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Document Title:	Staff Memo – Revisions to Cost-effectiveness Analysis for 2025 Energy Code, Section 1404(a)3
Description:	This is a staff memo to justify the proposed revisions to cost-effectiveness analysis for Section 140.4(a)3 of the 2025 Energy Code, on multi-zone space-conditioning system types, to support the August 2024 15-day language.
Filer:	Javier Perez
Organization:	California Energy Commission
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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 Cost-effectiveness Analysis for 2025 Energy Code, Section 140.4(a)3 on Multi-zone Space-conditioning System Types, to Support the August 15-day Comment Period.

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. For Large Office and Large School buildings, cost-effectiveness for this requirement was analyzed using a four-pipe fan coil (FPFC) system supplied with cold and hot water from a chiller and an air-to-water heat pump (AWHP), respectively. In the analysis, ventilation was provided by a dedicated outdoor air system (DOAS). Through the public process, stakeholders expressed concern that the HVAC zone sizes used for developing costs for the Large Office and Large School buildings were substantially larger than commonly used by designers (Appendix A). Resultingly, CEC staff validated typical HVAC zone sizing for buildings of these types with a range of mechanical designers. This memo describes the revised cost-effectiveness analysis after reducing the HVAC zone sizes to align with common design practice.

DISCUSSION

The primary changes to the Large Office and Large School incremental cost assumptions were as follows:

- The Large Office prototype is a perimeter-core zone model with simplified HVAC zoning for the purpose of energy modeling. Previously, the Large Office system costs were evaluated on the assumption that the prototype is served by 120 terminal units for both the 2022 Energy Code standard design with Variable Air Volume (VAV) terminal units, and the proposed design (FPFC units). This analysis is revised so that the analysis prototype is served by 500 terminal units – a single VAV terminal box or FPFC unit – corresponding to an average HVAC zone size of 1,000 ft². The Large School was revised similarly to increase the number of HVAC zones from 120 to 500.
- The FPFC unit costs and the VAV terminal unit costs are revised to account for smaller size units serving individual HVAC zones.
- For the FPFC units, a more detailed cost estimate is developed for the smaller size units. RS Means is used to source material costs. The basis of the installed costs are derived from a representative sample of typical California mechanical, electrical and plumbing office building

projects, matching the assumptions used in the docketed measure report[1]. $300/ton is added for condensate lines running from individual FPFC units as recommended by stakeholder comments (Appendix A).

- For terminal unit replacement costs, material and labor are included for the VAV terminal units and for the FPFC units, but condensate line costs were already included in the original measure report assumptions.
- Other assumptions in the incremental cost estimates do not change and are consistent with the measure report[2] posted to the docket (titled '2025 Nonresidential HVAC Heat Pump Baseline Report').

Table 1 shows the revised Large Office Long-term System Cost (LSC) savings, incremental first costs including maintenance and replacement costs, and the benefit-to-cost ratio (BCR) by climate zone. Table 2 shows revised Large School LSC savings and incremental costs. Measures are cost-effective when LSC benefits meet or exceed measure costs as indicated by BCRs that are 1.0 or greater.

[1] https://efiling.energy.ca.gov/GetDocument.aspx?tn=255318-2&DocumentContentId=91005
[2] https://efiling.energy.ca.gov/GetDocument.aspx?tn=255318-2&DocumentContentId=91005

Table 1: Revised Cost-Effectiveness Results for the FPFC+AWHP+DOAS system, Large Office

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$/sf)	Cost: Total Incremental First Costs and Maintenance Costs (PV$/sf)	Benefit-Cost Ratio (BCR)
1	2.88	9.58	0.30
2	5.11	10.44	0.49
3	1.02	10.22	0.10
4	7.13	10.39	0.69
5	1.06	10.39	0.10
6	2.48	10.08	0.25
7	6.72	9.98	0.67
8	9.61	10.03	0.96
9	9.80	9.94	0.99
10	9.59	10.10	0.95
11	13.41	10.14	1.32
12	8.95	10.38	0.86
13	13.24	10.09	1.31
14	10.82	9.96	1.09
15	18.05	9.71	1.86
16	6.65	9.77	0.68

Table 2: Revised Cost-Effectiveness Results for the FPFC+AWHP+DOAS system, Large School

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$/sf)	Cost: Total Incremental First Costs and Maintenance Costs (PV$/sf)	Benefit-Cost Ratio (BCR)
1	3.75	10.25	0.37
2	4.38	10.51	0.42
3	1.80	10.15	0.18
4	4.69	9.82	0.48
5	1.61	9.75	0.17
6	2.20	9.69	0.23
7	4.10	10.27	0.40
8	5.43	10.50	0.52
9	5.66	9.79	0.58
10	5.91	9.89	0.60
11	8.52	10.12	0.84
12	7.20	10.33	0.70
13	7.29	10.01	0.73

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$/sf)	Cost: Total Incremental First Costs and Maintenance Costs (PV$/sf)	Benefit-Cost Ratio (BCR)
14	6.14	10.04	0.61
15	7.80	10.01	0.78
16	4.19	9.89	0.42

With the revised HVAC zoning sizes, the FPFC with an AWHP and DOAS is cost effective in climate zones 11, 13, 14, and 15 for Large Offices. It is close to being cost effective in climate zones 8, 9 and 10, but the BCR is slightly below 1. The same system in Large Schools with the revised HVAC zoning sizes is not cost effective in any climate zones.

CONCLUSION

After revising the cost estimates based on revised HVAC zone sizes, in response to stakeholder comments, the FPFC with AWHP and DOAS system is cost effective for Large Offices in climate zones 11, 13, 14, and 15, and is not cost-effective in any climate zones for Large Schools.

As a result of this analysis, the CEC is proposing to modify the prescriptive requirements for buildings represented by the Large Office and Large School prototypes for the 2025 Energy Code. The CEC concludes that the FPFC with AWHP and DOAS system may be included as a prescriptive alternative only for medium and small offices and school buildings that are under 150,000 square feet and under 5 stories in the 2025 Energy Code.

Variable refrigerant flow (VRF) systems are determined to be cost effective in these building types (see memo titled "Justification for CEC-Proposed Revisions to 2025 Energy Code, Section 140.4(a)3 on Multi-zone Space-Conditioning System Types to Support the August 15-day Comment Period – Variable Refrigerant Flow Systems for School Buildings" for cost effectiveness analysis for school buildings; and '2025 Nonresidential HVAC Heat Pump Baseline Report' for office buildings).

PROPOSED REVISIONS TO CODE LANGUAGE

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

3. **Multi-zone zone space-conditioning system types.** Office buildings in all climate zones, and school buildings in climate zones 1 through 5 and 8 through 16, not covered by Section 140.4(a)2 and are less than 150,000 square feet and less than or equal to five stories shall meet the following requirements:

APPENDIX

Feedback on the cost-effectiveness analysis for the June 2024 Express Terms of the 2025 Energy Code, Section 140.4(a)3 was shared by Hwakong Cheng of Taylor Engineers in an email received on August 14, 2024. The technical comments were:

- The cost estimate has unit costs for VAV boxes and FPFCs, where the FPFCs are roughly 3X more expensive. That ratio is about right but the quantity of zones assumed is extremely low – that works out to 4155 ft^2 per zone for large office and 4584 ft^2 per zone for schools. More realistic average zone sizes are perhaps 800 and 1000 ft^2. If you increase the quantity of zones, there is a much more significant cost add to the FPFC system. Further, though the ratio of unit costs is about right, the absolute unit costs for these terminals are about 2X lower than the actual unit costs that we are seeing in the market. That further increases the cost differential.
- The AWHP unit cost of $1280/ton appears to be based on quotes for a Trane ACS, which is a chiller, not a heat pump. The unit costs that we are seeing for 2-pipe AWHPs is closer to $2700/ton.
- The FPFC system has distributed cooling coils at every zone, but the cost estimate does not account for the need for condensate control. A mechanical contractor estimated $2500/zone for condensate piping.