the market settles on a new term that can be defined in code. These definitions are used in Title 24, which is leading the market for demand responsive control requirements.

# The requirement to include ramp-up and ramp-down logic to prevent building peak demand from exceeding that without the demand response implementation has been removed because currently available thermostats that are otherwise compliant with the requirements in this proposal generally do not include this capability and therefore including this requirement risks substantially increasing costs for compliance.

# It includes requirements that demand responsive controls shall comply with accepted industry-standard communications signals and protocols, including flexibility to allow controls to use one of several currently-available options. These requirements align with California’s Title 24 energy code as well as proposal REPI-70.

# Reason Statement:

Grid-integrated controls for thermostats are added based on language from California Title 24 and ASHRAE Standard 189.1. Any

thermostat listed as “Title 24 compliant” would meet this requirement. The controls allow for dialing back heating and cooling, as well

as to accept additional heating or cooling when renewable energy generation is high or energy prices are low, and both ramp up and

down requirements in relationship to the utility/grid operator/third party aggregator signal to prevent rebound issues on the grid after

the signal is released.

In health care and assisted living facilities, thermostat setpoints can impact more than just thermal comfort, and temperature can be

part of the health care being provided. To ensure that this requirement cannot have an adverse impact on those services, these

facilities have been exempted from this requirement.

HVAC system control, often through thermostats, has been at the center of demand response (DR) programs for decades. DR

programs continue to rely deeply on thermostat control strategies, but the need for such controls is fast growing. As electricity systems

transform to include more variable wind and solar energy, demand flexibility becomes increasingly critical to both grid operation and

further transformation. Building systems that can use energy when it is abundant, clean, and low-cost not only help decarbonize the

entire energy system, they also insulate their owners from future increases in demand charges and peak hour energy rates – a current

and accelerating trend.

Today’s demand response programs typically set event (call) durations between 15 minutes and 4 hours. The preconditioning

strategies (cooling set point reduction / heating set point increase) and temporary setback strategies (cooling set point increase /

heating set point reduction) will enable substantial HVAC system energy savings over this time frame. In many cases, in a building compliant with this code, tenants are unlikely to even notice a change in their thermal comfort. The inclusion of preconditioning helps

ensure that the building is able to reduce electrical demand by adjusting HVAC setpoints while minimizing the risk of tenant disruption:

in many cases the event will end before the higher cooling (or lower heating) set point is reached in the space.

Based on modeling by LBNL (foundational modeling supporting the May 2021 DOE Grid-integrated Efficient Buildings Roadmap),

thermostat controls configured to deliver preconditioning and/or space temperature adjustments can reduce building peak demand by

roughly 10% in many cases.

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**Cost Impact:**

The code change proposal will increase the cost of construction.

For larger commercial buildings with building management systems, it is not common to install a thermostat without demand response capabilities. Therefore, there is no incremental equipment cost associated with this measure for those building types. However, there could be soft costs to ensure those demand responsive controls function properly with the building management system. Conversations with industry experts indicate these soft costs can be around $0.25/s.f. for a medium office building. The primary cost drivers in thermostats are not the grid-integration controls but rather other features. Therefore, incremental costs vary. An entry-level grid-integrated thermostat currently available from a national retailer costs about $70, while the same retailer lists a similar non-grid- integrated programmable unit for just over $35, indicating an incremental cost of about $35. This cost has dropped in the last five years. A 2017 study out of Vermont cited incremental costs for smart thermostats in new construction at roughly $150 – a decrease in incremental costs of $115 over just 4 years.

However, smart thermostats (i.e., those with grid-integrated controls) are very common in new construction and represent a growing share of the retrofit market. All major smart thermostat brands already include grid-integration controls that comply with this requirement, so there is generally no incremental cost to include these controls assuming a smart thermostat is installed either based on customer preference or efficiency requirements.

Multifamily buildings and smaller commercial buildings that install direct-attached thermostats, demand responsive thermostats (which were estimated in a 2011 study to cost $68 more than a programmable thermostat) were found to be extremely cost effective. It was estimated that installing demand responsive thermostats in a 10,000 s.f. office building resulted in 83kWh to 274 kWh of electricity savings and between 0.19 to 1.97kW in demand savings in Climate Zones 2-4. Every dollar spent on demand responsive thermostats yielded between $1.20 to $7 in operating cost savings over a 15-year period for office buildings. In the 10 years since, equipment prices have decrease and incremental costs are estimated to be only $40 making this measure even more cost effective than estimated previously for buildings without building management systems. This measure will not only result in cost savings for consumers but will also result in other significant societal benefits. According to DOE’s report, “A National Roadmap for Grid-Interactive Efficient Buildings,” every watt in peak demand savings was found to create 17 cents in annual electric grid system value. This value included energy savings, capacity savings, transmission deferral and ancillary services. A 10,000 square foot office building with a demand responsive thermostat which is estimated to reduce peak demand savings between 0.26 to 1.09kW would result in $44 to $334 in annual electric grid system value. Demand responsive thermostats which allow grid operators to reduce demand on the grid during the times when the carbon intensity of the electric grid is high also results in reduced carbon emissions generating additional significant societal benefits.

CEPI-129-21

# IECC®: SECTION 202 (New), C404.2.1, C404.2.2 (New), C404.2.2.1 (New), C404.2.2.2 (New), C406.7.4

**Proponents:**

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**2021 International Energy Conservation Code**

# Add new definition as follows:

C202 MULTI-PASS. A heat pump water heater control strategy requiring multiple passes of water through the heat pump to reach the final target storage water temperature.

C202 PRIMARY SERVICE WATER HEATING EQUIPMENT. Service water heating equipment intended to supply the majority of the service water heating load.

C202 SINGLE-PASS. A heat pump water heater control strategy using variable flow or variable capacity to deliver water from the heat pump at the final target storage water temperature in a single pass through the heat exchanger with variable incoming water temperatures.

C202 SUPPLEMENTAL SERVICE WATER HEATING EQUIPMENT. Equipment intended to heat any service water heating load that is not successfully heated by the primary service water heating equipment.

C202 TEMPERATURE MAINTENANCE. The system used to maintain the temperature of the building domestic hot water delivery system, typically by circulation and reheating or by a heat trace system.

# Revise as follows:

C404.2.1 High input service water-heating systems for groups other than R-1 and R-2 occupancies.

Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water- heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, E*t*, of not less than 92 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input- capacity-weighted-average thermal efficiency, E*t*, shall be not less than 90 percent.

# Exceptions:

1. Where not less than 25 percent of the annual service water-heating requirement is provided by on-site renewable energy or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of service water-heating equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of service water-heating equipment for a building.

# Add new text as follows:

C404.2.2 Service water heating for Group R-1 and R-2 occupancies.

In buildings that include Group R-1 or R-2 occupancies, the *primary service water heating equipmen*t for the residential uses shall not use direct combustion fossil fuel or electric resistance heating. Not less than 80 percent of annual building service hot water output capacity shall be provided by air-source heat pump water heating systems. *Supplemental service water heating equipment* shall be permitted in accordance with Section C404.2.2.1.

**Exceptions:**

1. Systems supplying 80 percent of annual building service hot water output capacity using renewable energy generated on site or site recovered energy.
2. Systems supplying 80 percent of annual building service hot water output capacity using gas-fired absorption heat pumps (GAHP) with a COP greater than 1.0.
3. Solar thermal, wastewater heat recovery, other approved waste heat recovery, biomass, ground source heat pump, other water-source heat pump system utilizing waste heat, and combinations thereof, may be used to offset up to 100% of the required air source HPWH capacity where these systems comply with this code and with the International Plumbing Code.

C404.2.2.1 Supplemental service water heating equipment.

Total supplemental water heating equipment shall not have an output capacity greater than the *primary service water heating equipment* at 40°F(4.4QC) and shall not exceed the capacity restrictions below. Supplemental water heating is permitted for the following uses:

1. Temperature maintenance of heated-water circulation systems, physically separate from the primary service water heating equipment. Temperature maintenance capacity shall be no greater than the primary water heating capacity at 40°F and shall be installed per manufacturer's recommendations.
2. Heat tracing of piping for freeze protection or for temperature maintenance in lieu of recirculation of hot water.
3. Supplemental hot water heating where all of the following are true:
   1. The supplemental heating capacity is no greater than the primary service water heating capacity at 40°F (4.4QC).
   2. During normal operations the supplemental heating is controlled to operate only when the entering air temperature at the air-source heat pump is below 40°F (4.4QC), and the primary HPWH compressor continues to operate together with the supplemental heating when the entering air temperature is below 40°F (4.4QC) and within the manufacturer's acceptable temperature range.
   3. The primary water heating equipment cannot satisfy the system load due to equipment failure or entering air temperature below 40°F(4.4°C).
4. Supplemental heating downstream from a multi-pass heat pump water heater system, no greater than the nominal output capacity of the heat pump water heaters.
5. Electric resistance or condensing, gas-fired water heaters serving single zones with a combined capacity no greater than 12 kW or 35,000 Btu/h input capacity.
6. Defrost of compressor coils.

C404.2.2.2 Alarms.

The control system shall be capable of and configured to send automatic error alarms to building or maintenance personnel upon detection of equipment faults, low leaving water temperature from primary storage tanks, or low hot water supply delivery temperature to building distribution system.

# Revise as follows:

C406.7.4 High efficiency heat pump water heater.

Where electric resistance water heaters are allowed, all service hot water system heating requirements shall be met using heat pump technology with a combined input-capacity weighted-average EF 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.

# Reason Statement:

Requiring the use of heat pump water heaters will significantly reduce the amount of energy required for service water heating. Studies of real buildings utilizing current heat pump water heating technology have shown that heat pump water heaters can provide service water heating with efficiencies greater than 300%, which would cut energy usage down to less than 1/3 of the energy required by a gas-fired or electric resistance water heater. This technology is readily available and has been successfully applied across a wide range of R1 and R2 applications throughout the United States.

# Cost Impact:

The code change proposal will increase the cost of construction.

The service water heating equipment cost will increase, but substantial energy efficiency gains will result. Furthermore, if electric heat pump water heaters allow installers to forego the installation of gas infrastructure in a building, the money saved from gas infrastructure permit and installation will offset the increased cost of water heating equipment.

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CEPI-131-21

# IECC®: C404.6.1

**Proponents:**

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**2021 International Energy Conservation Code**

# Revise as follows:

C404.6.1 Circulation systems.

Heated-water circulation systems shall be provided with a circulation pump. ~~The pump shall have an electronically commutated motor with a means of adjusting motor speed for system balancing~~. Gravity and thermo-syphon circulation systems are prohibited. The system return pipe shall be a dedicated return pipe. ~~or a cold water supply pipe. Gravity and thermo-syphon circulation systems shall~~ ~~be prohibited. Controls for circulating hot water system pumps~~ Controls shall be configured to automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water. ~~The controls shall limit the~~ ~~temperature of the water entering the cold water piping to not greater than 104QF (40°C).~~ Where the circulation system serves multiple risers or piping zones, controls shall include self-actuating thermostatic balancing valves or another means of flow control to automatically balance the flow rate through each riser or piping zone. For single or multiple riser systems, controls shall be configured with a means to turn off the circulation pump during extended periods when hot water is not required.

# Reason Statement:

In service water heating systems, circulation pumps with electronically commutated motors (ECM) offer energy savings compared to circulation pumps with standard induction motors by providing the ability to balance system flow based on demand. The use of thermostatic balancing valves optimizes hot water flow to each zone in multiple zone or multiple riser systems. Both of these strategies reduce waste of heated water.

As a clarification, language regarding the use of a cold water supply pipe as the return has been removed. This language is covered under Section C404.6.1.1 for demand recirculation systems.

# Cost Impact:

The code change proposal will increase the cost of construction.

# Cost Increase Information

Cost comparison is between a circulation pump with a standard A/C induction motor and a circulation pump with an electronically commutated motor.

Circulation pump size used for cost analysis - 2.5 - 5 gpm at 15 ft/hd, 145 psi Installed cost for circulation pump with A/C induction motor - $750

Installed cost for circulation pump with ECM - $1,000

$250 incremental cost increase per pump based on manufacturer data from Bell and Gossett. Refer to manufacturer literature attached.

# Projected Energy Savings

Assumptions - 4,000 hrs/yr pump operation; Circulation pump w/ECM ~ 30% more efficient Circulation pump with standard motor - 70 watts

Circulation pump with ECM - 100 watts

30 watt savings x 4,000 hours/yr/1,000 = 120 kWh/yr

**2021 PUBLIC INPUT TO THE 2021 IECC, IRC CH. 11, AND ICCPC CH. 15 CE382**