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Modulating DOAS Title 24 2028 Energy Code CEC June 24 DOAS Questions 2026 0717 Rv 2

See attached comments.

Additional submitted attachment is included below.

July 17th, 2026
Via Electronic Mail

California Energy Commission
715 P Street
Sacramento, CA 95814

Re: CEC Docket: 2028 Title 24, CEC June 24th DOAS Questions

The following comments are submitted for the record of the Commission's above-captioned rulemaking regarding the 2028 Energy Code CEC June 24th DOAS Questions.

I am a mechanical engineer who has worked as a design engineer, controls designer, and commissioning agent, and has led code development for the IECC and state energy codes.

Overview

Please consider my comments in response to the Energy Code CEC June 24th DOAS Questions. In addition to responding to these questions, I dispute many of the energy and cost analyses used to support the cost-effectiveness claim. I also question the DOAS design paradigm presented as a makeup-air unit with VAV boxes added downstream of the outside-air duct serving the fan coils. This design paradigm is not a DOAS system. Still, it masquerades as one due to a unique DOAS definition allowance in CA Title 24, which is not available in the IECC or the basic definition, as it is not dedicated. By claiming to be a DOAS system, they can claim a low EUI while omitting other valuable aspects of high-performance DOAS systems with low EUIs: heat recovery, low-pressure duct systems, ventilation decoupled from space conditioning, low fan energy use, and ventilation zones separate from thermal zones.

Feedback Request from the Public

1. **How are DCV and occupied standby requirements currently being interpreted in design, plan review, and acceptance testing of DOAS systems?**

   Response: In a high-performance DOAS system, similar room types, such as conference rooms, are grouped into a ventilation zone served by a heat-recovery ventilator. The air volume is allowed to vary via HRV's ECM fans between the minimum and maximum flows based on the highest CO2 level among the spaces in the ventilation zone. While this may result in some zones being overventilated during scheduled building hours, the additional heat or cooling energy supplied to these rooms is minimized by the high efficiency of the heat recovery ventilator (HRV), which is 80 to 90%, especially at flows below the HRV's full design flow. The fan energy between full and minimum flow is negligible due to low external static pressures and the HRV's limited ability to generate high external static pressures at nominal flow rates.

2. **Please share any project examples where DOAS systems were treated differently from mixed-air systems?**

   Response:

A. **Martinez Office Building** (PG&E ETCC Research), located in Martinez, CA, with a Heat Recovery DOAS and VRF system. Retrofit Office Building (2019). My understanding is that the project evaluated DOAS as an alternative to conventional mixed-air VAV systems for future Title 24 development. The Controls focused on ventilation airflow and heat recovery rather than outdoor-air damper modulation and mixed-air temperature control.[1]

B. **Sacramento Office Building**, located in Sacramento, CA, with an Energy Recovery DOAS and Heat Recovery VRF. The ETCC study demonstrated that separating ventilation from conditioning could achieve energy performance equal to or better than that of conventional mixed-air systems while simplifying ventilation control.[2]

C. **Santa Rosa Office/Classroom Building** located in Santa Rosa, CA, with DOAS and Energy Recovery Ventilator with VRF units. This project specifically evaluated whether decoupled ventilation systems should have a different Title 24 treatment than mixed-air systems[3]

These ETCC/PG&E demonstration projects are well-documented examples of DOAS systems intentionally designed, controlled, tested, and evaluated differently from conventional mixed-air systems. These projects directly informed updates to California Title 24, resulting in dedicated code language and acceptance testing requirements that distinguish DOAS from mixed-air HVAC systems.

Under the 2022 California Title 24, ventilation air ducted into the return (back) of a fan coil unit (FCU) was not considered a compliant DOAS delivery method except under very limited circumstances. The code required the DOAS air to be delivered directly to the occupied space. The difference in the direction in the 2025 Title 24 and 2022 and Title 24 2025 is a new exception 3, which states that a DOAS may supply ventilation to a downstream fan (including a terminal box, AHU, or other space-conditioning equipment) if: the total system airflow can be reduced to the ventilation minimum, or the downstream fan power is no greater than 0.12 W/cfm while the space is in thermostat deadband. Current development of the 2028 Title 24 CASE proposals includes a measure that would allow DOAS outdoor air to be ducted to the FCU return inlet as a new prescriptive option. I would argue that, since the proposal was introduced for the 2028 cycle, it strongly suggests the CEC did not previously consider FCU return-air injection a clearly accepted DOAS delivery method. I would argue that engineers who apply the best DOAS design practices do not consider outdoor air ducted to a fan-coil unit to be a DOAS system but rather a mixed-air system. Applying mixed-air system requirements to a true DOAS system will impose unnecessary costs, degrade

[1] " https:// www.etcc-ca.com/reports/code-readiness-case-study-heat-recovery-dedicated-outdoor-air-system-heat-recovery-vrf"

[2] "https:// www.etcc-ca.com/reports/code-readiness-case-study-energy-recovery-dedicated-outdoor-air-system-and-heat-recovery"

[3] "https:// www.etcc-ca.com/reports/code-readiness-case-study-energy-recovery-dedicated-outdoor-air-system-heat-recovery-vrf"

the efficiency of true DOAS systems, and flood the true DOAS market with mixed-air systems pretending to be DOAS systems. I think PG&E ETCC Research got its research right back in 2022. Where are the outdoor air ducted fan coil field research projects indicating that their mixed air/DOAS projects are as efficient as true DOAS projects? I think a key error is assuming that a true DOAS system is defined solely by a single characteristic; in fact, it is defined by many good design practices.

3. **Please suggest edits to clarify that DCV and occupied standby requirements apply to DOAS systems**

   I would suggest a code exception to the Demand Control Ventilation and Occupied Standby requirements if the DOAS system has a heat recovery ventilator of 80% or greater, decoupled ventilation, the HRV should total combined fan power less than 0.77 W/cfm at design flow and if similar spaces, they are grouped in the same ventilation zone with a dedicated HRV, provided the maximum ventilation requirement of the ventilation zone exceeds 500 cfm of OSA. A requirement to adjust the air volume in the HRV (ECM fan) based on CO_2 and occupancy would remain.

4. **What considerations do you foresee in trying to modulate outside air at each zone for DOAS systems serving multiple space-conditioning zones?**

   I foresee large VAV DOAS systems on the roof with the same problem that large VAV mixed-air systems have, which I see day in and day out in my work. Static pressure at the DOAS unit will be as high as possible. The static pressure reset will not work; there will be one box that resets the DOAS units' static pressure, or it will be overridden. The static pressure sensor is supposed to be 2/3 of the way down the ductwork, but it will be at the DOAS unit if there is one, and this is not included in the CASE study cost estimate. Pressure drops at VAV boxes on higher floors will have a significantly higher static pressure in the duct because they are near the DOAS units, and then experience a high pressure drop across the damper as it closes further, wasting a lot of fan energy. On hot days with low occupancy, the DOAS airflow may not be able to be turned down enough due to cooling-coil requirements in the DOAS unit, forcing operators to override several DOAS VAV boxes to prevent coil freezing. The CO_2 sensor will go out of calibration after 5 years and will default to full ventilation of the space during scheduled building hours. The system's complexity will create far more energy waste than it will ever save.

5. **Modulating DOAS – Alternative Design Pathways**

   Are there alternative design approaches that could provide similar ventilation reduction during low-occupancy periods?

   If so, what code language would make those approaches clear?

   Yes. The paradigm you describe above assumes that there is energy to save by reducing ventilation, which is true if you don't have heat recovery in your DOAS system, but not if you have a high-performance DOAS system with a heat recovery of 80% or higherSee item 3 for code language.

6. Modulating DOAS – Controls and BAS/DDC Assumptions

   - For new buildings with BAS/DDC controls, what level of additional programming, coordination, and commissioning is typically needed to support DOAS modulation, DCV, and occupied standby?

     Are there scenarios where the controls effort may be higher or lower?

     The potential new DOAS requirements will increase the number of ventilation zones to match the number of thermal zones, resulting in more control points for the true DOAS system, with 1.5 more zones with modulating dampers than typical. The cost of additional control points will likely be $500 per point. Instead of a fixed damper, a VAV box will be required. The Test Adjust and Balance (TAB) work will be $250 per VAV instead of $100 for a fixed damper. Acceptance testing will be $3000 to $4000, plus controls contractor support ($1000) for the testing. I would also think that occupied standby would require some additional points at the DOAS unit ($ 3,000) and BACnet integration to the room occupancy sensor ($50 to $100 per VAV box).

     Scenarios where the cost would be higher than in hospitals or labs.

7. FCU Return-Air-Inlet Delivery Option

   For designs that deliver DOAS air to the fan coil return-air inlet, what design details should be considered to ensure ventilation air reaches the occupied zone when the fan coil cycles off or operates at low airflow?

   Are there duct, plenum, return-path, or fan-minimum-flow conditions that should be clarified?

   The fan coil has a cooling coil and likely a heating coil. Without the fan on in the fan coil, the DOAS system has to overcome the static pressure of these coils and maintain sufficient velocity pressure to continue down the duct and flow out of the diffusers. The airflow path and the action are different depending on whether the fan in the fan coil is on. When the fan is not operating, the fan becomes an obstacle, increasing the pressure drop in the airflow through the fan coil, and it was not designed to operate this way. I estimate that the air will not flow down the supply duct but will trickle out of the return section, avoiding the circuitous pathway down the supply duct. To make this work, the fan in the fan coil needs to be turned on; at that point, it consumes additional fan energy. Depending on the motor type, such as a PSC motor, it does not follow the fan law in its energy use due to the motor's inefficiency at part load. Connections of the OSA downstream of the fan coil coils will not work, as when the fan is running, outside air will be impeded by the fan coil fan's positive pressure.

Further Review of the Cost-Effectiveness of the Proposed CA DOAS Measures

Costs

In the June 2026 Air Distribution CASE study, Appendix A: Assumptions for Cost-Effectiveness Analysis, section 3.43[4] , there is a lack of clarity in the pricing takeoff of the prototype used for the base case and the proposed case. I have done my best to address the issue below, but I suggest that backup for this takeoff be provided to the CEC to review labor, equipment costs, and quantities for the prototype cost estimate, which will serve as the basis for the unit cost for the measure.

See Table 38 below for a breakdown of the incremental first costs.

Table 38: Summary of Costs Incurred in the Base and Measure Cases per Zone

No.	Cost Element	Base Case	Proposed Case Non-Integrated	Proposed Case Integrated
1.	Manual volume damper (MVD)	$150	$ -	$ -
2.	Balancing per MVD	$250	$ -	$ -
3.	Modulating damper (e.g., Price RDV)	$ -	$600	$600
4.	Controls (not including Occupancy or CO2 sensors)	$ -	$1,250	$500
5.	Occupancy Sensor	$ -	$600	$100
6.	CO2 Sensor	$ -	$1,000	$260
7.	Duct Static Pressure Sensor (and associated fan speed controls)	$ -	$462	$462
-	**Total**	**$400**	**$3,912**	**$1,922**

I see the following issues: In all cases, I am dealing with the proposed integrated case discussed below.

1. Item 2 does not have a cost for field calibration of the VAV AFMS. I understand that in section 3.4.3.2, this issue is indicated as not required by Title 24 or the California Mechanical Code. The case study takes up the debate in Appendix A rather than with the Title 24 Acceptance Tests (e.g., NA7.5.x tests) on whether there is value in this field calibration. Many project specifications, however, require the TAB contractor to be NEBB-, AABC-, or TABB-certified, and when the specification calls for NEBB, the VAV calibration is performed as part of the NEBB TAB scope. The reality is that the market will require field calibration of the VAV box, and it should be included as an additional cost over a manual damper. The other activities the TAB contractor performs with VAV include: verify installation, set minimum and maximum flow, verify damper operation, check controller stability, and document final settings in the TAB report. All of the tasks are why it costs an extra $200 to set up a VAV box over setting a manual balance damper.

2. Item 4 indicated the control price of $500. There is a rule of thumb is a $500 per point and there is a CO2 sensor hardwired to the VAV controller, but a BACnet point of the occupancy

[4] " https:// title24stakeholders.com/wp-content/uploads/2020/09/2022_T24-Final-CASE-Report_Air-Distribution.pdf"

sensor is mapped over from the lighting system, or often just has a parallel signal wired from the occupancy sensor to the VAV box terminal strip to reduce the BACnet integration issues either way the price is more likley $1000 for the control ingreation with out the cost of the sensors.

3. Item 2 has the cost of buying and installing a manual damper, a cost of $250 (Section.2.4.3). The proposed case does not have any incremental additional labor costs for installing a VAV that would include: hanging and supporting the VAV box, connecting the inlet duct, connecting the discharge duct, attaching flexible duct (if applicable), installing access doors, sealing duct joints, and basic coordination with other trades. I would estimate the incremental unit labor cost at $500. I would also say the unit cost of the damper and the installation cost is about $175 in the base case, not $250, but the most important consideration is the cost difference between the base and proposed case.

Energy

The building schedule for energy analysis for this DOAS measure uses 90 hours a week. Appendix A, Page 133 indicates " The default schedules in the prototype do not accurately reflect the real-world condition". They relied on plug load information to indicate extended schedules, but what it really reflected was folks leaving various plug loads on at their cubicles and the janitorial staff cleaning the building. The plug load is independent of the schedule adjusted in the BAS for the air handler or at the VAV zone level. That is from my experience from optimizing buildings, even the worst ones don't have schedules as egregious as 90 hours a week. I realize this is my opinion and the CASE team my hve their own opinion, but lets dig into their studies indicated in CASE study, 3.4.2 item 4 (shown below)

4. **One of the key assumptions in the models is the HVAC hours of operation: 6a-8p weekdays, 8a-6p weekends (90 hours/week). The same HVAC hours are used in the base case and the proposed case.**
    a. **Two recent studies supporting this assumption:**
        i. **Strategic Energy Group HVAC Scheduling Study: Typical HVAC runtime:14 hours per day, Monday–Saturday, Off on Sundays. 14 x 6 = 84 hours/week (SEM Hub, n.d.)**
        ii. **UC Berkeley Center for the Built Environment survey of hundreds of buildings found typical HW heating systems operate 130 hours/week (Raftery, 2018)**
    b. **A sensitivity analysis was also performed showing the measure is cost effective at 53 hours/week of HVAC operation (this represents an 8 am – 6 pm weekday and 9 am – noon Saturday schedule). 10 x 5 + 3 = 53 hours/week. See 3.4.2.**

The Strategic Energy Group Study (item "i") [5] at the footnote 5 below is not a study but an example worksheet and represents no building (see snipe below). The sample indicated 84 hours, but does not reference any real building with a schedule of 84 hours.

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[5] "https:// semhub.com/assets/resources/SEM_Calculation_Guide_HVAC_Scheduling.pdf"

the old and new operating schedules and calculate the resulting *schedule savings percentage.*

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With our sample building, the current runtime schedule for our targeted space totals 84 hours a week. We can potentially reduce that to 66 hours a week by better matching runtime to the occupancy of the space as follows:

- *New proposed HVAC operations:*
    - *Mon.-Fri.: 12 hours per day*
    - *Sat.: six hours*
    - *Sun.: off*

This represents a schedule savings of 21.4 percent from the old runtime schedule, since *(84-66) / 84 = 21.4 percent.*

The UC Berkeley Report [6] Is the report indicated in item a "ii". This single building and is not representative of the building stock schedule.

Quantifying energy losses in hot water reheat systems

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1 ABSTRACT

We developed a new method to estimate useful versus wasted hot water reheat energy using data obtained from typically installed instrumentation that applies to all pressure independent VAV terminal units with discharge air temperature sensors. We evaluated the method using a year of 1-minute interval data for a 11,000 m^2 building with 98 terminal reheat units, and found a 14% upper bound for the uncertainty associated with this method. We found that just 21% of gas energy is converted to useful reheat energy in this building. The distribution losses alone were 44% of the heat output from the boiler. The results raise questions regarding the tradeoffs between hot water heating systems, which have significant distribution losses, and electric heating systems, which effectively have zero distribution losses. In this building, and likely many others, an electric reheat system supplied by a small photovoltaic panel system would have a lower operating energy cost and a lower initial cost than the hot water reheat system. Further investigations using

It is my position that no study supports the use of an 84-hour-per-week schedule. In my estimation, a new office building would have equipment scheduled for 50 hours a week, which would not be cost-effective for this measure.

Thank you for considering these comments.

Louis Starr, P.E.

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[6] "https:// escholarship.org/uc/item/3qs8f8qx"