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CA Utility CASE Team and Compliance Improvement Team Comments on 45-Day Express Terms MZ HP Baselines

Additional submitted attachment is included below.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Statewide CASE Team Comments on Multizone Heat Pump Baseline Requirements in 45-Day Express Terms

Docket Number 24-BSTD-01

May 7, 2024

Introduction

The California Statewide Utility Codes and Standards Enhancement (CASE) Team appreciates the opportunity to review the 2025 Building Energy Efficiency Standards, Title 24 Parts 1 and 6, Express Terms, 45-day Language (45-Day Express Terms). We commend the California Energy Commission (CEC) for encouraging public participation in the proceeding and value the opportunity to offer suggestions to refine the draft code language.

The CASE initiative presents recommendations in support of the CEC's efforts to update the Energy Code with new or updated requirements for various technologies. The three California Investor-Owned Utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison — and two Publicly Owned Utilities — Los Angeles Department of Water and Power and Sacramento Municipal Utility District— sponsored this effort. The program goal is to submit proposals that result in cost-effective enhancements to improve energy efficiency, energy performance, and GHG emissions reductions in California buildings.

The Statewide CASE Team strongly supports the CEC's strategy of using Title 24, Part 6 to encourage decarbonization of the built environment in California. At a high level, we support adding prescriptive requirements to Title 24, Part 6 that nonresidential multizone heating, ventilation, and air conditioning (HVAC) systems be served with heat pumps as proposed in Section 140.3(a)3. However, we do have some concerns about the requirements in the 45-Day Express Terms. Namely:

1. The proposed language in Section 140.4(a)3 excessively limits the prescriptive options available for multizone HVAC systems in offices and schools
2. Certain requirements such as dedicated controlled ventilation (DCV) and exhaust air heat recovery (EAHR) would add cost and complexity to the building automation system while providing minimal energy savings.

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3. Alternative options that are currently available through the performance approach are not accurate and do not provide sufficient design flexibility, so the compliance software should be enhanced to enable designers to use additional systems than those available in the prescriptive list.

We provide additional context for each issue in the following sections. In addition, we propose marked-up code language and a rationale for each mark-up that will address each issue.

Issue 1: Excessive Limits on Prescriptive Options

The proposed language excessively limits the prescriptive options available to the designer.

The Statewide CASE Team supports prescriptively requiring heat pumps for multizone systems. We strongly support converting the standard design for the entire HVAC system map in the ACM Reference Manual to be based on heat pumps.

The proposed prescriptive pathway for compliance presents a highly constrained set of options. Title 24 Part 6 has the "standard design" baseline with a chosen system for a certain building type, but prescriptively many more system types are allowed. As the proposed prescriptive requirements become more stringent the prescriptive pathway to compliance becomes more constrained.

Maintaining some degree of system flexibility is critical when enacting prescriptive multizone heat pump requirements. As buildings grow larger, the mechanical designer must choose from a larger variety of HVAC system choices. Fortunately, the market has rapidly matured with the growing demand for more electrification options. The amount of multizone heat pump system choices will grow steadily in the coming years. Limiting system choices[1] for the performance compliance path places more pressure on the compliance software to keep up with market innovation. We are concerned that in the short term an approach that is overly reliant on the performance approach to capture all the permutations of new heat pump systems could be a barrier to innovation.

In our view, a robust and flexible prescriptive code that appeals to designers while eliminating the ability to install gas equipment is the most compelling approach for Californians to achieve all-electric outcomes in nonresidential new construction. Thus, we recommend that CEC staff and their consultant evaluate additional heat pump-

[1] System choices not available with the proposed prescriptive compliance requirements: Airside DX VAV heat pumps, dual duct dual fan heat pumps, variable volume and temperature heat pumps, and ground source heat pumps.

based prescriptive pathways that provide cost effective operational energy cost and carbon performance.

Issue 2: Requirements for DCV and EAHR are Applied Too Broadly

Energy efficiency measures such as DCV and EAHR are required too broadly in situations where there are minimal benefits.

One issue with this measure is the requirement of "DCV in all zones" as proposed in Section 140.4(a)3Aiii. DCV should be required only in zones with peak occupancy rates that warrant the ability for the system to deliver air from large volumes to minimal volumes when the space is unoccupied. There is no benefit to requiring "DCV in all zones" in offices. Consider the values that are in Table 120.1-A– Minimum Ventilation Rates. For office spaces, the minimum occupant load density is 5 people per 1,000 sf (200 sf/person), the required minimum airflow per person is 15 cfm per person, and the area based minimum flowrate, Ra, is 0.15 cfm/sf. Even if the population density is doubled above the minimum to 10 people per 1,000 sf (100sf/person), ventilation required is 10 [people/1,000 sf] x 0.001 [1,000 sf/sf] x 15 [cfm/person] = 0.15 cfm/sf. As noted in Section 120.1(d)4E*: When the system is operating during hours of expected occupancy, the controls shall maintain system outdoor air ventilation rates no less than Ra × Az per Equation 120.1-F.* In this example the added DCV control would not save any energy during occupied periods because the area rate is equal to the design outdoor airflow rate with the space fully occupied. Reduction of people in the space has no impact on the required amount of outside air. After hours, the currently required occupied standby controls would turn the ventilation completely off. It is not clear how the DCV requirement saves energy in offices.

In Section 140.4(a)3Aiii (the mixed-air system with AWHP water loop), the following is specified regarding heat recovery: "All air systems shall be equipped with a heat recovery system in compliance with Section 140.4(q)." The requirements in Section 140.4(q) for heat recovery are contingent on minimum exhaust airflows that vary by climate zone and hours of operation and has a total of seven exceptions for different portions of this section. Is this reference intended to override the cost-effective threshold exhaust flowrates or the other exceptions? Calling out sections that are already required might give the impression that all other requirements of HVAC systems are waived. Overall, it is our view that other code development efforts that led to a given set of conditions for a technology (such as the airflow, climate zone, and percentage of outdoor air at design conditions components to the EAHR requirement) should be

respected and not overridden here. Adding them in inappropriate use cases causes an expensive addition to the HVAC system without providing sufficient energy efficiency benefit to offset the expense.

Issue 3: Compliance Software Does Not Offer Enough Design Alternatives

The design alternatives in the compliance software are limited and prevent a fully accurate comparison across system options.

The California Building Energy Code Compliance Software (CBECC) does not capture the full variability of HVAC system choices in the field. We also question the accuracy of modeling outputs for the capabilities that do exist in CBECC.

We urge CEC to commit to helping speed up additions of further high efficiency HVAC measures, including dual fan dual duct (DFDD), variable volume and temperature (VVT), mechanical HR options, and thermal energy storage options. We also recommend that CEC update the underlying HVAC performance maps for all system options collectively. A comprehensive update of all systems would help ensure that any future comparisons are being made with similar methods and consistent technical performance data generation approaches.

The value of energy modeling with a physics engine such as EnergyPlus is in determining how a set of HVAC system options compare thermodynamically. The current proposal leverages air source heat pumps (ASHP), but just focuses on the air-to-refrigerant (i.e., VRF) and air-to-water categories. Air-to-air heat pumps (AAHP) should perform roughly on par with the other types of ASHPs if installed in accordance with other mandatory and prescriptive sections of Title 24 Part 6. We do not see any inherent reason to restrict them relative to VRFs and AWHPs. If CBECC is not finding that AAHPs perform similarly to AWHPs and VRFs, then it is our position that the CBECC rulesets, objects, and performance data should be investigated and potentially updated.

Regarding our proposal to add an AAHP clause to the list of allowable system options, we are currently scoping a modeling effort that would use Title 24 CEC prototypes. In the meantime, we can share some external modeling data for systems modeled in EnergyPlus for a standard VAV + WCC + gas boiler system (essentially, System 6 in the ACM system map) as well as the DFDD heat pump system as a design option. The modeling outputs are shown in Table 1. We understand that this information is insufficient to justify a code requirement. We are showing it to point to the efficiency

potential of a DFDD system type. The key distinction between a DFDD and a single fan dual duct (SFDD) system is that in a DFDD system, the hot deck draws directly from the return air stream rather than from the mixed air plenum. The hot deck essentially has direct heat recovery which fully eliminates reheat. Ventilation is provided by the cold deck.

Table 1: Cost, Energy, and GHG Results from a Recent Comparative EnergyPlus Modeling Effort

Metric	**Units**	**SDVAV[a] Gas/Elec**	**DDVAV[b] Gas/Elec**	**DFDDHP[c] All Elec**
Cost	$/yr	$612,122	$589,590	$603,337
Site Energy	Mbtu/yr	13,457	11,847	9,070
Source Energy	Mbtu/yr	14,401	12,708	9,841
Site GHG Emissions	Lb/CO2/yr	1,696,342	1,411,956	665

a Single Duct Variable Air Volume
b Dual Duct Variable Air Volume
c Dual Fan Dual Duct Heat Pump

(Source: Taylor Engineers, used by permission)

This table shows a clear reduction in cost, site, and source energy. As noted above, additional work into an updated analysis generating hourly results that could be converted to LSC is underway.

Marked-up Code Language

For the marked-up language, revisions to the 2022 code language that appear in the 45-Day Express Terms are delineated with additions in black underlining and deletions in black ~~strikeouts~~. Our proposed revisions to the 45-Day Express Terms are delineated with additions in red underlining and deletions in red ~~strikeouts.~~

Recommended Changes to Section 140.4(a)3

3. Multizone zone space-conditioning system types. Multizone space conditioning systems in office buildings and school buildings not covered by Section 140.4(a)2 shall meet the following requirements.:

A. ~~Offices.~~ Schools and o~~O~~ffice buildings shall use space conditioning systems complying with one of the following requirements:

i. The space conditioning system shall be a variable refrigerant flow (VRF) heat pump system with a dedicated outdoor air system (DOAS) providing ventilation. Indoor fans shall meet the requirements of Section 140.4(a)3~~D~~Bii. The DOAS shall comply with Section 140.4(a)3~~E~~Biii; or.

ii. The space conditioning system shall be a four-pipe fan coil (FPFC) system with a DOAS providing ventilation. The FPFC hot water coils shall be supplied by an air-to-water heat pump (AWHP) space-heating hot water loop which complies with Section 140.4(a)3~~C~~Bi. The DOAS shall comply with Section 140.4(a)3~~E~~Biii; or.

iii. The space conditioning system shall utilize heating supplied through a hot water loop served by an AWHP which complies with Section 140.4(a)3~~C~~Bi. Ventilation systems shall include DCV in ~~all~~ zones where required by Section 120.1(d)3. All air systems shall be equipped with a heat recovery system ~~in compliance with~~ when required in Section 140.4(q). ~~A hydronic recirculated-air heating system complying with Section 140.4(a)3F shall be used in climate zone 16.~~; or.

iv. The space conditioning system shall utilize heating from air-to-air heat pumps meeting requirements of Table 110.2-B and serving variable volume and temperature (VVT) zones or the heating side of a dual fan dual duct system.

~~B. School buildings. The space conditioning system shall be four-pipe fan coil (FPFC) terminal units with a DOAS providing ventilation. The FPFC hot water coils shall be supplied by an air-to-water heat pump (AWHP) space heating hot water loop which complies with Section 140.4(a)3C. The DOAS shall comply with Section 140.4(a)3E.~~

B. The space conditioning systems used to comply with 140.4(a)3A shall include the following characteristics:

~~C.~~ i. AWHP space-heating hot water loop. Air-source heat pumps used for space-heating hot water shall have a rated heating COP ~~of not less than 3.29 when the outdoor air temperature is 47°F dry-bulb and 43°F wet-bulb at a leaving water temperature not less than the design supply water temperature of the hot water loop~~ that meets the requirements of Table 110.2-N. ~~If chilled water produced by an AWHP is used for space-cooling it shall only be used when the AWHP is simultaneously supplying space-~~

~~heating hot water equal to the AWHP's space-heating hot water demand.~~ If simultaneous cooling and heating loads are present and Section 140.4(s) is triggered, the AWHP cooling waste heat shall be used to supply the hot water loop. The loop fluid volume shall not be less than 8 gallons per nominal ton of heating capacity of the loop. Supplemental heating shall be an electric resistance boiler with a capacity ~~of not greater than 50% of the design hot water loop heating capacity~~ that complies with Section 140.4(g). The electric resistance boiler will be controlled so that it is operated only when the AWHP system alone is not able to satisfy the building heating loads.

~~D.~~ ii. VRF indoor fans. If VRF is used, its indoor fans shall have an energy consumption at design airflow of not greater than 0.35 W/cfm, shall have not less than three speeds, and shall turn off when there is no demand for heating or cooling in the space.

~~E.~~ iii. DOAS. If DOAS is used, it shall comply with Section 140.4(p), shall be equipped with a heat recovery system in compliance with Section 140.4(q), and shall have a maximum fan energy consumption at design airflow of 0.77 W/cfm. ~~If heating coils on the DOAS are included, they shall be hydronic heating coils utilizing the AWHP space-heating hot water loop. If cooling coils are included on the DOAS, they shall be hydronic cooling coils utilizing space-cooling chilled water.~~

~~EXCEPTION to Section 140.4(a)3E: If an AWHP space-heating hot water loop is not included in the design, or space-cooling chilled water is not included in the design, DOAS heating and cooling shall be supplied by heat pump coils.~~

Rationale for Recommended Changes

- Combine the school and office lists: Prescriptively allowing schools to choose only four-pipe fan coil systems is extremely limiting for designers. Other heat pump options, including VRFs, should be available to designers of large schools. Of course, this does not preclude associating the standard design for the particular building types with whatever HVAC system choices that CEC's market and efficiency research has deemed appropriate, whether that be four pipe fan coils, VRFs, or otherwise.
- Add another option at 140.4(a)3iv to allow air-to-air heat pumps: Only allowing AWHPs in mixed air systems is highly limiting and prevents innovative large

multizone DX heat pump system options from entering the California market at scale.

- Place specific HVAC system attributes and requirements in their own subsection: The proposal in the 45-day language begins with a list of building types (i.e., A – offices, B – schools) and then transitions to a list of system attributes and requirements (e.g., C – AWHP requirements, D – indoor fan requirements) in the same list. This may result in confusion. Our recommendation is to instead group allowable system types together in a list and then specific system requirements in a separate list.
- Change DCV and EAHR clauses to point to appropriate code sections: It is counterproductive to always require DCV in all zones and EAHR in all systems. Prior to being added to Title 24 Part 6, these technologies were analyzed in-depth, and the resulting code requirements were crafted so that they are only required when the amount of energy savings is meaningful enough to justify their additional costs and complexity.
- Delete hydronic recirculating statement from 140.4(a)3iii due to invalid reference to 140.4(a)3F: As written, there is no 140.4(a)3F, so this sentence should be deleted. If CEC intends to add this requirement for CZ16, then perhaps a similar statement could return.
- Convert AWHP 3.29 COP requirement to a reference to Table 110.2-N: Our interpretation of this requirement as well as the current state of the market is that this requirement would effectively limit hot water supply temperatures to 105 °F, give or take. AWHP technology is not currently capable of achieving COPs at this level at HWSTs in the 120-130 °F range. This requirement would be incredibly restrictive on hydronic designs. Instead of this, we recommend a reference to the COP efficiency requirements in Table 110.2-N, which is based on ASHRAE 90.1 and forms the basis of manufacturer design considerations.
- Reword simultaneous cooling and heating clause: As written, this clause appears to only allow AWHPs to provide cooling if there is also a heating load present. We appreciate the intent behind requiring simultaneous mechanical heat recovery when available based on the CASE analysis that led to 140.4(s), and hopefully the reworded statement will be clearer for designers.
- Refer to 140.4(g) to ensure electric resistance boiler is sized correctly: As written, the proposal does not comply with 140.4(g). In addition, there is no requirement that the electric resistance boiler serve as a second stage or backup unit, and if poorly controlled, then buildings may experience long runtime hours from the

electric resistance boilers which defeats the purpose of having a heat pump baseline.

- Delete hydronic coil requirement for DOAS if the building has an AWHP: It is unclear how this requirement would improve the energy efficiency of the building. If the DOAS unit requires its own active mechanical conditioning, there are many situations when it is more appropriate for the designer to use a DX DOAS instead of one served by hydronic coils. If the AWHP/chiller is physically far from the DOAS unit, then pumping and thermal energy losses will occur.

Other Changes to Consider

- Loop storage volume per nominal heating ton: We think 8 gallons/ton is excessive in most cases. It is our understanding that this statement is informed by designer interviews and is included to limit AWHP short cycling, which is an important consideration. However, our recommendation would be to advise designers to follow manufacturer guidance or lower the limit to 6 gallons/ton, since the requirement may simply result in larger buffer tanks while providing limited benefits.
- Encouraging designers to use zone cooling systems will reduce indoor air quality: In Title 24-2019, CEC introduced the requirement that all recirculated air pass through a filter with a MERV rating of not less than 13. The wisdom of this decision became clear during the pandemic, and ASHRAE now recommends MERV-13 filtration as the most energy-efficient way to reduce occupants' exposure to airborne viruses.[2]

  However, as stated at Section 120.1(c)1A, fan coils that are non-ducted or have a duct length of less than ten feet are exempt because they cannot support MERV-13 filtration in many cases. Since the proposed language requires fan coils or a VRF system, occupants may be exposed to more infectious aerosols than with a central system. Further, designers who want to maintain a high level of filtration will need to add separate air-cleaning devices, which would increase energy consumption significantly.

  Occupants will also forego the health benefits of airside economizing. While economizing provides easily measurable energy savings, its health benefits are often ignored. Economizing has similar health benefits to opening all the windows on a nice day. California's climate allows thousands of hours of economizer

[2] ASHRAE Positions on Infectious Aerosols
https://www.ashrae.org/file%20library/about/position%20documents/pd_-infectious-aerosols-2022.pdf

operation. Discouraging using systems that employ airside economizing will deprive Californians of the health benefits they would have otherwise received.

- We encourage CEC to consider whether the requirement to shut off zone fans during periods of no heating or cooling is justified: The proposed language requires that VRF fans "…shall turn off when there is no demand for heating or cooling in the space." This leaves the designer with two options to supply outdoor air:
    - Provide a diffuser separate from the indoor unit, or
    - Increase the fan power of the DOAS to overcome the resistance from the stopped fans.

  The first option is the most energy efficient, but industry experts say it would likely result in poor mixing of the outdoor air.[3] The second option was studied in a Code Readiness report that concluded there are not enough energy savings to justify changing Exception 3 to Section 140.4(p)2, which allows outdoor air to be supplied through fan coils if "downstream fan power is no greater than 0.12 watts per cfm when space temperatures are within the thermostat deadband."[4]

  While we do not take a position on this, we are aware that the industry favors supplying outdoor air through fan coils and wonder if there is value in adding this requirement for VRF fans. In addition, we note that the requirement does not apply to other types of fan coils and ask CEC to consider whether it should.

Conclusion

The Statewide CASE Team would like to reiterate our overall support of CEC's endeavor to prescriptively require heat pumps for multizone HVAC systems. We hope that CEC carefully considers these comments and recommended markups to 140.4(a)3 as we believe these changes improve flexibility and the palatability of the new heat pump requirements for designers and manufacturers. These changes preserve the intent of requiring efficient heat pump-based heating in multizone applications while broadening the flexibility of the prescriptive language.

[3] Personal communication with Gus Faris and Daniel Int-Hout of Nailor Industries, Inc., June 2023

[4] Code Readiness Report: Evaluation of Dedicated Outdoor Air System and Variable Refrigerant Flow System Controls at Nonresidential Field Sites https://www.etcc-ca.com/reports/code-readiness-report-evaluation-dedicated-outdoor-air-system-and-variable-refrigerant-flow