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Document Title:	Staff Memo – Revisions to 2025 Energy Code, Section 1404(a)3 - Variable Air Volume with AWHP and Parallel Fan-Powered Boxes
Description:	This is a staff memo to justify the proposed revision to Section 140.4(a)3 of the 2025 Energy Code, on multi-zone space conditioning system types, specifically for parallel fan power box systems, to support the August 2024 15-day language.
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CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

MEMORANDUM

TO: 2025 BUILDING ENERGY EFFICIENCY STANDARDS DOCKET (24-BTSD-01)

FROM: CALIFORNIA ENERGY COMMISSION (CEC)

SUBJECT: Justification for CEC-proposed Revisions to 2025 Energy Code, Section 140.4(a)3Aiii on Multi-zone Space-conditioning System Types to Support the August 15-day Comment Period – Variable Air Volume with Air-to-Water Heat Pump and Parallel Fan-Powered Boxes

DATE: AUGUST 22, 2024

INTRODUCTION

The June 2024 Express Terms for the 2025 Building Energy Efficiency Standards (Energy Code) included proposed prescriptive requirements and options for multi-zone space-conditioning system types in Section 140.4(a)3. As proposed, Section 140.4(a)3Aiii allowed for prescriptive compliance using any HVAC air distribution system used in conjunction with an air-to-water heat pump (AWHP) space-heating loop. This system would be used to comply together with additional energy efficiency measures specified in the subsection. The intent of this proposal was to allow Variable Air Volume (VAV) reheat systems to be used in combination with an AWHP.

Based on stakeholder feedback received during the June 15 day comment period, Section 140.4(a)3Aiii was reevaluated to determine if more flexibility could be provided in the proposed prescriptive regulations. In addition, stakeholders expressed concern that the Section 140.4(a)3Aii specified system, a four-pipe fan coil (FPFC) system with an AWHP and dedicated outside-air system (DOAS), would be very efficient in terms of California's Long-term System Cost (LSC) and Source Energy compliance metrics. The concern expressed was that using the FPFC+AWHP+DOAS system as the standard design in the performance approach would set the energy budget at a level that would be difficult to meet by other heat pump systems.

This memo describes the analysis performed in evaluating other VAV+AWHP system configurations which provide the basis for the proposed revised code language in Section 140.4(a)3Aiii and for changing the 2025 standard design from a FPFC+AWHP+DOAS system to a VAV+AWHP, Parallel Fan-Powered Boxes (PFPB) system. PFPBs are a type of VAV unit that use a fan to pull warm air from the ceiling plenum and recirculates air to deliver heating more efficiently.

DISCUSSION

To address stakeholder feedback, the CEC explored other standard design HVAC system options that are more efficient than the 2022 Energy Code standard design ('2022 standard design') but less

efficient than the FPFC+AWHP+DOAS option, Section 140.4(a)3Aii. The goal was to achieve LSC savings compared to the baseline 2022 standard design, a VAV system with chiller and natural gas boiler with reheat. The Large Office and Large School prototypes were used to analyze these system options with a VAV+AWHP, PFPB system. This analysis compared the VAV+AWHP, PFPB system configurations to a VAV system with chiller and natural gas boiler with reheat. That same VAV+AWHP, PFPB system would result in more LSC savings when compared with the Package VAV with reheat system (includes gas furnace heating and direct expansion cooling). This Package VAV system is the 2022 standard design that could also apply for multi-zone HVAC systems used for the Medium Office and School prototypes. Therefore, the analysis performed for Large Offices and Schools is a conservative approach to determine savings for the Medium Office and School prototypes.

Revised VAV+AWHP, PFPB Measures

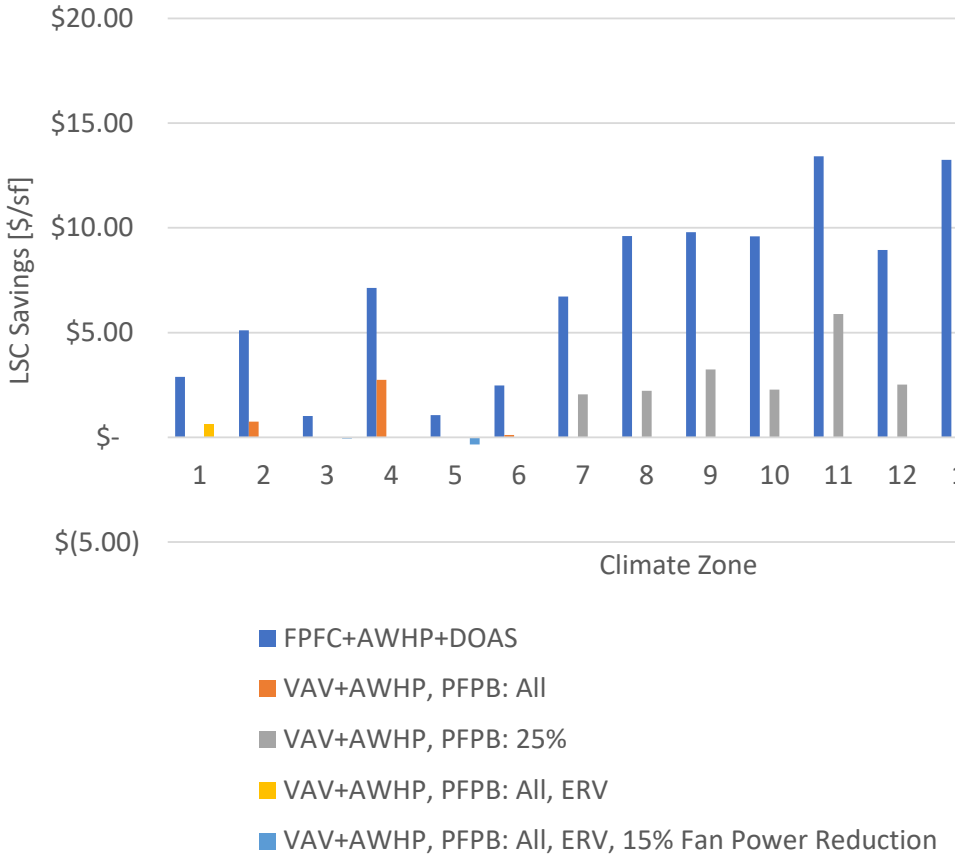
LARGE OFFICE

The following measures combined with a VAV+AWHP, PFPB system for the Large Office prototype were determined to achieve LSC savings compared to the 2022 standard design system:

- Parallel fan powered boxes (PFPB) on all perimeter zones in climate zones 1 through 6, and 16, and on 25% of the perimeter heating capacity in climate zones 7 through 15.
- Heat recovery in combination with the VAV in compliance with Section 140.4(q) in climate zones 1, 3, and 5.
- Reduced central air handling unit (AHU) fan power specified in Section 140.4(c)1 by 15% in climate zones 3 and 5.

Figure 1 presents the Large Office LSC savings results of the revised VAV+AWHP, PFPB system compared to the 2022 standard design. Requiring PFPBs on all orientations was necessary to achieve enough LSC savings for climate zones 1 through 6 and 16. Additional measures, detailed above, were needed for climate zones 1, 3, and 5. Climate zone 16 with 25% PFPBs for only 25% of perimeter zone heat capacity achieved LSC savings but resulted in a high number of hours where the thermostat setpoint could not be maintained. Requiring PFPBs for all orientations in climate zone 16, reduced the number of hours where the thermostat setpoint could not be maintained to a reasonable level. Requiring PFPBs on all orientations for climate zones 7 through 15 was determined to not be needed to achieve LSC savings. So, requiring PFPBs for only 25% of perimeter zone heat capacity was deemed sufficient for these climate zones. These system configurations for the revised VAV+AWHP, PFPB system are being proposed instead of the FPFC+AWHP+DOAS system to establish the 2025 Energy Code standard design. It is anticipated that this standard design will offer more flexibility and provide a more achievable energy budget for other HVAC designs that leverage heat pumps, including those that could be prescriptively allowed through the Executive Director approval path as provided in Section 140.4(a)3Av of the August 2024 Express Terms.

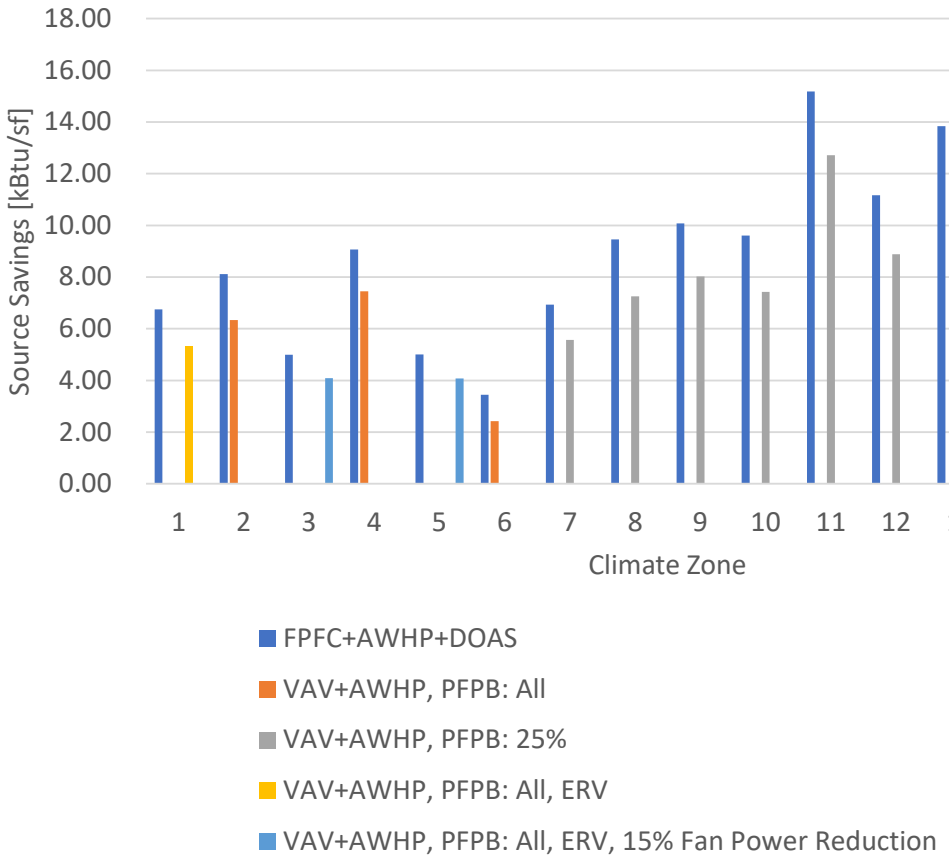
Figure 1: Large Office LSC Savings for the Revised VAV+AWHP, PFPB compared to the 2022 Standard Design



Note: Only bars for the set of measures deemed appropriate as the prescriptive requirement for the climate zone are shown

Figure 2 presents the Large Office Source Energy savings results of the revised VAV+AWHP, PFPB system compared to the 2022 standard design. This figure shows that although the LSC savings are reduced with the revised VAV+AWHP, PFPB, there remain Source Energy savings compared to the 2022 standard design.

Figure 2: Large Office Source Energy Savings for the Revised VAV+AWHP, PFPB compared to the 2022 Standard Design



Note: Only bars for the set of measures deemed appropriate as the prescriptive requirement for the climate zone are shown

LARGE SCHOOL

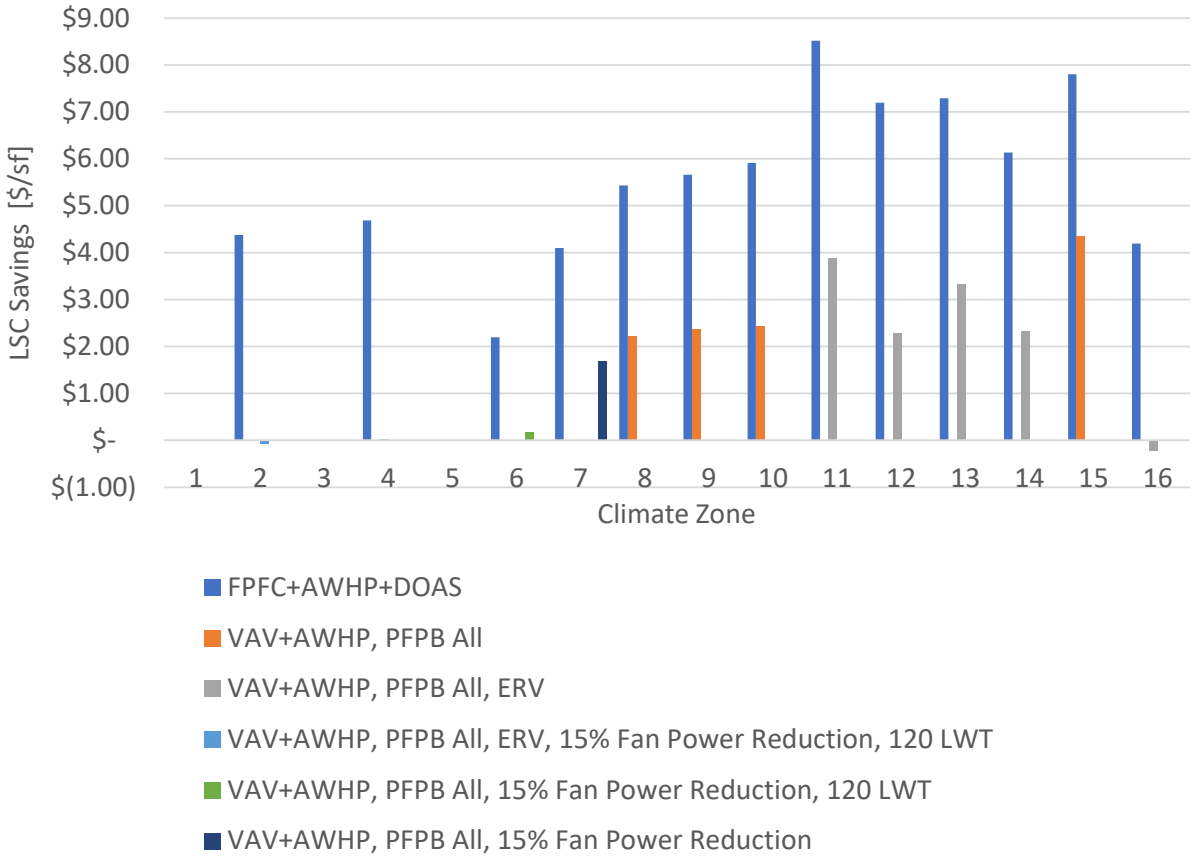
When a VAV+AWHP is combined with additional measures the Large School prototype achieves sufficient LSC savings when compared to the 2022 standard design, except for climate zones 1, 3 and 5. For climate zones 2, 4, and 6 through 16, the following cumulative measures are required to be combined with a VAV+AWHP, PFPB system to achieve sufficient LSC savings:

- Parallel fan powered boxes (PFPB) on all perimeter zones.
- Additionally, heat recovery in combination with the VAV in climate zones 2, 4, and 11 through 16.
- Additionally, reduced central AHU fan power by 15% in climate zones 2.
- Additionally, reduced maximum design leaving water temperature of the heating loop to 120°F in climate zones 2.

Figure 3 presents the Large School LSC savings results of the revised VAV+AWHP, PFPB system compared to the 2022 standard design. Because there are no solutions that achieve LSC savings in climate zones 1, 3, and 5, no results are shown in Figure 3 for those climate zones. Combined with the measures described, the revised VAV+AWHP, PFPB system achieved approximately the same LSC savings in climate zones 2, 4, and 11 through 16. Climate zones 6 through 10 had LSC savings

but less than the FPFC+AWHP+DOAS system. Like the Large Office, these system configurations for the Large School prototype are anticipated to provide more flexibility and provide a more achievable energy budget for other HVAC designs that leverage heat pumps, including those that could be prescriptively allowed through the Executive Director approval path as provided in Section 140.4(a)3Av of the August 2024 Express Terms.

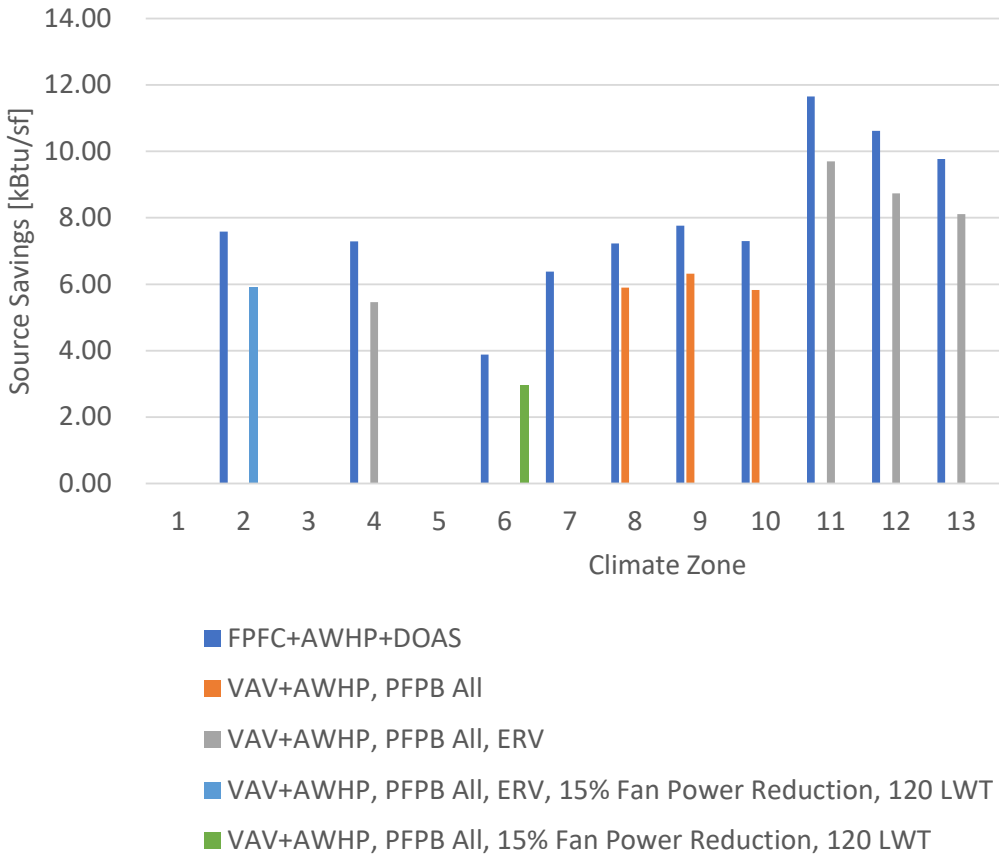
Figure 3: Large School LSC Savings for the Revised VAV+AWHP, PFPB compared to the 2022 Standard Design



Note: Only bars for the set of measures deemed appropriate as the prescriptive requirement for the climate zone are shown

Figure 4 presents the Large School Source Energy savings results of the revised VAV+AWHP, PFPB system compared to the 2022 standard design. Like the Large Office, this figure shows that LSC savings are reduced with the revised VAV+AWHP, PFPB.

Figure 3: Large School Source Energy Savings for the Revised VAV+AWHP, PFPB compared to the 2022 Standard Design



Note: Only bars for the set of measures deemed appropriate as the prescriptive requirement for the climate zone are shown

CONCLUSION

The revised VAV+AWHP, PFPB system configurations, analyzed above, provide more flexibility in complying with Section 140.4(a)3. This also allows for alternative systems to be incorporated into Section 140.4(a)3 through the Executive Director approval path and will be used to set the energy budget in the performance approach. The Executive Director approval path and the revised energy budget increase designer flexibility as raised by stakeholder comments. Although the revised VAV+AWHP, PFPB system configurations lower LSC savings, as compared to the FPFC+AWHP+DOAS system, the Source Energy savings remain above the 2022 standard design.

PROPOSED REVISIONS TO CODE LANGUAGE

Delete Section 140.4(a)3aiii and replace with the following:

iii. For office buildings in all climate zones, and school buildings in climate zones 2, 4, and 6 through 16, the space conditioning system shall be a VAV system that utilizes heating supplied through a hot water loop served by an AWHP that complies with Section 140.4(a)3C, and the following:

a. For office buildings:

I. The portion of perimeter zone terminal unit heating capacity utilizing parallel fan powered boxes complying with Section 140.4(a)3E shall be:

a. 100 percent in climate zones 1 through 6, and 16.
b. 25 percent in climate zones 7 through 15.

II. Ventilation systems in climate zones 1, 3, and 5 shall be equipped with a heat recovery system in compliance with Section 140.4(q).

III. The maximum allowed fan power in climate zones 3 and 5 shall be 15 percent lower than specified by Section 140.4(c)1.

b. For school buildings:

I. All perimeter zone terminal units shall be parallel fan powered boxes complying with Section 140.4(a)3E.

II. Ventilation systems in climate zones 2, 4, and 11 through 16 shall be equipped with a heat recovery system in compliance with Section 140.4(q).

III. The maximum allowed fan power in climate zones 2, shall be 15 percent lower than specified by Section 140.4(c)1.

IV. The design leaving water temperature of the heating loop shall be no greater than 120°F in climate zones 2.