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Comments on DOAS CASE Measure

Additional submitted attachment is included below.

April 27, 2026

TO: California Energy Commission, Building Energy Efficiency Standards Division

RE: Formal Comment on 2028 Title 24, Part 6 Draft CASE Report: HVAC Air Distribution (Section 3, Modulating DOAS)

FROM: Neil Bulger, A2 Efficiency

FROM: Neil Bulger, Principal, A2 Efficiency, Santa Rosa, CA. More than a decade of DOAS field research, design, and code development in California and the Pacific Northwest. Primary Author, PG&E Code Readiness DOAS Field Research Program (2018-2024). Co-Author, 2022 Title 24 CASE Report on HVAC Controls.

Executive Summary

These comments address the Modulating DOAS measure in Section 3 of the 2028 Title 24, Part 6 Draft CASE Report on HVAC Air Distribution. I am submitting these comments having designed many DOAS systems in California and researched and monitored many DOAS system installations, including co-authoring the 2022 Title 24 CASE Report on HVAC controls where the current requirements for DOAS were established.

The 2028 Draft does not cite two PG&E-funded California field research publications that are directly relevant to its conclusions:

1. The 2023 Controls Report (ET18PGE1902-5) and
2. The 2024 Field Report (ET18PGE1902-8).

Both were published before this CASE cycle began, both were produced specifically to inform Title 24 DOAS requirements, and both contain findings that cut against the proposed measure. That omission is addressed throughout these comments.

My positions on each submeasure:

- **Submeasure A (mandatory per-zone air valves): OPPOSE**. This measure will result in excess HVAC equipment, increased costs and hardware, increasing embodied carbon as well, for HVAC systems, all while also introducing confusing and complexity.
  - The current T24 2025 code criteria already accomplishes this outcome when airflow control is required.
  - Thermal zones are not the same as ventilation zones and to assume they are and apply hardware as such confounds the purpose of DOAS as a system and adds excess costs and complexity.
  - Other codes, WSEC 2018 and beyond, already established a more elegant solution for insurance on ventilation controllability, establishing a maximum zone rather than dictation of application to each thermal zone.
  - The cost-effectiveness analysis excludes the risk of buildings without BAS or a simple BAS now requiring a much more complicated system, dramatically increasing cost. Further, PG&E field data showing per-zone DCV was not cost-effective at

California sites, and proposes mandatory hardware where a simpler, cheaper alternative already exists in comparable codes.

- **Submeasure B (occupied standby language cleanup): OPPOSE**. The code table is not able to be easily created since the criteria is not only for specific space types but also when those space types exceed a floor area. This code reference to physical space would make any table much more intricate or require many statements to indicate when it was or was not applicable. The simplified space type list drops the area-dependent occupancy sensor trigger from Section 130.1(c)5 and 6. This will either over-trigger or under-trigger the requirement depending on interpretation and may increase costs, especially coordination, installation and maintenance costs of occupancy sensors.
- **Submeasure C (FCU return air inlet delivery option): OPPOSE**. When the FCU fan cycles off, ventilation air delivered to the FCU return air inlet has no reliable path to the occupied zone. This is the exact failure mode DOAS is designed to avoid. The code language as written currently is intentional, where the benefits of zone fans cycling fully off far out weighs any small cooling benefit of a DOAS economizing ventilation slightly prior to the FCU cooling. Ability to fully cycle off FCU will reduce total system fan energy by 30% to 50% from field studies, demonstrating the immense energy inefficiency of systems which remain on at all times, even at a low-flow power level.
- **Submeasure D (55 degrees F / 75 degrees F SAT limits): OPPOSE**. The proposed 55 degrees F limit has no California field basis and turns the DOAS unit into a primary sensible cooling device, which is not what DOAS is designed to do. A DOAS system configuration is primarily made to de-couple the provision of cooling and heating from ventilation management. This unlocks heating and cooling to be vastly more efficient, moving heat far more efficiently than with a fan. Forcing a DOAS to not only actively control and monitor the building, integrate with heating and cooling, transforms the system into something it is not and will waste energy and create complex control systems that will fail more frequently and instill operator frustration. 60F as stated in the code currently for a DOAS supply temperature when the building is in a state of cooling is fine, reliable, and on the whole more efficient as a systems. It is the control sequence that runs a 150,000 sf office building at a large bay area airport, it is the sequence which drives over half a dozen low energy, net zero offices in the south bay, it is the sequence repeatedly used in some of the lowest energy buildings built.

1. Background and Basis for Comment

These comments draw on the following body of published research I was personally involved in over the past 7 years as well as many designs and installations for the 10 years prior. Publications directly cited in the comment body are marked with an asterisk.

Title	Year	Sponsor / Venue
Economic Analysis of Heat Recovery Equipment in Commercial Dedicated Outside Air Systems	2019	NEEA
CASE T24 2022 Initiative: Nonresidential HVAC Controls (DOAS)	2020	CA IOUs
Electrifying Space Heating in Existing Commercial Buildings: Opportunities and Challenges	2020	ACEEE

Retrofit DOAS, VRF and Networked Lighting Controls Demonstration: UC Davis	2020	CA IOUs
Energy Efficiency Analysis of Commercial DX-DOAS and ERV/HRV-DOAS	2021	NEEA
Analysis of Expanded Efficiency Parameters for Very High Efficiency DOAS	2022	NEEA
*** Code Readiness: DOAS Field Assessment Results**	2022	CA IOUs
*** Code Readiness Case Study: ERV-DOAS and Heat Recovery VRF Retrofit, Sacramento**	2022	CA IOUs
*** Code Readiness Case Study: HRV-DOAS and Heat Recovery VRF Retrofit, Martinez**	2022	CA IOUs
*** 2022 Title 24 CASE Report: Nonresidential HVAC Controls (2022-NR-HVAC4-F)**	2022	CA IOUs
Energy Modeling Guide for Very High Efficiency DOAS	2023	NEEA
Calibrated Energy Savings for Very High Efficiency DOAS in Multi-Family Housing	2023	NEEA
Code Readiness Case Study: ERV-DOAS and Heat Recovery VRF, Palm Springs	2023	CA IOUs
Code Readiness Case Study: ERV-DOAS and Heat Recovery VRF, Santa Rosa	2023	CA IOUs
Code Readiness: Electrification of Nonresidential Space Heating, Designer Interview Report	2023	CA IOUs
*** Code Readiness: Energy Savings Analysis of Dedicated Outdoor Air HVAC in California**	2023	CA IOUs
*** Code Readiness: Evaluation of DOAS and VRF System Controls at Nonresidential Field Sites [2023 Controls Report]**	2023	CA IOUs
*** Energy Efficiency Potential of Dedicated Outdoor Air Systems in Commercial Buildings [2024 Field Report]**	2024	CA IOUs
*** How DOAS Will Be a Key Contributor to Building Decarbonization**	2024	ACEEE

The 2023 Controls Report and 2024 Field Report are the most directly relevant prior research to the questions the 2028 CASE Report tries to answer. Neither is cited in the Modulating DOAS section.

2. Submeasure A: Mandatory Per-Zone Air Valves (OPPOSE)

2.1 The Proposed Requirement May Already Be Required by Current Code

The report's central premise is that DOAS systems cannot comply with occupied standby and DCV because there is no explicit modulation requirement. This is not established. Under current Title 24, the DCV trigger at Section 120.1(d)3 already applies to any system with design outdoor airflow above 3,000 cfm, including DOAS. Once triggered, per-zone modulating capability is implied. Occupied standby under Section 120.1(d)5 applies based on space type and lighting sensor requirements without a DOAS exemption.

The assertion that designers interpret these requirements as not applying to DOAS is stated without citation: no survey, no compliance form review, no plan check data, no enforcement record. The report then states, in the same section, that *'many DOAS systems in the field today are specified with airflow modulating measures such as DCV and occupied standby.'* Both statements cannot be correct. The report never reconciles them.

If the problem is a compliance gap, the solution is enforcement and clarification, not a new mandatory hardware requirement. A mandatory code change requires actual evidence of the gap it is closing.

2.2 A Less Costly Alternative Already Exists in Comparable Codes

The Washington State Energy Code (WSEC 2018 and 2021, Section C403.2.1) addresses DOAS ventilation control through an isolation area requirement with a 25,000 sf and single-floor cap, a 5,000 cfm fan system exception, and technology-neutral compliance options. Designers can comply by subdividing DOAS units so each serves a separate isolation area below the threshold, by providing zone-level shutoff controls, or by any other means that achieves independent shutoff per isolation area. Section 2.7 of this comment reproduces the full WSEC language and provides a suggested Title 24 adaptation.

The 2024 PG&E Field Report makes this same recommendation for Title 24, stating: *'Requirements for a maximum ventilation zone size should be added to section 120.2 to improve ventilation control granularity and limit DOAS fan power. The ventilation zone size should be determined based on whether the building has a central building automation system.'*

The report's Appendix D includes proposed code language including a DDC table entry requiring DDC for DOAS systems serving ventilation zones of 25,000 sf or larger.

Field evidence backs this up. The Sunnyvale field site in the PG&E study used four HRV-DOAS units dividing a 38,900 sf building into four ventilation quadrants, achieved excellent energy performance, and required no per-zone air valves, no central BAS, and no modulating damper controls. The San Francisco and Palm Springs sites used similar configurations.

The 2028 Draft does not acknowledge the WSEC approach, does not reference the 2024 Field Report recommendation, and provides no comparison of the per-zone air valve approach against the zone size cap alternative. For a mandatory proposal, this is a material gap.

2.3 California Field Evidence Shows Per-Zone DCV on DOAS Is Not Cost-Effective

The 2023 PG&E Controls Report tested zone DCV on DOAS systems at California field sites with the explicit purpose of evaluating potential Title 24 adoption. Its conclusion was clear:

> *"The research team determined that adding DCV controls for ventilation airflow to individual thermal zones on the ERV-DOAS was not cost-effective" at the Santa Rosa site. (Weitze et al., 2023 Controls Report, p. 44)*

At the Sacramento site, where zone DCV was already installed and tested, achieved savings were 0.16 kWh/sf-yr, representing approximately 2% of whole building energy. The report's Title 24 recommendation was the opposite of what the 2028 CASE Report proposes: **that the 120.1(d)3 DCV threshold should be larger for DOAS systems than for mixed air systems.**

The 2028 Draft does not cite, acknowledge, or respond to these findings. This is not a peripheral publication. It is a PG&E Code Readiness program report produced specifically to inform Title 24 DOAS requirements. Its omission from the literature review undermines the cost-effectiveness analysis.

2.4 The BAS Cost Is Missing from the Analysis

The cost table presents two scenarios: integrated (air valve control integrated into terminal unit controls) and non-integrated (standalone controller). The integrated scenario drives the BCR calculations showing cost-effectiveness. Neither scenario includes the cost of a building automation system.

The 2023 PG&E Controls Report found that manufacturer controllers were insufficient to implement the control sequences required for DCV and occupied standby, and that a central BAS was required for successful implementation and verification. The 2024 Field Report confirms this across eight California sites: the three sites that operated at constant volume with no BAS could not have run DCV or occupied standby sequences using manufacturer time-clock controllers alone.

If the integrated scenario does not actually function without a BAS, the incremental cost is substantially higher than modeled and the BCR results are overstated. The CASE Team should either include BAS costs or demonstrate with specific product documentation that the integrated control scenario works without one.

2.5 Ventilation Rate Assumptions Favor the Measure

The energy model analysis, developed in a spreadsheet, uses 0.15 cfm/sf for office buildings. California office buildings with a realistic mix of open office, enclosed private offices, conference rooms, and support spaces typically design to 0.20 to 0.25 cfm/sf. Educational buildings commonly design to 0.35 to 0.50 cfm/sf depending on occupant density and space type mix.

Using 0.15 cfm/sf reduces absolute fan energy available to be saved (less airflow means less fan power to modulate) while also reducing the per-zone cost denominator (fewer cfm per dollar of air valve hardware). The prototype simplification skews the BCR in favor of the measure. The report provides no sensitivity analysis at more representative ventilation rates.

2.7 Recommended Code Language

The full WSEC C403.2.1 text and a suggested Title 24 adaptation are provided below for the CEC's consideration. The WSEC language is reproduced verbatim; the Title 24 draft tracks its structure but uses Title 24 terminology and section references.

WSEC C403.2.1 Zone Isolation Required (2021 Edition)

HVAC systems, DOAS and exhaust systems serving areas that are intended to operate or be occupied nonsimultaneously shall be divided into separate isolation areas. Zones intended to be occupied simultaneously may be grouped into a single isolation area provided the combined total area does not exceed 25,000 square feet of conditioned floor area and does not include more than one floor. Each isolation area shall be equipped with isolation devices and controls configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section C403.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. *Exhaust air and outdoor air connections to isolation areas where the fan system to which they connect is not greater than 5,000 cfm.*
2. *Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.*
3. *Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a zone are inoperative.*

Why this approach is preferable to mandatory per-zone air valves

This language accomplishes the same goal as the proposed Submeasure A without prescribing the means of compliance. Key differences:

- **Technology-neutral**. A designer can comply by subdividing the building into multiple DOAS units each serving an isolation area below 25,000 sf, by providing zone-level modulating controls, or by any other means that achieves independent shutoff. The proposed Submeasure A mandates specific hardware (pressure-independent air valves with AFMS) regardless of whether the building configuration warrants it.
- **The 5,000 cfm fan system exception is critical.** It means a small DOAS unit serving a single building quadrant below that threshold does not require active isolation controls at each zone. This directly supports the design strategy that PG&E field research showed performs well: multiple smaller DOAS units subdividing the building rather than one large unit with per-zone valves.
- **The 25,000 sf / single floor cap aligns with what the 2024 PG&E Field Report** recommends for Title 24's DDC table in Section 120.2 and with the isolation area threshold already present in Title 24 Section 120.2(g) for space conditioning systems.
- **Exhaust is addressed.** The WSEC language covers exhaust systems in the same provision. The 2028 proposal does not address exhaust zone coordination with DOAS modulation, which is a real design challenge.

Recommended Title 24 translation

The following is a suggested adaptation of WSEC C403.2.1 for inclusion in Title 24 Section 120.2, as an alternative to the proposed 120.1(d)6 mandatory air valve requirement:

Proposed Section 120.2(g) Revision (suggested draft for CEC consideration)

HVAC systems, dedicated outdoor air systems, and exhaust systems serving areas that are intended to operate or be occupied nonsimultaneously shall be divided into separate isolation areas. Zones intended to be occupied simultaneously may be grouped into a single isolation area provided the combined conditioned floor area does not exceed 25,000 square feet and does not include more than one floor. Each isolation area shall be equipped with isolation devices and controls that automatically shut off the supply of conditioned air and outdoor air to, and exhaust air from, the isolation area during periods of non-occupancy. Central systems and plants shall be capable of continuous operation serving only the smallest isolation area.

Exceptions:

4. *Outdoor air and exhaust connections to isolation areas where the fan system serving them has a design airflow of 5,000 cfm or less.*
5. *Exhaust airflow from a single isolation area where that airflow is less than 10 percent of the design airflow of the exhaust system.*
6. *Isolation areas intended to operate continuously, or intended to be inoperative only when all other isolation areas served by the same system are also inoperative.*

This approach requires a cost-effectiveness analysis by the CASE Team before adoption, but that analysis should be straightforward: the incremental cost is primarily the isolation damper or valve at the DOAS branch serving each isolation area, not a per-zone AFMS and controller at every thermal zone. For buildings that achieve compliance by subdividing into multiple smaller DOAS units, there may be no incremental cost at all relative to current practice.

3. Submeasure B: Occupied Standby Language Cleanup OPPOSE

The intent of consolidating occupied standby trigger conditions into a single readable location in 120.1(d)5 is understandable. The current code structure requires cross-referencing Table 120.1-A, Section 130.1(c)5, and Section 130.1(c)6, which is cumbersome. However, the reason that structure is complex is because the underlying requirement is genuinely complex. A simplified table cannot accurately represent it, and the attempt to do so creates a worse compliance problem than the one it is trying to solve.

Occupied standby does not trigger on space type alone. Under current code, three conditions must all be satisfied:

- The space type appears on Table 120.1-A with a designation permitting ventilation to be reduced to zero during occupied standby.
- An occupancy sensor is required for the space by the lighting code under Section 130.1(c)5 and 6, which is itself conditioned on the space meeting an applicable floor area threshold, typically 250 sf.
- The zone is not on pneumatic controls.

The floor area condition in item two is not a formatting detail. It is a substantive threshold that determines whether OS applies to a given space. A 200 sf enclosed private office is on the space type list but does not require a lighting occupancy sensor under 130.1(c)5, and therefore does not trigger occupied standby under current code, regardless of space type.

A simplified table listing space types without the area threshold cannot be made accurate without becoming significantly more complex.

The practical consequence of publishing an incomplete simplified list is that it will either over-trigger OS, requiring occupancy sensor installation and ongoing maintenance in small spaces that do not currently trigger the requirement and adding coordination and cost, or it will silently expand the requirement beyond its current scope without a cost-effectiveness analysis to support that expansion. Neither outcome is stated as the intent in the draft report, and neither is analyzed.

The correct approach is to leave the current cross-reference structure in place and invest compliance improvement resources in better explanatory guidance and examples in the nonresidential compliance manual, rather than a code language change that introduces new ambiguity. If the CASE Team believes the current area-dependent trigger is wrong policy and wants to expand OS to all instances of a space type regardless of size, that is a substantive policy change that requires its own cost-effectiveness analysis before adoption. It should not be introduced as an editorial cleanup.

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4. Submeasure C: FCU Return Air Inlet Delivery Option (OPPOSE)

4.1 When the FCU Cycles Off, Ventilation Does Not Reliably Reach the Zone

The core efficiency benefit of DOAS is enabling zone fan coils to fully cycle off when there is no call for heating or cooling. PG&E field research found that sites with fully decoupled ventilation achieved zone fan energy as low as 0.8 kBtu/sf-yr, compared to 2.8 kBtu/sf-yr at sites where fans ran continuously for ventilation. This is where the majority of DOAS system configuration savings come from.

When ventilation air is delivered to the FCU return air inlet and the FCU should be left on for ventilation. Cycling the FCU off would result in the ventilation air having no reliable path to the occupied zone. Depending on duct geometry and distance to diffusers, it may pressurize the FCU cabinet and short-circuit back to return, stagnate in the inlet duct, or simply not travel the 10 to 20 feet to reach occupants at the diffusers.

The report acknowledges that DOAS air valves and FCU controllers *'typically don't communicate with one another.'* Proposing that ventilation enter the FCU return air inlet while also allowing the FCU to cycle off independently makes that coordination problem worse, not better, and adopts it as a prescriptive compliance pathway.

4.2 Field Evidence Does Not Support FCU Inlet Delivery

The 2024 PG&E Field Report documents ventilation delivery configurations at all eight field sites. Sites with fully decoupled delivery to the zone independent of the FCU had the lowest zone fan energy. Sites with coupled delivery through the FCU required fans to run continuously, even at low speeds where fans were measured to only be capable of 50% minimum flow. Those which fully cycled off produced significantly higher zone fan energy. The report does not recommend FCU return air inlet delivery. It recommends decoupled pathways as a key efficiency feature. This is the same criteria used in the WSEC 2018 and subsequent energy codes as well as by NEEA’s Very High Efficiency DOAS system requirements to define efficient DOAS configurations.

Submeasure C would add FCU return air inlet delivery as a new prescriptive option without field evidence supporting it as a reliable ventilation delivery path and without noting the delivery risk when the FCU is off.

5. Submeasure D: 55 Degrees F / 75 Degrees F SAT Limits (OPPOSE)

5.1 DOAS Efficiency Does Not Work This Way

The rationale for lowering the SAT limit from 60 degrees F to 55 degrees F is that colder supply air reduces zone cooling loads, saving energy. This applies to mixed-air VAV systems, where the central air handler delivers both ventilation and primary sensible cooling to all zones simultaneously. It does not apply to DOAS, especially DOAS systems in California.

In a properly designed DOAS system, the ventilation unit handles ventilation air only, typically 15 to 25 percent of total supply airflow. Zone sensible cooling is handled by the fan coil or VRF system, which operates at much higher efficiency when it handles only sensible loads (often little to no latent dehumidification, higher suction temperatures, better COP at part load). The efficiency gains of DOAS come from:

- Decoupling latent loads from sensible loads, allowing zone heat pumps to operate at elevated suction temperatures.
- Enabling zone fan coils to fully cycle off during unoccupied or low-load periods.
- Delivering near-neutral supply air that does not impose a heating or cooling penalty on the zone conditioning system.

Delivering 55 degrees F supply air from the DOAS unit does not save energy in this configuration. It shifts primary cooling from zone equipment (handled efficiently by heat pumps at high COP) to the DOAS DX coil, while imposing cold ventilation air on every zone regardless of whether cooling is needed. Zones in heating mode, low-load perimeter zones, and occupied low-density spaces all receive cold air they must then reheat. Driving the temperature 55 degrees F will create more complex controls to ensure comfort and avoid a zone-reheat scenario.

5.2 California Field Research Points the Other Way

The 2024 PG&E Field Report monitored supply air temperature across eight California DOAS sites, including three with active mechanical cooling in the DOAS unit. The data does not support 55 degrees F as a target for California conditions.

At the Palm Springs site, an ERV-DOAS with heat pump heating and cooling delivered a constant 68 degrees F supply air temperature. Mechanical cooling in the DOAS unit only activated when outdoor air exceeded 65 degrees F, meaning the system operated passively through heat recovery for a large fraction of operating hours. The 68 degrees F constant setpoint required no reheat, imposed no cold air penalty on zones in heating or low-load conditions, and is well within the range the 2028 proposal would prohibit.

At the five passive HRV and ERV sites in the PG&E study, DOAS supply air temperature was determined by heat recovery effectiveness and outdoor conditions. The Martinez and Sunnyvale sites delivered supply air in the 60 to 65 degrees F range across most California ambient conditions without any active mechanical cooling. The current 60 degrees F code limit aligns with how these systems naturally operate. Lowering the limit to 55 degrees F would require

active DX cooling to achieve a setpoint that passive heat recovery is already delivering within, adding compressor energy and reheat risk to a system designed to avoid both.

The 2028 report cites ASHRAE RP-1865 as the sole basis for 55 degrees F. That research was conducted for DOAS applications in humid climates where dehumidification at the central unit drives design and where delivering cold supply air to the space is justified by latent load management. In California's dry climate, dehumidification at the central DOAS unit is rarely needed and the latent load argument does not apply. The CASE report makes no attempt to evaluate whether RP-1865 findings translate to California's 16 climate zones.

5.3 The 75 Degrees F Heating Floor Has No California Basis

In California's mild, dry climates, HRV-DOAS units frequently deliver ventilation air in the 60 to 70 degrees F range during mild weather without any mechanical heating or cooling. This is not re-cooling; it is passive delivery of outdoor air at near-neutral conditions through heat recovery, which is exactly the intended operating mode for most of the California climate year.

A 75 degrees F lower bound in heating mode would require mechanical heating of outdoor air that is already in the 60 to 75 degrees F range in much of California, adding unnecessary energy and mechanical operation to what should be passive ventilation. No California-specific analysis is provided to support this limit.

5.4 The Current 60 Degrees F Limit Is Appropriate

DOAS systems in California are designed and specified as near-neutral ventilation delivery systems. Designers target supply air 5 to 10 degrees F below room temperature, roughly 62 to 68 degrees F. The current 60 degrees F limit provides a reasonable floor and is consistent with field practice.

Mandating 55 degrees F requires DX cooling in the DOAS unit across a much wider range of California ambient conditions, converting a passive or lightly conditioned ventilation system into a primary sensible cooling device. If the intent is to provide 55 degrees F supply air for primary sensible cooling, the right system type is a VAV mixed air system designed and sized for that purpose.

6. General Concerns

6.1 Relevant Prior Research Was Not Cited

The 2028 Draft does not cite the 2023 PG&E Controls Report (ET18PGE1902-5) or the 2024 PG&E Field Report (ET18PGE1902-8) in the Modulating DOAS section. Both were published before this CASE cycle began, both were funded specifically to inform Title 24 DOAS requirements, and both contain findings relevant to the proposed measure. The 2028 report does cite PG&E's CR24PGE0001, but only for a narrow calibration point, with no reference to the broader DOAS controls findings.

A mandatory code proposal that does not engage with available field evidence that cuts against its conclusions does not meet the standard of rigorous cost-effectiveness analysis required under California law. The CEC should require the CASE Team to formally address the 2023

Controls Report's cost-effectiveness findings and the 2024 Field Report's SAT and zone size recommendations before any language is adopted.

6.2 Claims About Designer Behavior Are Not Supported

Several factual claims about designer practice and market behavior appear without citation. These claims are used to establish why the measure is needed, but none have a source:

- "Designers typically specify DOAS systems without airflow modulating controls."
- "There is an inconsistent awareness that DOAS systems should be complying with DCV and occupied standby."
- "This approach is cheaper and simpler to design and install, and therefore many designers favor it."
- "The typical DOAS system is designed to provide steady delivery of code minimum ventilation air to the zones during occupied periods."

These are empirical claims about market behavior. For a mandatory requirement, they need a basis: a survey, compliance form analysis, plan check data, or field observations. As written, they are assertions.

6.3 The Occupancy Rate Data Is Not California-Specific

The cost-effectiveness analysis uses four post-pandemic occupancy studies (Table 16) showing that buildings are occupied only 20 to 36 percent of HVAC operating hours. These studies are global or North American in scope and are based primarily on office badge-swipe or sensor data.

For K-12 schools, which are one of the building types where the report claims significant savings, classrooms operate on mandated occupancy schedules that are not subject to remote work trends. Using post-pandemic office occupancy rates to justify cost-effectiveness for school buildings is not a valid comparison. No California-specific occupancy data is provided for any building type covered by the measure.

6.4 The Energy Model Workaround Is Not Validated

The report acknowledges that CBECC cannot model modulating DOAS and uses a hybrid EnergyPlus and spreadsheet approach where DOAS fan energy is represented by adjusting plug load schedules in a single-zone heat pump model. This is not a necessary workaround. EnergyPlus natively supports two systems serving one zone, which enables ventilation flow to be controlled and modeled independently alongside a heating and cooling device controlled in any configuration. This architecture directly represents the scenarios described in the CASE report: a DOAS unit modulating ventilation airflow to a zone while a fan coil or VRF unit provides sensible conditioning. The model can represent maintained ventilation with the fan coil at design flow, reduced ventilation with the fan coil cycling off, or any intermediate state based on the specified control logic. The physical limitation of a terminal unit serving the inlet of a zone fan coil does exist as a topology constraint in EnergyPlus, but it does not limit the ability to represent the energy flows and system operations that define whether the measure saves energy.

The PG&E field research program produced exactly the kind of measured operational fan energy data needed to validate an EnergyPlus model of these systems.

7. Summary of Requested Actions

Before any language from the Modulating DOAS measure is adopted into the 2028 Title 24, Part 6 standards, the following actions are requested:

1. Withdraw Submeasure A and replace it with a DOAS isolation area requirement in Section 120.2, modeled on WSEC C403.2.1. The recommended draft language is provided in Section 2.7 of this comment. A new cost-effectiveness analysis for the isolation area approach should be conducted before adoption, using PG&E field data as validation inputs.
2. Withdraw Submeasure B as the additional criteria table is likely to increase confusion for when lighting sensors are required without address the area requirement from Section 130.1(c)5 and 6.
3. Withdraw Submeasure C. The current discharge delivery and direct-to-zone delivery options are adequate. Adding FCU return air inlet delivery as a prescriptive option without addressing the ventilation delivery failure mode when the FCU is off creates a compliance pathway that field evidence does not support.
4. Withdraw Submeasure D and retain the current 60 degrees F limit. If the CEC wishes to revisit DOAS SAT requirements, evaluate the 2024 PG&E Field Report recommendation of 65-70 degrees F neutral SAT for DX-DOAS units as an alternative, with analysis specific to California climate conditions.
5. Expand the hybrid EnergyPlus/spreadsheet fan energy modeling methodology against PG&E field measurement data. Further, the current proposed approach may not fully meet the Warren-Alquist Act which requires publicly available software where methods can be understood and replicated in CBECC.

8. Closing

DOAS is a growing part of California's nonresidential HVAC market. The 2022 Title 24 CASE cycle made well-supported advances in DOAS code requirements and the market is responding. Further enhancements are appropriate, but they need to be grounded in California field evidence, not modeling assumptions borrowed from non-California research, and they should not impose mandatory hardware requirements when less costly, equally effective alternatives already exist in comparable codes.

The Modulating DOAS measure as drafted does not engage with the best available California field evidence, selects a costly compliance pathway over a flexible and field-validated alternative, and includes SAT requirements that contradict California field research and the operating principles of efficient DOAS design.

Neil Bulger

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April 27, 2026

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