Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

Air Distribution

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Acronyms

Table 1 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a glossary of terms.

Table 1. List of Acronyms

Acronym	Definition
ACM	Alternative Calculation Method
ADA	Americans with Disabilities Act
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ATT	Acceptance Test Technician
BCR	Benefit-to-cost Ratio
BEM	Building Energy Modeling
Btu	British Thermal Units
CALGreen	California Green Building Standards Code
Cal/OSHA	California Division of Occupational Safety and Health
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBSC	California Building Standards Commission
CBECC	California Building Energy Code Compliance Software
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CBO	Community-Based Organization
CPUC	California Public Utilities Commission
CSE	California Simulation Engine
CTF	Conduction Transfer Functions
CZ	Climate Zone
DAC	Disadvantaged Community
DGS	California Department of General Services
DOAS	Dedicated Outdoor Air System
DOSH	Division of Occupational Safety and Health
ECC	Energy Code Compliance
EIR	Environmental Impact Report
EPIC	Electric Program Investment Charge
ESJ	Environmental and Social Justice
FSOR	Final Statement of Reasons
GHG	Greenhouse Gas

GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISOR	Initial Statement of Reasons
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LSC	Long-term System Cost
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
NAICS	North American Industry Classification System
NPDI	Net Private Domestic Investment
PEP	Public Engagement Plan
PV	Present Value
SDD	Standards Data Dictionary
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
TON	12,000 Btu/h of heating or cooling capacity
W	Watt

1. Introduction

This is a draft report. The Statewide Codes and Standards Enhancement (CASE) Team encourages readers to provide comments on the proposed code changes and supporting analyses. The CEC will evaluate proposals that the Statewide CASE Team and other stakeholders submit and may revise or reject proposals. More information about the rulemaking schedule and how to participate in the process can be found on CEC's 2028 code cycle website. Suggested revisions will be considered when refining proposals and analyses. The final CASE Report will be submitted to the CEC later in 2026.

For this report, the Statewide CASE Team is requesting input on the following:

1. *Cost assumptions for the PVAV Turndown measure. Are we estimating product redesign costs accurately?*
2. *How we are modeling the VAV system in the PVAV Turndown measure, including assumptions regarding system operation.*
3. *Incremental costs for the Modulating DOAS measure.*
4. *Prevalence of DOAS and packaged VAV system installation rates in new construction and existing buildings in California by building type*

Email comments and suggestions to info@title24stakeholders.com *and* bboyce@energy-solution.com*. Comments will either remain confidential or anonymized if shared publicly.*

1.1 Report Context

This proposal describes specific energy efficiency code changes (referred to as "measures") aimed at reducing wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. These measures are submitted to the California Energy Commission (CEC) for consideration and potential inclusion in California's Energy Code (Title 24, Part 6), which sets statewide energy efficiency requirements for newly constructed buildings and for additions and alterations to existing buildings. Measures may also be considered for inclusion in CALGreen (Title 24, Part 11) as voluntary energy efficiency standards, which would take effect only if adopted by a local jurisdiction seeking to exceed the minimum requirements of the Energy Code. Measures submitted to the CEC will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. To be included in the Energy Code, proposed measures must be both cost effective and technically feasible.

1.2 Proposal Sponsors

Three California Investor-Owned Utilities (IOUs) — Pacific Gas & Electric Company, San Diego Gas & Electric, and Southern California Edison sponsored this effort as a group. Where the term, “Statewide CASE Team” is used in this report, it refers the authors of the CASE report and the Codes & Standards programs of the supporting California Investor-Owned Utilities.

1.2.1 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders including manufacturers, Title 24 energy analysts, state agencies, and others involved in the code compliance process. The proposal incorporates feedback received during a public stakeholder workshop that the Statewide CASE Team held on September 23, 2025.

For the PVAV Turndown measure, manufacturers highlighted the potential need for equipment redesigns to meet the requirements. This feedback was incorporated into the measure’s cost effectiveness analysis.

For the Modulating DOAS measure, stakeholder feedback focused on questions regarding the proposed supply air temperature limitations. The Statewide CASE Team has engaged with ASHRAE Research Project (RP) 1865 researchers as part of the DOAS supply temperature revisions.

See Appendix E for details on the Statewide CASE Team’s stakeholder engagement.

2. Packaged Variable Air Volume (PVAV) Turndown

2.1 PVAV Turndown - Measure Description

2.1.1 Proposed Code Change

This proposed code change would modify prescriptive requirements for multi-zone variable air volume (VAV) HVAC systems in Section 140.4(m). The change would require the central supply fan to be capable of and configured to turn down to the larger of 15 percent of design airflow or the sum of the minimum outdoor air required by Section 120.1(c)3. The equipment must be able to provide mechanical cooling at that airflow.

Multi-zone VAV systems control space temperature by modulating airflow to the space. The systems also provide a minimum flow of outdoor air to the space, in accordance with the outdoor airflow requirements specified in Section 120.1(c)3. Section 140.4(d)(2)(A)(ii) and 140.4(d)(2)(B)(ii) currently require terminal units in the individual zones for these systems to be capable of turning down airflow to no greater than the minimum required outdoor airflow during deadband operation, where there is no demand for heating or cooling. In many applications, this would be 15 percent or less of the air handler's design airflow. However, there is no requirement that the central air handler be able to turn down flow to any level and have mechanical cooling enabled.

The measure would also help ensure that systems can comply with the mandatory demand control ventilation (DCV) requirements in Section 120.1(e) and the occupied standby requirements in Section 120.1(f). Even in buildings that have relatively high outdoor air requirements, DCV and occupied standby reduce outdoor airflow, so those buildings will benefit.

Additionally, there is currently no limitation on multi-zone VAV direct expansion (DX) compressors from locking out at low airflow levels, a challenge that has been encountered in the field. That is, even if the unit can turn down its airflow below 50 percent of design airflow, the compressor is often locked out by the unit, preventing it from providing mechanical cooling if some zones require it. This is typically encountered during times when the integrated economizer is used to satisfy space conditioning requirements.

Current workarounds to deal with DX PVAV units that do not turn down below 50 percent of design airflow or lock out their compressors at a relatively high part-load airflow (e.g., 40 percent of design airflow) lead to significantly more energy consumption than is needed. Designers have two ways to handle the mismatch: (1) they can set the minimum zone airflow to match the higher airflow if they use a modeling compliance path, or (2) they can specify a bypass duct that returns the excess airflow directly to the unit. In either case, the central air handler's fan uses more energy than necessary, and in the first case, it is extremely likely that the reheating energy needed to maintain occupant comfort will exceed other code limitations around simultaneous cooling and heating. If these workarounds are not adequately employed, then occupant comfort is likely to suffer.

With the proposed change, in all modes of operation (i.e., mechanical cooling, integrated economizer, full economizer, deadband, and compressor heating, if applicable), the maximum airflow rate through an air handler would not exceed the greater of 15 percent of the design airflow or the sum of the primary airflow of the associated terminal units.

This proposed code change would apply to new construction, additions served by a new DX or hydronic unit, and alterations in which a new DX or hydronic air handler unit is installed. For alterations, users are expected to reset the minimum airflow settings of the associated VAV boxes to realize the savings. This can be accomplished through the BMS system in most cases. The proposed code change will apply to all climate zones and to all building and space types that have multi-zone VAV systems. This does not apply to single-zone VAV systems that control mechanical cooling capacity directly based on space temperature.

Table 2 summarizes the scope of the proposed code change.

Table 2: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☑ New Construction	☐ Mandatory
☐ Multifamily	☑ Additions	☑ Prescriptive
☑ Nonresidential (not Group R uses)	☑ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 6, Section 140.4 • Nonresidential Reference Appendix Section 7.5.6	N/A	Mandatory

Third Party Verification	Updates to Compliance Software
☐ No changes to third-party verification	☐ No updates
☑ Update existing verification requirements	☑ Update existing feature
☐ Add new verification requirements	☐ Add new feature

2.1.2 Benefits of Proposed Change

A modern, code-compliant building with a multi-zone VAV system is likely to experience significant periods where the airflow to the zones is much lower than the design rate. This is due to both social factors and other code requirements. Commercial building occupancy densities can vary widely, resulting in reduced cooling demand on building HVAC systems during scheduled occupied periods. Other code requirements, such as demand-controlled ventilation and occupied standby (OS) (both located in section 120.1(d)), place mandatory zone airflow turndown requirements on the air distribution system when appropriate.

Section 140.4(d)2ii requires that the terminal units in the individual zones turn down airflow to no greater than the design outdoor airflow during deadband operation when there is no demand for heating or cooling. In many applications, this would be equivalent to 15 percent or less of the air handler's design airflow. However, there is no requirement that the central air handler be able to turn down flow to any level. Furthermore, at low airflow levels, multi-zone VAV DX equipment will automatically lock out mechanical cooling, which presents significant challenges to occupant comfort and system energy performance at low loads. This measure will address these issues.

This measure is expected to improve occupant comfort and system efficiency performance for buildings that use this equipment type. Currently, the workarounds for buildings using multi-zone VAV DX systems include a bypass duct or unacceptably high amounts of reheat at the zone terminal units. Both workarounds significantly degrade the energy efficiency performance of the HVAC system. With this new measure in place, manufacturers will be required to offer equipment with significantly improved airflow turndown capabilities, ensuring support for the mechanical cooling system to operate under part-load conditions. This enhancement will be particularly beneficial during periods of very warm ambient temperatures (e.g., >80 °F) with very low occupancy or slightly milder ambient conditions (e.g., 70 °F) when an integrated economizer is appropriate.

2.1.3 Background Information

As of the 2025 Title 24 Part 6 Standards, code requirements are not properly aligned between multi zone (MZ) DX VAV equipment performance and existing airside energy efficiency measures that are geared to limiting airflow to zones where occupancy or demand is low. There is currently a disconnect between what the code requires of equipment in terms of its ability to turn down airflow and the capabilities of some products being offered on the market. If designers or other decision makers are not careful, an inadvertent misalignment could occur from purchasing a DX PVAV unit with limited capabilities in low part load conditions. Measures such as occupied standby and demand-controlled ventilation (DCV) permit airflow rates to dip below mandatory minimum values. If enough zones are lightly occupied or unoccupied simultaneously, then it is highly likely that the cumulative demand on the unit will be less than 50 percent of rated airflow. However, it is also likwly that there is some demand for mechanical cooling in these situations, and if the unit cannot provide mechanical cooling at an airflow rate of, say 25 percent of design airflow, then significant problems will arise for the building in terms of comfort and efficiency.

This measure is based on the approved ASHRAE Addendum u to 90.1-2022. Work on this addendum began in 2023 and concluded in December 2024 with its passage by the full committee and publication on December 31, 2024. The driver of this measure was feedback from design consultants that pointed out the inability of MZ VAV DX systems to perform in a manner consistent with other airflow-limiting code requirements such as occupied standby and DCV. Furthermore, building occupancy habits changed significantly during the COVID-19 pandemic and resulted in much lower occupancy rates in general, which helped bring this equipment shortcoming to the forefront of everyone’s attention. Even if occupancy rates rebound in the coming years, it remains the case that on many occasions, building ventilation rates will be allowed by code to drop to less than 50 percent of design airflow rates. And it is also true that in lots of instances, there will be some demand for mechanical cooling during low airflow conditions, which makes this measure an important advancement in MZ VAV DX equipment capabilities.

2.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See 02.5.6 of this report for detailed revisions to code language.

2.1.4.1 Energy Code Change Summary

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

Subsection 140.4(m): This is a new requirement that requires manufacturers to provide equipment that does not lock out the unit's mechanical cooling capabilities at all part-load airflow settings would be added. Since this measure is directly based on Addendum u to ASHRAE 90.1 2022, federal pre-emption is not an issue. In addition, the system must be configured to be able to turn down to 15 percent of design airflow even if the sum of the primary airflows at the VAV boxes is more than that. This allows the system to take advantage of DCV and occupied standby.

2.1.4.2 Reference Appendices Change Summary

Nonresidential Appendix (NA) 7 – Installation and Acceptance Requirements for Nonresidential Buildings and Covered Processes: The proposed changes update the acceptance testing for multizone VAV equipment to demonstrate that the system can reduce airflow to 15 percent of design and that mechanical cooling is available. Testers will use the BMS system to fully close the outside air dampers and enough VAV boxes until the remaining boxes account for no more than 25 percent of the system's design airflow. The maximum airflow for those boxes will be reduced to 15 percent of the system design airflow. Finally, the setpoint in those zones will be reduced to force mechanical cooling to engage. The entire test is performed at the central controller. Technicians will not need to manually adjust VAV boxes or climb to the roof.

2.1.4.3 Compliance Manuals Change Summary

The "Prescriptive Requirements" subsection to "HVAC System Control Requirements" in Chapter 4 of the 2025 Nonresidential Compliance Manual will need to be modified to describe the changes being proposed in this measure. Designers will need to calculate the required minimum airflow for mechanical cooling and include it in their schedules. Manufacturer submittals will need to include confirmation that mechanical cooling is or can be enabled to that level. In cases where the equipment controls are not set to meet the requirement from the factory, designers will need to instruct technicians to adjust the minimum airflow.

2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The ACM Reference Manual would be modified to better describe more capable PVAV equipment features that would result from the passage of this measure. The specific modifications would be to update the PVAV first stage cooling parameters in the energy modeling software so that it can provide better capacity modulation in part loads. Currently PVAV systems are modeled with two stages of cooling in the standard design (as described in section 5.7.5.3 of the 2025 NRMF ACM Reference Manual), which would be unlikely to meet the requirements in this measure. Detailed markups are shown in section 2.6.6.

2.1.4.5 Compliance Forms Change Summary

The compliance forms would change by adding fields to NRCC-MCH-E that describe the new prescriptive requirements of 15 percent airflow turndown with no DX lockout. These fields would be intended to ensure that designers are prompted to include these aspects in their design drawings and specifications. In addition, the NRCA-MCH-07-A “Supply Fan Variable Flow Controls” form would be modified to reflect the proposed changes to the acceptance test.

2.1.5 Measure Context

2.1.5.1 Comparable Model Codes or Standards

As noted above, this measure is based on Addendum u to ASHRAE 90.1-2022, which was officially approved on December 31, 2024, and will appear in the 2025 edition of ASHRAE 90.1. Further, the measure will be included in the 2027 edition of the International Energy Conservation Code (IECC). Additionally, the United States Department of Energy finalized new appliance standard requirements for unitary equipment that is expected to impact multizone VAV DX products, which will take effect on January 1, 2029. This measure does not violate pre-emption because it is based on ASHRAE 90.1-2022 Addendum u.

2.1.5.2 Interactions with Other Regulations

The proposed measures do not conflict with other state or federal laws and regulations. This measure will not be federally pre-empted, because the design requirement to not lock out mechanical cooling above 15 percent of design airflow or the sum of design minimum airflows will be in ASHRAE 90.1-2025. The Energy Policy and Conservation Act allows states to adopt higher equipment efficiency and design requirements for commercial unitary air conditioners and heat pumps if those requirements are identical to or less stringent than those in ASHRAE 90.1.

Link to addendum u to ASHRAE 90.1-2022:
https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2022_u_20241231.pdf

2.2 PVAV Turndown - Compliance and Enforcement

2.2.1 Compliance Considerations

First, it is important to understand that this measure enables compliance with the established requirement that the minimum airflow for individual zones does not exceed the minimum required outdoor airflow. When equipment cannot provide mechanical cooling at that airflow rate, building operators are forced to violate the requirement to maintain the cooling setpoint.

We expect that most manufacturers will be able to comply with this measure, as the requirement will be published in ASHRAE 2025 and is in the published draft of IECC 2027. The IECC proposal received only one public comment, and that was editorial. Further, the new DOE test procedure for commercial air conditioners and heat pumps encourages manufacturers to provide mechanical cooling at low airflows.

Section 2.1.4 outlines the new considerations for designers, installers, acceptance-testing technicians, and code officials. Designers need to ensure they specify equipment that can reduce airflow to 15 percent of the design without locking out mechanical cooling. Installers or control technicians must ensure the equipment controls are configured correctly.

Acceptance-testing technicians will need to understand the expanded test. They will need to refer to the equipment schedules to determine the design airflow and, if necessary, calculate 15 percent of that. Unlike the existing test, which only requires showing the fan can be turned down to an unspecified value, they will need to understand the VAV box airflow schedule to determine which boxes to shut off and the required maximum airflow for the remaining boxes. Finally, the technician must confirm that mechanical cooling is enabled by recording the temperature drop between the return and supply air.

Education must be provided to code officials so they understand the requirements. More importantly, the code official must understand that if the central air handler or air conditioner cannot provide mechanical cooling at 15 percent of airflow, it is likely that the minimum airflows will be reset upwards to provide necessary cooling.

As noted elsewhere in this report, this measure is directly based on the approved Addendum u to ASHRAE 90.1-2022. Therefore, manufacturers are already obliged to provide compliant products to any jurisdiction that adopts ASHRAE 90.1-2025. The measure’s presence in California’s Title 24, Part 6 energy code provides an added signal to the manufacturers that this measure will exist in actual state building codes (as opposed to 90.1, which is a model code).

The primary audience of this measure is the manufacturers. The measure requires a certain level of airflow turndown (i.e., 15 percent of design airflow) along with continued ability to enable DX cooling at these low airflow levels in multizone unitary VAV equipment. This capability is fully within the purview and control of the manufacturer.

Some form of manufacturer label or attestation of Title 24, Part 6 compliance with this measure would be helpful. A historical issue with this capability has been the opacity regarding the degree to which equipment can turn down airflow rates as well as which specific airflow rate that mechanical cooling is locked out. This has inhibited designers from specifying the correct equipment. Better advertising of equipment capabilities in manufacturer literature would be beneficial to designers and equipment purchasers.

The Statewide CASE Team is recommending changes to the acceptance test for multizone VAV units to ensure compliance with this measure. The new testing requirements will confirm that the unit can turn down to at least 15 percent of design airflow and confirm the fact that the compressor is not locked out at the minimum airflow rate.

2.2.2 Impact on Market Actors

Table 3 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 3: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders [a]	Equipment that meets this requirement will likely be more expensive than non-compliant equipment.	Make sure builders are aware of the large energy savings and that compliance with Sections 140.4(c) and 140.4(d) is difficult without meeting this requirement.
Design Professionals [b]	Designers must specify the minimum airflow at which mechanical cooling is enabled.	Use local ASHRAE chapters and CI team trainings to raise awareness and ensure capabilities are reflected in designs.
Construction Team [c]	Must understand the requirement and be prepared to set the equipment controls to meet the requirement.	Outreach through Energy Code Ace and manufacturer training.
Building Departments [d]	Must be vigilant for low fan turndown and compressor non-lockout issues when PVAV systems are integrated into designs.	Inform officials about new requirements through newsletters and training sessions.
Verification Testers [e]	Modification to the PVAV acceptance test to ensure new measure requirements are met.	The proposed acceptance test modifications are very straightforward and should be easily understood by testers once they are made aware.
Building Owners, Managers, and Occupants	Reduced energy bills and improved occupant comfort.	Awareness of new equipment capabilities will enable building owners to demand compliant products. Relevant trade associations could be contacted to spread awareness.
Manufacturers and Distributors	Manufacturers may need to redesign their in-scope equipment to allow for lower achievable airflow rates and eliminate compressor lockout. An enhanced description of these equipment capabilities in the product literature would also benefit the industry. Distributors should be aware of these new features but otherwise should not experience much of a change.	Manufacturers are aware of this upcoming requirement due to the ASHRAE 90.1-2022 Addendum u measure passing in 2024. Additional outreach by the CI team could underscore the need to have compliant equipment in time for the 2028 code cycle's enforcement period which begins on 1/1/2029.

a. Builders include builders and developers.

b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.

c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plan reviewers, building inspectors, specialty inspectors, permit counter technicians, and sustainability department staff.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. The analysis in the methodology report is not specific to the code change presented in this report. The following provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Manufacturers. As noted elsewhere, this measure may result in the need for certain PVAV equipment manufacturers to perform a one-time product redesign to meet the proposed requirements. Our research indicates that some manufacturers already produce compliant products, but others have indicated that changes are needed. This impact could be passed down to the consumer through higher equipment costs. To our knowledge, none of the major HVAC manufacturers are California-based businesses or manufacture products in California.

Another driver for manufacturers is the new federal test procedure that will encourage manufacturers to provide equipment that can mechanically cool at low airflows. The new cooling metric is called Integrated Ventilation, Economizing, and Cooling Efficiency (IVEC), and is designed to emphasize performance at low part load conditions. While the new test procedure and new energy conservation standards that also take effect on January 1, 2029, do not directly require any level of fan turndown, equipment ratings will be significantly penalized if mechanical cooling will not operate at 25% of the rated airflow. The IVEC test procedure was finalized in 2023, and manufacturers have been working since then to redesign equipment.

2.2.3 Compliance Software Updates

This measure is intended to result in an increase in the performance capabilities of multizone unitary VAV equipment in terms of enhanced airflow turndown capabilities and the elimination of compressor lockout in low airflow conditions. As such, the new, lower airflow capabilities paired with mechanical cooling should be available to modelers in the compliance software. Any updates to compliance software would be minor adjustments to current capabilities. No additional modeling objects are expected to be needed; rather, adjustments to input settings and parameter ranges are what would be needed to address this measure.

2.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

There is some incremental enforcement cost due to the acceptance testing taking a little longer. However, the proposed modification to the acceptance test will increase the time required by not more than a few hours, and probably much less, as all the testing can be conducted through the BMS system. To be conservative, we included an additional eight hours for a tech at $250/hour in the cost-effectiveness calculation.

2.3 PVAV Turndown - Market and Economic Analysis

2.3.1 Market Structure and Availability

2.3.1.1 Current Market Structure and Availability

PVAV equipment has been on the market for decades and is a mature product. All major HVAC manufacturers produce a version of this product. A review of the AHRI Directory [1] indicates 34 brands, though some of these brands are subsidiaries of a parent brand) are listed for unitary large equipment at capacities greater than 240,000 Btu/h (which is a proxy for PVAV systems). There are 9,587 active listings in the AHRI database for sale in the United States as of August 2025.

While products comply with the current prescriptive requirement to provide 50 percent airflow turndown for multizone VAV systems, designers typically specify much lower turndown. Not all equipment on the market today can turn down to 15 percent of design airflow. Additionally, some products will lock out the compressor at a relatively high airflow, anecdotally, 40 percent of design airflow. This presents significant challenges with efficiently providing space conditioning in part loads.

Major manufacturers have asserted that their equipment already complies with this measure’s requirements and that they would not incur product redesigns. During the ASHRAE 90.1 proceeding, two manufacturers expressed concern about requiring turndown to 15 percent, but in the end agreed that they could do it. The same proposal is included in the draft of IECC 2027, and no manufacturer submitted a public comment. One of the manufacturers that submitted a comment to ASHRAE 90.1 was a member of the IECC committee and voted in favor of the proposal.

1 https://www.ahridirectory.org/https://www.ahridirectory.org/

Designers have noted that it can be challenging to find information on compressor lockout at low airflow in product literature. However, as this will be a national requirement, designers from all over the country will request this information, which will lead manufacturers to include it.

2.3.1.2 Market Challenges and Solutions

The market challenges for this system type include a lack of clarity around how low the equipment can deliver airflow without cycling and at what part load airflow rate the compressor is locked out. This lack of clarity impacts designers, installers, and building owners. Designers may have difficulty specifying the correct products for the job due to a lack of information from manufacturers.

This measure is expected to result in some product redesigns for units that are currently unable to reduce airflow to 15 percent of design capacity or lock out compressor operation at low airflow rates. Without redesigns, some equipment could encounter issues with oil return or coil freezing. However, it is worth noting that, since the requirement will be in ASHRAE 90.1-2025, manufacturers must meet these design requirements regardless of whether they are adopted in Title 24.

There are several options available to manufacturers to modify their equipment to meet this measure's requirements: adding a reheat coil (already a standard option), hot gas bypass to allow mechanical cooling at low airflow, smart control logic for intelligent cycling control of compressor stages in the unit, adding baffles, creatively redesigning coil circuiting, supply air temperature reset controls, and adding additional stages of mechanical cooling (including introducing variable speed, variable capacity, digital, two-stage, or multiple compressors in the unit). It is important to reiterate that with Addendum u to ASHRAE 90.1-2022, manufacturers must undertake this work regardless of the outcome of this Title 24, Part 6 code change proposal.

See Section 2.2 for a description of workforce training that may be needed to ensure effective design, installation, and commissioning.

2.3.2 Design and Construction Practices

2.3.2.1 Current Design and Construction Practices

The current best practice for dealing with this equipment limitation is to install a bypass duct in the air distribution system. The purpose of the bypass duct is to prevent conditioned supply air from being delivered to zones at excessive rates when there is a low demand for cooling. Without a bypass duct, the zones would be overcooled which would trigger reheating energy in the terminal units, which is not energy efficient. Furthermore, the bypass duct recirculates air, which wastes fan energy.

As noted above, some manufacturers do produce compliant products; however, it can be difficult to ascertain which ones comply due to insufficient labeling and advertising of these capabilities in product literature. This places a burden on designers and equipment procurers to conduct significant research prior to specifying and purchasing equipment.

Recent changes to code requirements and building occupancy patterns are increasing the need for more clarity around the technical capabilities of PVAV equipment. Code measures such as DCV and occupied standby are contributing to reductions in airflow requirements on the system during part-load conditions. As noted above, the pandemic has led to lower commercial building occupancy patterns, further depressing the need for airflow delivered to the zones.

If a bypass duct and compliant products are not installed in the building, a 'last resort' workaround would be to elevate the zone terminal unit's minimum airflow settings to ensure the system remains effective. As noted above, this would result in unnecessary amounts of reheat energy being used at the terminal unit, which may violate Title 24, Part 6 limitations on simultaneous cooling and heating.

2.3.2.2 Health and Safety Considerations

There are no health and safety considerations or impacts.

2.3.2.3 Design and Construction Challenges and Solutions

This measure is seen as a critical enhancement to the PVAV equipment so that it can continue to satisfy evolving building needs. As noted elsewhere in this report, measures that reduce airflow delivered to zones in low load and/or low occupancy periods are becoming increasingly widespread in recent years (both in California as well as nationally). Equipment must be able to turn down airflow to sufficiently low rates to efficiently provide conditioning in light of new code requirements. Additionally, as noted elsewhere, the lack of clarity around which specific PVAV options can deliver this capability is a major barrier to the design and construction community. This measure would level the playing field by providing assurance to the entire stakeholder community.

Due to the lack of advertised minimum airflow settings and compressor lockout controls for PVAV equipment, some designers and installers are not even aware of these limitations prior to installation and startup. This could result in the aforementioned challenges with energy efficiency and occupant comfort. This barrier would be overcome by this measure in the sense that stakeholders would gain confidence that all products on the market can meet low airflow conditions without locking out the compressor.

See Table 3 in Section 2.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

2.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities,[2] including impacts related to race, class, and gender.

This measure is expected to have no disproportionate impact on ESJ communities.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Please reach out to Bryan Boyce (bboyce@energy-solution.com) if you have input on how this proposal may impact ESJ communities or if you would like to offer your perspective.

2.3.4 Impacts on Jobs and Businesses

There will be negligible impacts on businesses. As this measure will likely increase the cost of replacement RTUs, some businesses may choose to repair a unit instead of replacing it. There will be little effect on jobs since there are no RTU manufacturers in California.

2.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

[2] The CPUC refers to ESJ communities as “low-income or communities of color that have been underrepresented in the policy setting or decision-making process, are subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socio-economic investments in their communities” (CPUC 2022). ESJ communities also include the CPUC definition for Disadvantaged Communities, which comprises “(1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0 (1,984 tracts); (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores (19 tracts); (3) Census tracts identified in the 2017 DAC designation as disadvantaged, regardless of their scores in CalEnviroScreen 4.0 (307 tracts); and (4) Lands under the control of federally recognized Tribes (OEHHA 2022).

2.4 PVAV Turndown - Cost Effectiveness

2.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost-effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on Long-term System Cost (LSC), which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

2.4.2 Energy and Energy Cost Savings Results

PVAV systems are commonly found in three types of buildings - Medium Offices, Large Schools, and Medium Laboratories. For this analysis, only the Medium Office was modeled for two reasons: (1) The Large School and Medium Laboratory prototypes are not available for CBECC 2025, and (2) the per-square-foot savings in schools and labs will be much smaller than medium offices because the measure will only save money when a large number of spaces have low outdoor airflow when the spaces are empty and demand control ventilation is in effect.

The Statewide CASE Team believes that the vast majority of the applications will be alterations in existing buildings. For new buildings and additions, 50 percent of the floor space is expected to be served by PVAV, which is 7.7 million square feet per CEC construction forecast. For existing medium office buildings, the Statewide CASE Team assumes 80 percent is served by PVAV systems that are replaced every 15 years. Per the CEC existing building stock, the measure would apply to 515.2 million square feet each year.

Modifications to the CBECC Medium Office Baseline

The original baseline .idf file was created using CBECC 2025 v1. It was subsequently modified to reflect realistic conditions in existing buildings and new buildings constructed to meet the prescriptive code. The changes detailed below apply to the following components:

- Design zone airflow
- Use of single-duct VAV boxes instead of parallel boxes
- Limiting supply air temperature reset to 58ºF
- Updates to occupancy, lighting, and receptacle schedules

Design Air Flow

Section 5.6.7 of the 2025 Alternative Calculation Manual prescribes that the design airflow for a zone is based on the following:

> The standard design peak cooling load is based on a supply-air-to-room-air temperature difference of 20°F for exterior zones or 15°F for interior zones, the required ventilation air from Table 120.1-A of the Energy Code, or makeup air, whichever is greater.

For the medium office model, this yields a design airflow of about 0.7 cfm/ft^2, which is much less than the typical 1.0 cfm/ft^2 used by most engineers. The low design airflow drives the PVAV unit to an airflow that results in 260 cfm/ton at design conditions, which, even if it is unrealistic, is undesirable in California's dry climate. The Statewide CASE Team modified the design airflow to 1.0 cfm/ft^2 which yielded 360 cfm/ton, a more realistic result.

The change was implemented by:

1. For *sizing:zone*, change the *Cooling Design Airflow Rate* from autosize to 1.0 cfm/ft^2.
2. For *AirTerminal:SingleDuct:ParallelPIU:Reheat* and *AirTerminal:SingleDuct:VAV:Reheat*, changing *Maximum Airflow Rate* from a fixed value to autosize.

Convert Parallel VAV Boxes to Single Duct

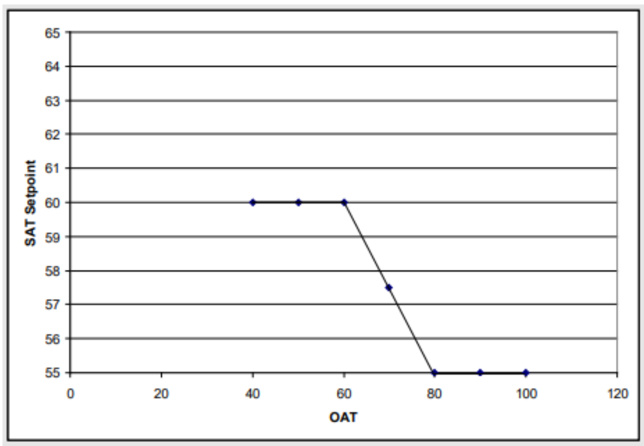
There is a new language in Title 24-2025 that prescribes parallel VAV boxes for perimeter zones in Section 140.4(a)(3)(A). Colder climates must have parallel boxes on all perimeter zones, and warmer climates on 25 percent of the zones. The reality is that single-duct VAV boxes are used in existing stock, and it is likely they will be used in new construction that follows the performance path. The purpose of requiring parallel boxes is to prevent the need to reheat cooled air when the zone is in heating mode, as the primary air damper can be closed, and ventilation is supplied by transfer air. If single duct boxes are used, the primary air damper must be set to provide the minimum flow, which increases reheating.

Converting each parallel box in the .idf files to single-duct boxes would have been extremely time consuming. Instead, the *Fan on Flow Fraction* object in *AirTerminal:SingleDuct:ParallelPIU:Reheat* was changed from 0 to 0.3 to match the primary airflow fraction during cooling.

Supply Air Temperature Reset

The ACM Reference Manual specifies that in the baseline building, the supply air temperature (SAT) reset should be such that the SAT should increase from 55ºF to 60ºF based on outdoor temperature, using the relationship shown in Section 5.7.2.3, Figure 7:

Figure 7: SAT Cooling Setpoint Reset Based on Outdoor Air Temperature (OAT)



Source: California Energy Commission

However, the Statewide CASE Team's design engineer, who has designed and reviewed many PVAV systems, believes that 60ºF is not normal, and that a maximum of 58ºF is representative of real-world installations.

The Maximum Setpoint Temperature object in *SetpointManager:Warmest* was changed from 60ºF to 58ºF.

Updates to occupancy, lighting, and receptacle schedules

The occupancy, lighting, and plug loads schedules have been modified away from default values to reflect more realistic occupancy patterns in commercial buildings. These changes are based on the professional judgment of an HVAC design engineer on the Statewide CASE Team. The changes are further described in Appendix A.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 4. Per-unit savings for the first year are expected to range from 0.81 to 2.74 kWh/yr, depending upon climate zone. Demand reductions/increases are expected to range between -0.38 kW and 0.78 kW, depending on climate zone.

Table 5 presents total per-unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 4: Energy and Energy Cost Savings – Per Square Foot Medium Office

Climate Zone	First Year Electricity Savings (kWh)	First Year Peak Demand Reduction (kW)	First Year Natural Gas Savings (kBtu)	First Year Source Energy Savings (kBtu)	Total 30-Year LSC Savings (2029 PV$)
1	1.22	(0.06)	0	1.76	10.19
2	1.26	0.02	0	1.91	10.72
3	1.49	0.06	0	2.33	12.88
4	1.13	0.09	0	1.76	9.75
5	1.41	0.13	0	2.18	12.34
6	1.62	0.04	0	2.52	14.07
7	1.60	0.02	0	2.56	14.13
8	1.43	(0.01)	0	2.30	12.79
9	1.24	(0.01)	0	2.00	10.78
10	1.21	(0.04)	0	2.01	10.74
11	1.11	(0.02)	0	1.69	9.41
12	1.14	(0.11)	0	1.66	9.57
13	1.09	(0.06)	0	1.81	9.35
14	0.87	0.05	0	1.33	7.50
15	0.86	(0.05)	0	1.60	7.52
16	0.72	0.14	0	1.15	6.68

Table 5: 2029 PV LSC Savings Over 30-Year Period of Analysis – Per Square Foot – Alterations – Medium Office

Climate Zone	30-Year LSC Electricity Savings (2029 PV$)	30-Year LSC Natural Gas Savings (2029 PV$)	Total 30-Year LSC Savings (2029 PV$)
1	7.85	0.79	8.63
2	8.67	0.69	9.36
3	11.38	0.44	11.82
4	8.20	0.54	8.74
5	10.84	0.51	11.34
6	13.83	0.07	13.90
7	14.02	0.03	14.05
8	12.40	0.13	12.54
9	10.26	0.18	10.44
10	10.01	0.25	10.26
11	7.75	0.60	8.34
12	8.54	0.38	8.92
13	8.07	0.43	8.50
14	6.61	0.33	6.94
15	7.24	0.08	7.32
16	5.46	0.47	5.93

2.4.3 Incremental First Cost

When addendum u to ASHRAE 90.1-2022, was discussed during an SSPC 90.1 Mechanical Subcommittee meeting, the proponent, who represents a manufacturer, claimed there would be zero incremental cost, because there are many units on the market that already have the capability to reduce airflow to 15 percent of design airflow. The Statewide CASE Team does not agree that there is no incremental cost.

The Statewide CASE Team interviewed other manufacturers who make products that do not turn down so low, even with variable-speed compressors, though they concede it is technically possible with variable-capacity compressors, hot-gas bypass, or hot-gas reheat coils. Our literature review shows that manufacturers who make equipment meeting the proposed requirement offer options are not standard. Therefore, the first cost must be higher than for a standard unit.

To be conservative, the Statewide CASE Team used the incremental cost to go from a unit that has only single-speed compressors to an equivalent one that has one variable-speed compressor and single-speed for the other compressors. There is limited public information on the cost of PVAV units, as they tend to be larger equipment sold through manufacturers' representatives. Furthermore, publicly available quotes are not useful, as they typically bundle equipment, installation, and ancillary work into a single price. However, the Statewide CASE Team found a publicly available Government Services Agency contract price list for one manufacturer, effective from 2024 to 2029. The largest variable speed RTU on the list costs $9,000 more than the standard unit. The variable speed unit does have higher-quality construction, but the Statewide CASE Team attributes the entire cost increase to the compressor.

The medium office building prototype has three 50-ton units. To get to an incremental cost for the units, we made the following conservative assumptions:

- For a 50-ton unit, the Statewide CASE Team multiplied the cost by two (now $18,000/unit)
- A contractor will pay 25 percent more than the GSA (now $22,500/unit)
- The contractor will mark up the cost to the customer by 40 percent (now $31,500/unit)

With three units on the building, the incremental cost for the equipment is $94,500. No other equipment is different.

Since the Statewide CASE Team proposes a modification to acceptance testing that will take longer to complete, an additional 8 hours of technician time at $250 per hour has been included. No additional labor costs are expected.

2.4.4 Incremental Maintenance and Replacement Costs

Description of the incremental maintenance and replacement costs, and estimation of the present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report.

The only notable difference between variable-capacity and standard-capacity RTUs is the compressor. The Statewide CASE Team assumes the compressor will be replaced after ten years, within the unit's estimated 15-year service life. A comparison of the list prices of appropriately sized fixed-speed and variable-speed compressors, based on a review of parts suppliers, showed an estimated $3,000 incremental cost per compressor for the variable-speed option, with an estimated $9,000 incremental maintenance cost in year ten.

2.4.5 Cost Effectiveness

Results of the per-unit cost-effectiveness analyses are presented in Table 6 and Table 7 for new construction/additions and alterations, respectively

In the tables below, all values are presented in 2026 present value dollars (2029 PV$). Benefits represent 30-year LSC savings and other savings, including incremental first-cost savings if the proposed first cost is less than the current first cost, incremental maintenance cost savings if the proposed maintenance costs are less than the current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including equipment, replacement, and maintenance costs over the analysis period. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero, the benefit-cost ratio (BCR) is considered infinite. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate. If there are no total incremental PV costs, the BCR is infinite.

Table 6: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	10.19	1.87	5.45
2	10.72	1.87	5.74
3	12.88	1.87	6.89
4	9.75	1.87	5.22
5	12.34	1.87	6.60
6	14.07	1.87	7.53
7	14.13	1.87	7.56
8	12.79	1.87	6.85
9	10.78	1.87	5.77
10	10.74	1.87	5.75
11	9.41	1.87	5.04
12	9.57	1.87	5.12
13	9.35	1.87	5.00
14	7.50	1.87	4.01
15	7.52	1.87	4.02
16	6.68	1.87	3.58

Table 7: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	8.63	1.87	4.62
2	9.36	1.87	5.01
3	11.82	1.87	6.33
4	8.74	1.87	4.68
5	11.34	1.87	6.07
6	13.90	1.87	7.44
7	14.05	1.87	7.52
8	12.54	1.87	6.71
9	10.44	1.87	5.59
10	10.26	1.87	5.49
11	8.34	1.87	4.47
12	8.92	1.87	4.78
13	8.50	1.87	4.55
14	6.94	1.87	3.71
15	7.32	1.87	3.92
16	5.93	1.87	3.18

2.5 PVAV Turndown - Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context of estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 8) and alterations (Table 9) by climate zone. Table 10 presents first-year statewide savings from new construction, additions, and alterations.

Table 8: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	65,100	0.08	(0.00)	0	0.11	$0.66
2	238,050	0.30	0.00	0	0.45	$2.55
3	686,000	1.02	0.04	0	1.60	$8.83
4	372,100	0.42	0.03	0	0.66	$3.63
5	185,250	0.26	0.02	0	0.40	$2.29
6	600,500	0.97	0.02	0	1.52	$8.45
7	402,300	0.64	0.01	0	1.03	$5.68
8	823,000	1.17	(0.01)	0	1.90	$10.53
9	1,592,000	1.97	(0.02)	0	3.18	$17.17
10	587,000	0.71	(0.02)	0	1.18	$6.31
11	134,250	0.15	(0.00)	0	0.23	$1.26
12	1,399,500	1.60	(0.16)	0	2.32	$13.39

13	292,950	0.32	(0.02)	0	0.53	$2.74
14	174,100	0.15	0.01	0	0.23	$1.31
15	131,450	0.11	(0.01)	0	0.21	$0.99
16	51,000	0.04	0.01	0	0.06	$0.34
Total	**7,734,550**	**9.91**	**(0.08)**	**0**	**15.61**	**$86.13**

Table 9: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	135,160	0.13	0.01	0.12	0.27	$1.17
2	1,239,600	1.30	0.05	0.97	2.53	$11.61
3	3,151,600	4.30	0.08	1.50	7.31	$37.25
4	1,691,200	1.64	0.05	1.01	3.08	$14.78
5	532,800	0.67	0.02	0.31	1.19	$6.04
6	1,912,400	3.05	0.01	0.13	4.80	$26.57
7	1,754,800	2.79	0.00	0.06	4.48	$24.66
8	2,364,400	3.29	0.02	0.32	5.34	$29.64
9	3,453,600	4.10	0.03	0.63	6.72	$36.04
10	2,667,600	3.04	0.04	0.68	5.20	$27.36
11	677,600	0.63	0.02	0.44	1.18	$5.65
12	4,068,000	4.18	0.09	1.72	7.03	$36.29

13	1,007,200	0.97	0.02	0.46	1.77	$8.56
14	533,200	0.41	0.01	0.18	0.70	$3.70
15	410,000	0.34	0.00	0.03	0.64	$3.00
16	162,520	0.09	0.00	0.09	0.21	$0.96
Total	**25,761,680**	**30.95**	**0.45**	**8.64**	**52.45**	**$273.28**

Table 10: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
New Construction & Additions	9.91	(0.08)	0.00	15.61	86.13
Alterations	30.95	0.45	8.64	52.45	273.28
Total	**40.86**	**0.37**	**8.64**	**68.06**	**359.41**

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 11 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid xx metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, and data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 11: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	826	0	826	101,697
Alterations	2,383	451	2,834	348,961
Total	**3,209**	**451**	**3,660**	**450,658**

2.5.3 Statewide Water Use Impacts

The proposed code change will not result in water use impacts.

2.5.4 Statewide Material Impacts

This measure is not expected to result in a meaningful change to materials.

2.5.5 Environmental Impacts

This proposal would result in improved building energy efficiency and corresponding GHG emissions reductions. The requirement ensures that PVAV systems can efficiently turn down fan speeds during part load conditions without disabling compressor operation if needed.

There are no identified indirect adverse environmental impacts nor indirect environmental benefits from this code change proposal.

2.5.6 Other Non-Energy Impacts

This measure is not expected to result in any non-energy impacts.

2.6 PVAV Turndown - Proposed Code Language

2.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

2.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

2.6.3 Energy Code (Title 24, Part 6)

Section 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(m) Fan and mechanical cooling control. Each cooling system listed in Table 140.4-I shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

1. Single-zone DX and chilled water cooling systems ~~that control the capacity of the mechanical cooling directly based on occupied space temperature~~ shall:

   A. Have a minimum of two stages of fan control with no more than 66 percent ~~speed~~ design airflow when operating on stage 1; and

   B. Draw no more than 40 percent of the fan power at ~~full fan speed~~ design airflow, when operating at 66 percent ~~speed~~ of design airflow.

2. ~~All other systems, including but not limited to~~ Multiple-zone VAV DX cooling systems and chilled water systems ~~that control the space temperature by modulating the airflow to the space~~, shall have ~~proportional~~ modulating fan control. ~~such that at~~ At 50 percent air flow the power draw ~~is no more than~~ shall not exceed 30 percent of the fan power at full fan speed.

3. Multiple-zone VAV DX cooling systems and chilled water systems shall be configured to be able to reduce airflow from the supply fan to the larger of 15 percent of design airflow or the minimum outdoor airflow required in Section 120.1(c)3. The system shall be capable of providing mechanical cooling at that airflow.

Exception to Section 140.4(m)3: *Group R occupancies and common or public use areas.*

2.6.4 Reference Appendices

***NA7.5.6* Supply Fan Variable Flow Controls**

NA7.5.6.1 Construction Inspection

Prior to Functional Testing, verify and document the following:

(a) Supply fan includes device(s) for modulating airflow, such as variable speed drive

or electrically commutated motor.

(b) For multiple zone systems:

1. Discharge static pressure sensors are either factory calibrated or field calibrated.
2. The static pressure location, setpoint, and reset control meets the requirements of §140.4(c)2A and §140.4(c)2B.
3. The central fan(s) and compressor(s) are capable of and configured to meet the requirements of §140.4(m)3.

NA7.5.6.2 Functional Testing

Step 1: Simulate demand for full design airflow. Verify and document the following:

(a) Supply fan controls modulate to increase capacity.

(b) For multiple zone systems, supply fan maintains discharge static pressure within

+/-10 percent of the current operating setpoint.

(c) Supply fan controls stabilize within a 5 minute period.

Step 2: For multiple zone systems, ~~Simulate demand for reduced or minimum airflow~~,

1. Close the outdoor air dampers.
2. Close and turn off or reduce the maximum airflow of enough air terminal dampers such that the full airflow of the remaining air terminals is not more than the greater 15 percent of the system design airflow or the minimum outdoor airflow required in Section 120.1(c)3.
3. Reduce the temperature setpoint in those zones enough to engage mechanical cooling.
4. Verify and document the following:

(d) Supply fan controls modulate to decrease ~~capacity~~ airflow to the greater of 15 percent of the system design airflow or the minimum outdoor airflow required in Section 120.1(c)3.

(e) Confirm that mechanical cooling is operating by showing a temperature drop of not less than 5ºF between the return and supply air.

(~~e~~f) Current operating setpoint has decreased (for systems with DDC to the zone level).

(~~f~~g) The supply fan maintains discharge static pressure within +/-10 percent of the current operating setpoint.

(~~g~~h) Supply fan controls stabilize within a 5 minute period.

Step 3: Restore the system to the correct operating conditions.

2.6.5 Compliance Manuals

The Statewide CASE Team will provide the CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

2.6.6 ACM Reference Manual

Table 2: System Descriptions

System Type	Description	Detail
System 5 – PVAV	Packaged VAV	Multizone packaged system with variable-air-volume fan, direct expansion cooling, and hot water heating provided by central gas boiler. See Table 3: System 5 – PVAV and System 6 – VAV: Standard Design Criteria for additional system details.
System 6 – VAV	Built-up VAV	Multizone built-up system with variable-air-volume fan, chilled water cooling provided by a central water-cooled chiller and cooling tower, and hot water heating provided by central gas boiler. See Table 3: System 5 – PVAV and System 6 – VAV: Standard Design Criteria for additional system details.
System 15 – PVAVAWHP	Packaged VAV with	Multi-zone packaged system with variable-air-volume fan, direct expansion cooling, and hot water heating provided by an air to water heat

	AWHP heating	pump (AWHP). See Table ~~3~~4: System 15 – PVAVAWHP: Standard Design Criteria for additional system details based on occupancy served and climate zone.

Table 3: System 5 – PVAV and System 6 – VAV: Standard Design Criteria

Note: all other rows remain unchanged.	
Supply air turndown	The PVAV unit is capable of reducing airflow the greater of 15 percent of the system design airflow or the minimum outdoor airflow required in Section 120.1(c)3.
Mechanical Cooling	Mechanical cooling is available at all airflows.
Outdoor airflow control	Demand control ventilation and occupied standby required in Section 120.1 are enabled. *Note: The CASE Team will work with the CEC to create zone occupancy schedules that reflect real-world zone occupancies.*

Table ~~3~~4: System 15 – PVAVAWHP: Standard Design Criteria

	Schools	Offices
Note: all other rows remain unchanged.		
Supply air turndown	The PVAV unit is capable of reducing airflow the greater of 15 percent of the system design airflow or the minimum outdoor airflow required in Section 120.1(c)3.	
Mechanical Cooling	Mechanical cooling is available at all airflows.	
Outdoor airflow control	Demand control ventilation and occupied standby required in Section 120.1 are enabled. *Note: The CASE Team will work with the CEC to create zone occupancy schedules that reflect real-world zone occupancies.*	

5.6.7 Terminal Airflow

5.6.7.1 Variable Air Volume (VAV) Airflow

TERMINAL MINIMUM AIRFLOW

Applicability: Systems that vary the volume of air at the zone level

Definition: The minimum airflow that will be delivered by a terminal unit.

Units: Unitless fraction of airflow

Input Restrictions: Input must be greater than or equal to the outside air ventilation rate. For packaged VAV, built-up VAV, and built-up VAV with AWHP heating where the Control System Type Certified Guideline 36 Libraries specify that certified Guideline 36 libraries are not being used, the modeled minimum airflow shall be the maximum of 2 times the minimum airflow input and 2 times the minimum outside air ventilation rate. For laboratories, users may input separate minimum rates for occupied and unoccupied. The unoccupied rates shall be used when the occupancy schedule indicates an occupancy fraction below 0.10.

Standard Design: For healthcare facilities, same as the Proposed Design. For systems 5, ~~and~~ 6, and 15, packaged VAV units and built-up VAV air handling units, set the minimum airflow to be the maximum of the minimum outside air ventilation rate or 10% of the design airflow.

For laboratories, the occupied minimum airflow fraction shall be fixed at a value equivalent to the greater of the proposed design occupied minimum exhaust requirements or the occupied minimum ventilation rate. The unoccupied minimum airflow fraction shall be 0.33 cfm/ft2 less than the occupied minimum airflow fraction.

5.7.5.3 Direct Expansion

NUMBER OF COOLING STAGES – SYSTEMS OTHER THAN MULTI-ZONE VAV SYSTEMS

Applicability: Single zone VAV systems and DX systems with multiple stages that are not multi-zone VAV systems.

Definition: This applies to single zone VAV and any HVAC systems with multiple compressors or multiple discrete stages of cooling that are not multi-zone VAV systems. This system is a packaged unit with multiple compressors and a two-speed or variable-speed fan.

Units: None (Integer).

Input Restrictions: As designed, but systems with more than 2 stages will be modeled with 2 stages.

Standard Design: The standard design shall be two for the single zone VAV baseline and packaged VAV baseline.

NUMBER OF COOLING STAGES – SYSTEMS OTHER THAN MULTI-ZONE PACKAGED VAV SYSTEMS

Applicability: Multi-zone packaged VAV systems

Definition: This applies to multi-zone packaged VAV systems. This system is a packaged unit with multiple compressors or a variable-speed compressor and a two-speed or variable-speed fan.

Units: None (Integer).

Input Restrictions: As designed

Standard Design: The standard design shall be three for the single zone VAV baseline and packaged VAV baseline.

TOTAL COOLING CAPACITY RATIO BY STAGE – SYSTEMS OTHER THAN MULTI-ZONE PACKAGED VAV SYSTEMS

Applicability: Single zone VAV systems and DX systems with multiple stages that are not multi-zone packaged VAV systems.

Definition: This provides the total cooling capacity of each cooling stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated cooling capacity for the unit. For example, if the first stage cooling capacity is 4 tons (48,000 Btu/h) and the total cooling capacity is 8 tons (96,000 Btu/h), the capacity is expressed as “0.50” for that stage.

Units: Array of fractions.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the default shall be (0.50, 1) for the single zone VAV baseline.

TOTAL COOLING CAPACITY RATIO BY STAGE – MULTI-ZONE PACKAGED VAV SYSTEMS

Applicability: Multi-zone packaged VAV systems.

Definition: This provides the total cooling capacity of each cooling stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated cooling capacity for the unit. For example, if the first stage cooling capacity is 10 tons (120,000 Btu/h) and the total cooling capacity is 50 tons (600,000 Btu/h), the capacity is expressed as “0.20” for that stage.

Units: Array of fractions.

Input Restrictions: As designed.

Standard Design: For healthcare facilities, same as the Proposed Design. For all others, the default shall be (0.2, 0.50, 1) for the multi-zone packaged VAV baseline.

2.6.7 Compliance Forms

As discussed in Section 2.1.4.5, the Statewide CASE Team proposes that NRCC-MCH-E and NRCA-MCH-07-A forms change to reflect the new requirements in this measure.

3. Modulating DOAS

3.1 Modulating DOAS - Measure Description

3.1.1 Proposed Code Change

This measure seeks to establish mandatory and prescriptive requirements for Dedicated Outdoor Air Systems (DOAS) in non-residential new construction and additions and alterations, aligning with cost-effective best practices.

These measures apply to new construction, additions, and alterations (specifically, system replacements and new installations) in all 16 California climate zones.

The proposal would add the following mandatory requirements to section 120.1:

(a) Add a new subsection to 120.1(d) that requires large DOAS systems to include a means (such as air valves) to modulate and/or shut off airflow to individual thermal zone required to have DCV or occupied standby, while maintaining required ventilation to all zones served by the system.

(b) Clarify where Occupied Standby is currently required in Section 120.1(d)5A.This change is intended to improve the efficacy of the HVAC occupied standby measure in both mixed air as well as DOAS systems.

Additionally, the following prescriptive changes are being proposed in section 140.4:

(c) Modification to the language at 140.4(p)2 that describes how the DOAS ventilation air is being delivered to the zone. The intent of this adjustment is to provide additional efficient prescriptive options for the designer.

(d) Revise 140.4(p)4 to adjust the Supply Air Temperature (SAT) requirement from 60°F to 55°F when the building is in cooling mode and add language that limits the system from providing air below 75F when the system is in heating to prevent re-heating or re-cooling. The measure applies to DOAS with cooling, heating (direct and or heat recovery) and ventilation, which serves multiple zones. This aligns with ASHRAE Technical Committee (TC) 1.4's current DOAS RP-1865.

Table 12 summarizes the scope of the proposed code change.

Table 12: Scope of Proposed Code Change

A ☑ indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
☐ Single Family	☑ New Construction (all submeasures)	☑ Mandatory
☐ Multifamily	☑ Additions (submeasures c and d)	☑ Prescriptive
☑ Nonresidential (Not Group R uses)	☑ Alterations	☐ Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	• Part 1, Section • Part 6, Section 120.1, 120.2, 120.5, 140.4 • Nonresidential Reference Appendix Section	NRCC-MCH-E, NRCA-MCH-06-A, NRCA-MCH-19-A	TBD

Third Party Verification)	Updates to Compliance Software
☑ No changes to third party verification	☐ No updates
☐ Update existing verification requirements	☑ Update existing feature
☐ Add new verification requirements	☐ Add new feature

The sub-measures are further distinguished in

Table 13. This table shows which aspects of the proposal require a cost-effectiveness analysis and which sections of the code that they apply to as well as some other key information.

Table 13: Modulating DOAS Submeasure Information

No	Submeasure Name	Code Section	Applicable To	Substantive code change	Upfront Costs	Supporting Analysis
a	Modulating DOAS (Air Valves)	Mandatory	New Construction	Yes	Yes	Full cost-effectiveness
b	Occupied Standby Cleanup	Mandatory	New Construction	No	No	None
c	Supply Air Delivery Option	Prescriptive option	NC, Additions, Alterations	Yes	No	LSC/source parity
d	SAT Revisions to reduce Reheat / re-cooling	Prescriptive requirement	NC, Additions, Alterations	Yes	No	None

3.1.2 Benefits of Proposed Change

Submeasure (a): The most important substantive change of this proposal is the inclusion of a new mandatory requirement in section 120.1(d)6 which specifies that large DOAS systems must modulate airflow. Currently, some DOAS designs do not have outlets for each thermal zone, just one outlet for several thermal zones. This causes the DOAS system to effectively behave like a constant air volume system and prevents the system from meeting occupied standby and DCV. The 2025 edition of Title 24 requires these measures for mixed-air but does not explicitly include DOAS systems. Requiring airflow modulation equipment in DOAS systems allows these systems to comply with occupied standby and DCV, which saves energy by dynamically ventilating the zones as needed.

With this measure, DOAS systems serving spaces required to have occupant sensing ventilation controls shall include modulating pressure independent air valves or other means of modulating outside air at all space conditioning zones. This shall be done to disable ventilation to unoccupied zones while maintaining measured outside air ventilation rates to occupied zones within ten percent of the design minimum outside air ventilation rate per 120.1(f)2 and shall include demand ventilation controls for high-density spaces per 120.1.(d)3.

This aspect of the measure would also ensure that in-scope DOAS systems provide more precise ventilation and airflow management. This will reduce energy consumption and fine-tune the total airflow based on the individual zone requirement, which may consequently result in cooling and heating savings.

Requiring the DOAS system to be variable air volume (VAV) will result in energy savings when controlled properly, in addition to providing system balancing and reducing stress on motors and other components during startup and operation.

Submeasure (b): The proposal also seeks to clarify the occupied standby language in section 120.1(d)5. Currently, occupied standby requirements are drawn from Table 120.1-A and Section 130.1(c)5 and 6, which is believed to result in poor compliance rates since it is very time consuming to understand when which space type may or may not be required to include occupied standby controls for ventilation. This editorial change proposed to simply list the required ventilation occupied standby spaces in one place at 120.1(d)5 which should improve compliance rates and save energy. Figure 1 displays the relationship between 1. Where occupied standby is allowed for ventilation, 2. Where occupied standby is required for lighting, and 3. Where occupied standby is required for ventilation. The issue is that while items 1 and 2 are well articulated in the code, item 3 is just a reference to both other sections and has therefore suffered from poor understanding and compliance in the market.

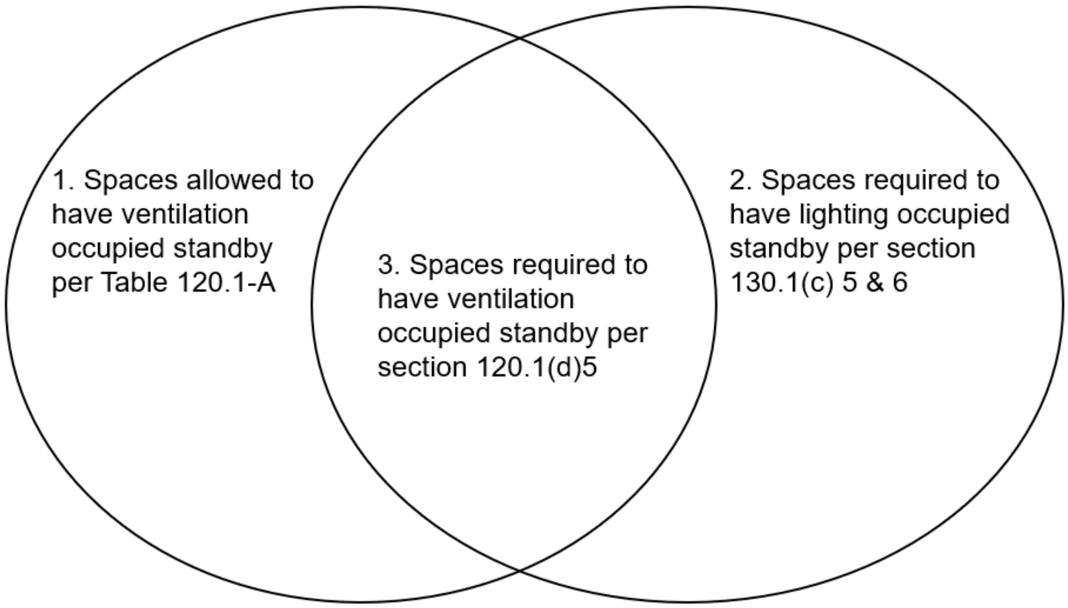


Figure 1: Venn Diagram of Title 24 Occupied Standby Requirements

Submeasure (c): The Statewide CASE Team proposes edits to the allowable ventilation air delivery language at 140.4(p)2. The current language states that the zonal system “shall cycle off any zone heating and cooling equipment fans, circulation pumps and terminal unit fans when there is no call for heating or cooling in the zone.” Cycling off the zonal system just means that the “critical zone” on the DOAS system adds approximately 0.2” in additional external static pressure (ESP) to the central DOAS system. Of course, this means that every other zone also is supplied with that added 0.2” of static and throttles as necessary at terminal unit air valves. So, in practice little to no fan energy is saved since it’s just shifting from the turned-down/low speed zonal fan coil units (FCU) to the DOAS. The other issue is that it means—unless engineers intend to provide separate diffusers for DOAS and zonal terminals—that the DOAS air is discharging into the discharge duct of the FCU. The issue here is that the DOAS air valve and sensible conditioning unit typically don’t communicate with one another, meaning there is the potential that the FCU may be operating at high speed while the DOAS air valve is providing at least minimum ventilation—and possibly more airflow if the DOAS air valve has been sized for economizer duty. There are three issues with that:

(1) It means that the discharge ductwork and diffusers need to be sized for the worst case combined FCU + DOAS airflow

(2) if this is not done, it creates a situation where the FCU discharge ductwork is over-pressurized, possibly causing the FCU to ride back on its curve and deliver less airflow/capacity.

(3) It means the DOAS unit, when FCUs are in heating/cooling, still has to overcome the ESP of the FCU discharge ductwork (which is now greater because the FCU is on, too).

In summary: this approach likely saves no energy, adds costs at the zonal level (larger or more ducts and diffusers) and the central DOAS system (fans sized for greater external static pressure), and creates a possible operational risk without very thoughtful design on the part of the engineer (fans riding back on curves/coil icing). The proposed revisions increase flexibility and would allow air delivery to the inlet of the FCU and let the airflow decrease to the ventilation minimum, avoiding this problem.

Submeasure (d): In the prescriptive section 140.4(p), the Statewide CASE Team also proposes to reduce the DOAS supply air temperature (SAT) from current 60ºF under heating or heat recovery mode to 55°F when most zones require cooling. This will result in energy savings, as preventing warmer air to enter the space would decrease the energy for the space cooling equipment. The current 60°F was based on ASHRAE 90.1 Section 6.5.2.6. ASHRAE TC1.4 has completed a research project (DOAS RP-1865: Optimizing Supply Air Temperature Control for Dedicated Outdoor Air Systems) on revising the SAT. The Statewide CASE Team is proposing 55°F based on this research.

The proposed recommendations will reduce fan energy at part load, eliminate or reduce re-cooling energy of warm ventilation air when the majority of the zones call for cooling, and reduce ventilation system cooling and heating energy for all zones.

3.1.3 Background Information

Allowance for occupied standby in HVAC systems has been in Title 24 Part 6 beginning with the 2013 edition and required for a selection of space types since the 2019 edition. Submeasure a, Air Valves, improves upon the current practice of low levels of DOAS compliance with occupied standby and DCV measures that are interpreted to only apply to mixed-air systems.

A DOAS is an energy-efficient HVAC system that maintains indoor air quality by bringing fresh air into interior spaces and handling ventilation independently from heating or cooling. Unlike multi-zone VAV systems (e.g. VAV reheat) that mix large portions of return air with outdoor air, it brings in a dedicated supply of 100% outdoor air, dehumidifies it, conditions it, and then delivers at the right temperature and humidity to occupied spaces, decoupling the latent loads from sensible loads.

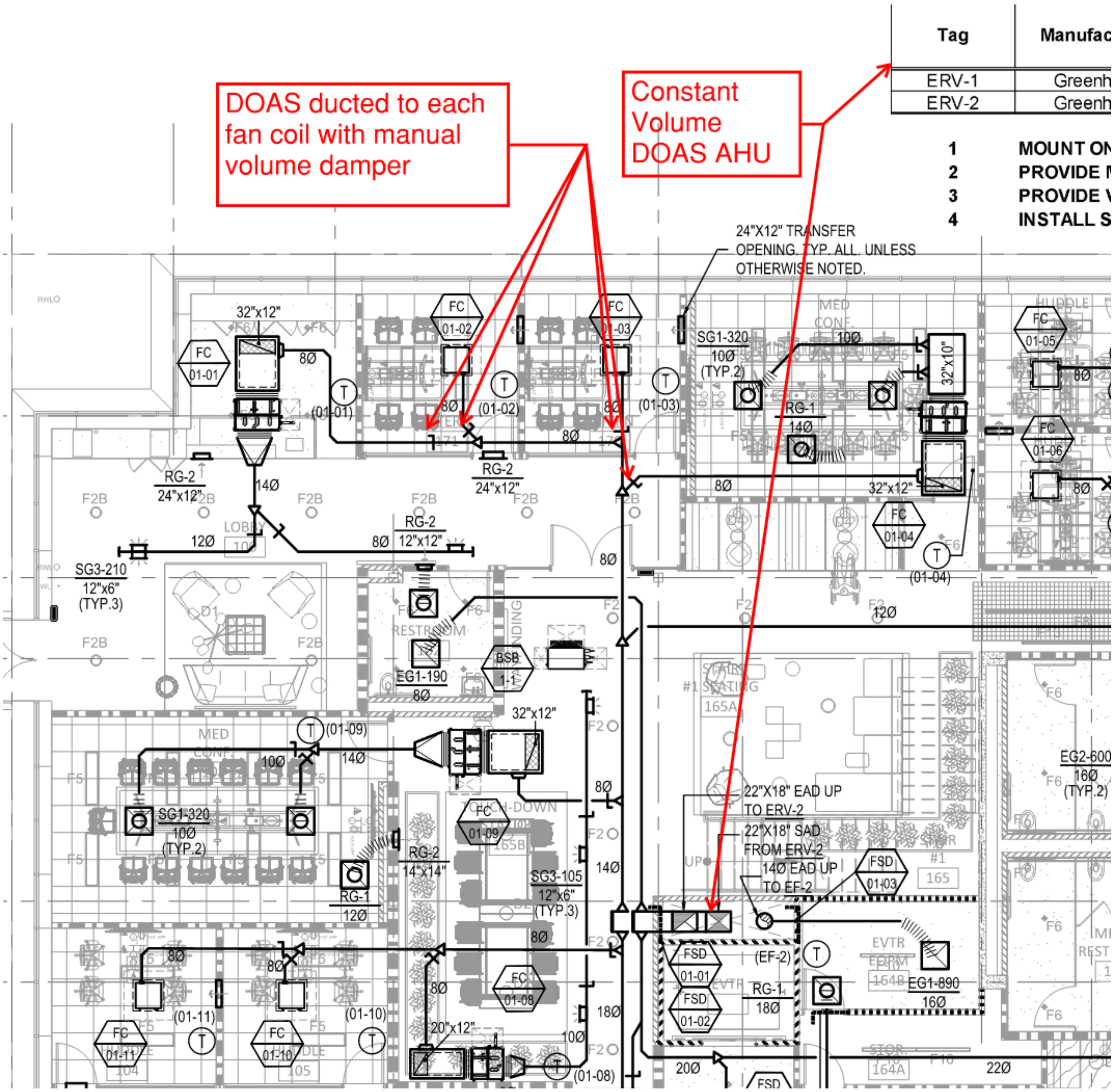
Modulating DOAS incorporates existing acceptance testing and automatically complies with both the demand control ventilation (DCV) and energy recovery requirements. It uses Variable Frequency Drive (VFD) fans to match ventilation demand, and leverages energy recovery ventilators to precondition the incoming air – reducing cooling and heating loads.

Most DOAS systems are constant volume. Design ventilation is provided whenever the building is scheduled to be occupied. For most low density spaces (e.g., open office), the ventilation rate is 0.15 cfm/ft2. For high density spaces (e.g., conference rooms, classrooms) the ventilation rate depends on the density with a common ventilation rate of 0.75 cfm/ft2. This design or maximum ventilation is provided even when the zones are unoccupied or partially occupied. With constant volume DOAS manual volume dampers (MVDs) are required at every zone. The dampers are manually balanced to maintain the design ventilation rate to all zones. The DOAS air handing unit that serves the zones is constant speed and constant volume.

Figure 2 is an example of a constant volume DOAS system.

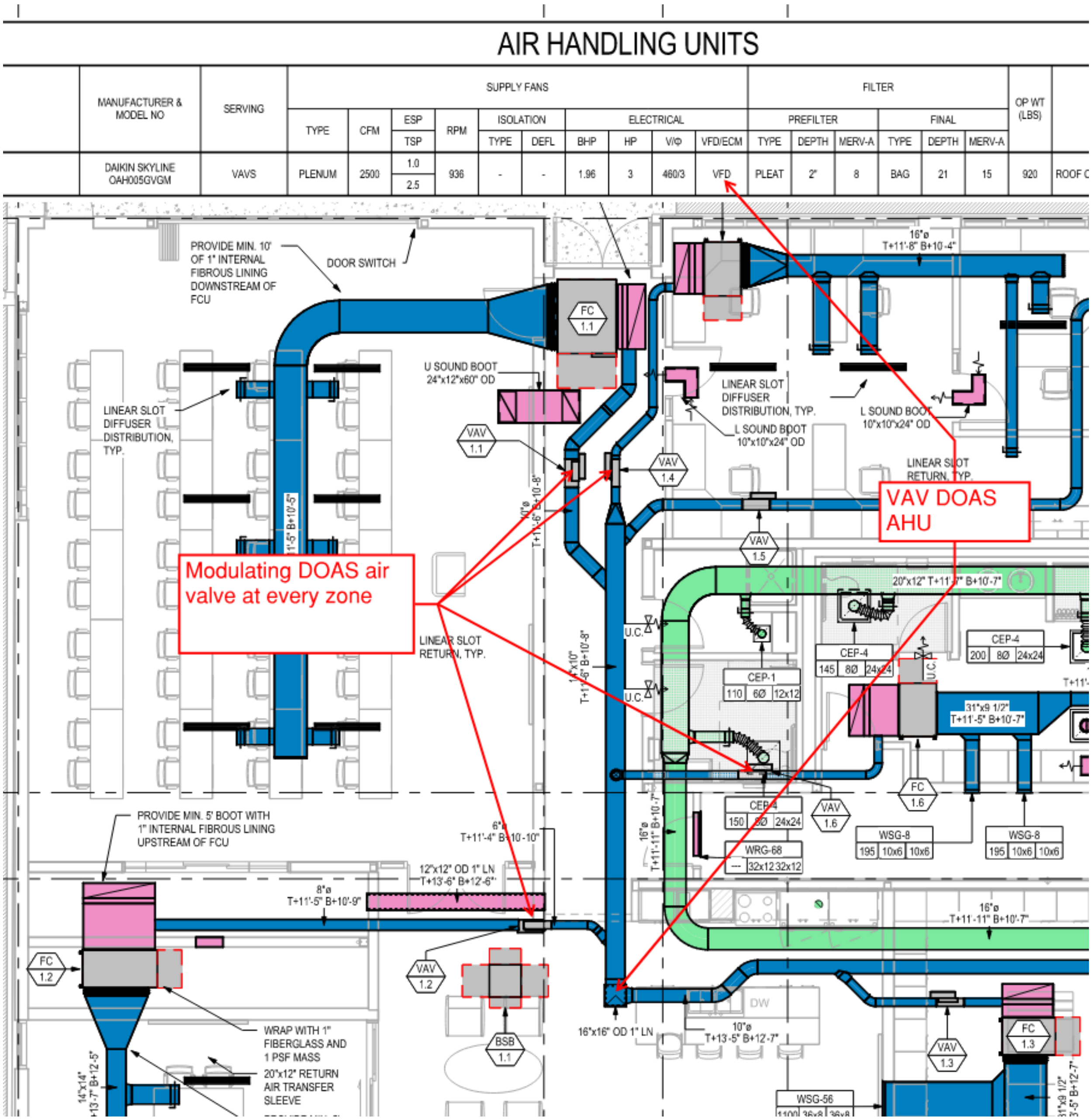
A constant volume (CAV) DOAS unit cannot have a full economizer and is not required to have an economizer by Title 24. Though as CAV ventilation systems, all DOAS units can provide partial economizing during favorable ambient conditions (i.e., when the ambient temperature is below the room temperature and the zone is in cooling mode) by virtue of the fact that they are always providing outdoor air to zones. The economizer requirement in 140.4(e) is based on the capacity of the “cooling air handler”. The common interpretation is that the cooling air handler is the unit doing most or all the cooling. For DOAS that is the zonal unit, e.g., the VRF fan coil. This interpretation is reinforced by exception 6, which states that the economizer refers to the fan coil, not the DOAS. Most fan coil zones are less than 33kbtuh so do not need economizers. Even zones between 33kbtuh and 54kbtuh do not need economizers if the DOAS has ERV and is oversized, also per exception 6. Note the only way to comply with Exception 6 without zonal air valves the only way to economize is to exceed min ventilation for all zones, but if some zones are in cooling and some are in heating then you incur extra reheat by overcooling zones in heating or end up driving zones into heating. Thus an oversized DOAS system that can modulate at the system level, but not at the zone level, may waste more energy than it saves by attempting to economize. Adding ERV and oversizing all DOAS zones so that one zone between 33kbuth and 54kbtuh can avoid an economizer is expensive. That is why it is common to “divide and conquer” by using multiple fan coils < 33 kbtuh for zones over 33 kbtuh. The analysis herein assumes zones are less than 33 kbtuh in baseline and the proposed case.

Figure 2. Constant Volume DOAS Example



With a modulating DOAS system the MVDs are replaced with modulating control dampers (a.k.a. air valves) and airflow monitoring stations (AFMS). The air valves and AFMS insure that the correct ventilation is maintained at all times. The main advantage of modulating DOAS is that it allows the implementation of Occupied Standby (OS) and Demand Control Ventilation (DCV). OS uses occupancy sensors (that are separately required for lighting controls) to shut off ventilation to zones that are scheduled to be occupied but are currently unoccupied. DCV allows ventilation rates in high density spaces (e.g., classrooms) to be modulated during partial occupancy based on CO2 concentration. This effectively tailors the ventilation rate to 15 cfm/person based on the current occupancy. For example, if the design ventilation rate is 0.75 cfm/ft2 but the current occupancy is only about 50% of the design occupancy then the DCV controls will modulate the ventilation rate to about 0.38 cfm/ft2. OS and DCV have been required in Title 24 for multi-zone VAV reheat systems for many years. This requirement would simply expand OS and DCV to a portion of DOAS systems going forward. Figure 3 is an example of a Modulating DOAS system.

Figure 3. Modulating DOAS Example



3.1.3.1 DX Compressor Lockout

California has a drier climate and frequently, DOAS is handled by a supply fan with or without an energy recovery ventilator and no direct expansion (DX) coil. However, some DOAS units in California have DX mechanical cooling/heating. In most applications, heating and cooling is provided by the zone terminal units (e.g., VRF fan coils, 4-pipe chilled water fan coils, water-source heat pumps). Thus it is usually not necessary to include DX at the DOAS unit. If the DOAS unit has energy recovery then there is even less need/value to DX.

However, some DOAS units do have DX. A common misperception in the industry is that DX DOAS is needed to “neutralize” the outside air to 70F to reduce the outside air load on the terminal units. This is not true (terminal units can be sized for the outside air load) and it is in fact not allowed by Title 24 Part 6 at section 140.4(p)4. DOAS units cannot heat outside air above 60 °F because this incurs unnecessary reheat.

Sometimes there are legitimate reasons for DX DOAS. If the zonal system cannot do latent cooling (e.g. chilled beams) then DX or chilled water is typically required in the DOAS unit for dehumidification. Note that DX DOAS makes a lot more sense in high humidity climates on the East Coast where dehumidification at the central DOAS unit can reduce maintenance costs at the zone level and avoid condensation problems. But it comes at a high cost of reheat, which is why it is largely prohibited in California, where high humidity loads are very rare.

Most DX units of all categories (e.g., DOAS units, single zone unitary heat pumps, multizone rooftop units) cannot operate DX at low airflow, with most products ranging from 15% to 60% of design airflow. If the building is largely unoccupied such that the sum of the zone air flows is less than the minimum airflow for DX operation and DX operation is required (e.g., for dehumidification) then some or all of the zone air valve flow setpoints will need to be raised in order to allow DX operation.

Most of the time a DX DOAS unit can safely operate without DX. DX DOAS units are typically only sized for the peak ventilation rate (e.g. 0.2 CFM/ft2). So, if some zones are unoccupied and the ventilation rate only calls for 0.1 cfm/ft2 then the DX DOAS system would be at 50% airflow.

There are several reasons why DX DOAS units should not be exempt from the proposed modulating DOAS requirement:

- The measure is still cost effective for DX DOAS units that have high minimum flow requirements for DX operation. DX operation is only required a small percentage of the time. As shown in Section 3.4, the measure is cost effective even if zones are occupied 85% of the time. So, if the minimum flow on the DX unit was 85% of the maximum flow the measure is still cost effective. Again, the forced higher than minimum airflow only comes into play when DX is required to avoid lockout.
- DX is not required for DOAS units, particularly in most of California’s mild climates. It might be required for chilled beam or radiant systems, but these systems are not required by the Energy Code. They are also more expensive than most of the alternatives and less efficient. So, the code should not encourage them with an exception to the proposed requirement.
- An exception for DX DOAS would create an unacceptable loophole: Owners and contractors will simply include DX in DOAS units to avoid modulating DOAS.

Another unintended consequence is that it would encourage the wasteful practice of “neutralizing” outside air with DX (which, is prescriptively banned in the current edition of Title 24 Part 6).

- DX units are improving in terms of minimum flows for DX operation. Manufacturers will be improving their products due to ASHRAE 90.1 Addendum u to 90.1-2022 (and the analogous Packaged VAV measure of this CASE effort), which requires DX units to be able to operate DX at 15% airflow.

3.1.3.2 DOAS Unit Minimum Airflow

If the DOAS unit does not have DX or does not need to operate DX at that moment, then the DOAS unit minimum airflow is effectively zero. For example, if the DOAS unit serves 20 zones, all with occupied standby and only one zone is occupied then the DOAS unit can provide 5% of its design flow to serve just that one zone. There will be a minimum fan speed (e.g., 10% or 6 Hz) but the zone air valve will modulate to maintain its flow rate at setpoint. The DOAS fan will ride back on its curve and thus meet the zone setpoint. The duct static pressure may be slightly above setpoint at this point, but the fan energy penalty is completely insignificant because the fan is already at about 2% of design power at 10% fan speed.

3.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 3.6 of this report for detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

SECTION 120.1 – REQUIREMENTS FOR VENTILATION AND INDOOR AIR QUALITY

Subsection 120.1(d): The proposed regulations would add a requirement to modulate airflow delivered by the DOAS unit based on the actual ventilation needed by each space type with considerations given to occupancy status (e.g., occupancy or CO2 sensors), rather than simply rely on the minimum ventilation airflow rate set by section 120.1(c). This requirement is proposed to apply to DOAS systems delivering greater than 3,000 cfm. Furthermore, the language describing which spaces are required to meet occupied standby controls requirements is proposed to be clarified and improved, which should improve compliance rates. These changes cost-effectively increase the stringency of the Energy Code, thereby minimizing the energy use of nonresidential buildings, which in turn improves the state’s economic and environmental health.

SECTION 120.2 – REQUIRED CONTROLS FOR SPACE CONDITIONING SYSTEMS

Subsection 120.2(e): The proposed regulation would add some clarifying language indicating that shut-off controls apply to both space conditioning and ventilation systems.

Subsection 120.2(f): The proposed regulation would add some clarifying language indicating that outdoor air supply and exhaust equipment dampers shall automatically close upon fan shutdown or during periods of non-occupancy.

SECTION 120.5 – REQUIRED NONRESIDENTIAL MECHANICAL SYSTEM ACCEPTANCE

Subsection 120.5(a): The proposed regulation would add a reference to the new DOAS airflow modulation requirements to the demand-controlled ventilation and occupied standby acceptance test requirements to ensure that in-scope DOAS systems are tested for compliance.

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

Subsection 140.4(p): This section would also be modified by altering the supply air temperature requirement to more clearly state that mechanical cooling shall not be used to reduce outside air below 75 °F during a call for heating; and heating or heat recovery shall not be used to raise outside air above 55 °F during a call for cooling before delivery to the zone. The purpose of this is to prevent re-cooling or reheating of air. These changes cost-effectively increase the stringency of the Energy Code in all 16 climate zones, thereby minimizing the energy use of nonresidential buildings, which in turn improves the state's economic and environmental health. In addition, this section would be modified to allow for additional flexibility regarding how ventilation air is delivered to the zone.

3.1.4.2 Reference Appendices Change Summary

No changes to the reference appendices are anticipated due to any aspects of this measure.

3.1.4.3 Compliance Manuals Change Summary

Chapter 4 of the Nonresidential Compliance Manual will be updated. The new requirement for airflow modulating controls on DOAS systems serving >3,000 cfm, the change from 3-speed to variable speed fans for such systems, and the changes to supply air temperatures for all DOAS systems would be explained in the revisions to the compliance manual.

3.1.4.4 Alternative Calculation Method Reference Manual Change Summary

Section 5.7 of the nonresidential Alternative Calculation Method (ACM) Reference Manual would be modified to ensure that the standard design reflects the new airflow modulation requirements for in-scope DOAS systems. The details of the object type "VAVDOAS" will be reviewed for accuracy. Additionally, the supply air settings will be reviewed and modified as necessary to align with the proposed new prescriptive supply air temperature requirements.

3.1.4.5 Compliance Forms Change Summary

The existing nonresidential compliance form NRCC-MCH-E would need to be modified to ensure that DCV and occupied standby controls are present if the DOAS system is triggered by the new mandatory requirement for airflow modulation. Additionally, NRCA-MCH-06-A (DCV) and NRCA-MCH-19-A (occupied standby) may be determined to need modifications to factor in DOAS equipment.

3.1.5 Measure Context

3.1.5.1 Comparable Model Codes or Standards

IECC and ASHRAE 90.1 both contain occupied standby and DCV requirements, similar to the 2025 edition of Title 24 Part 6. However, there is no explicit requirement for DOAS systems to meet these measures in either of these two model codes.

3.1.5.2 Interactions with Other Regulations

The proposed mandatory and prescriptive measures do not conflict with other state or federal laws and regulations. The mandatory component of this measure can be complied with by installing actuated dampers on the DOAS system zone terminal units, which does not trigger federal pre-emption. Other state and local requirements are not anticipated to be impacted by this proposal either.

3.2 Modulating DOAS - Compliance and Enforcement

3.2.1 Compliance Considerations

This measure will likely result in a change in design approach for certain projects that rely on DOAS systems. Most crucially, designers will need to more actively consider whether their projects can take advantage of DCV and occupied standby opportunities and design their DOAS systems accordingly.

There are no major changes or additional concepts being introduced by this measure. Instead, what this measure is doing is forcing existing technologies and controls methods to be considered together in cases where they had not been thought to overlap. Currently, there is an inconsistent awareness that DOAS systems should be complying with DCV and occupied standby. However, both DOAS and airflow modulating measures are widely understood and leveraged by designers. This measure simply combines these two approaches and makes it explicit when they need to be jointly leveraged.

Any additional commissioning or field verification required on DOAS systems would simply borrow current methodologies and approaches used for mixed air VAV systems; no new field-testing strategies are required.

Compliance rates with existing occupied standby requirements are expected to improve with the code language markups being proposed here due to the introduction of explicit space types listed in 120.1(d)5.

3.2.2 Impact on Market Actors

Table 14 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 14: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders [a]	Will be expected to factor airflow modulating controls into more of their DOAS systems.	Coordination with design professionals and the compliance improvement team to raise awareness.
Design Professionals [b]	Improved awareness of which space types and system types are required to use occupied standby. Increased requirements to use occupied standby and DCV with DOAS systems where triggered. Increased flexibility regarding DOAS supply air to the zones.	Newsletter or email announcement of new requirements. Lunch and learn or other virtual training sponsored by compliance improvement or local ASHRAE chapter leading up to new requirements being in effect.
Construction Team [c]	More systems require controls for DCV and occupied standby.	Announcement of changes via compliance improvement team.
Building Departments [d]	Awareness of when to look for DCV and occupied standby controls specifications on drawings and compliance forms.	Raise awareness of these measures via the compliance improvement team.
Verification Testers [e]	DOAS systems will be much more likely to be paired with airflow modulating equipment that would need to be verified for proper functionality.	Any changes to acceptance testing are minor and incremental to current requirements, so it is expected that a high-level announcement should suffice.
Building Owners, Managers, and Occupants	Reduced energy bills.	Ensure awareness of new energy efficiency opportunities so that they are requesting them on projects.
Manufacturers and Distributors	Not applicable.	Not applicable.

a. Builders include builders and developers.
b. Design professionals include architects, interior designers, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians, and sustainability department staff.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. The analysis in the methodology report is not specific to the code change presented in this report. The following provides a qualitative description of how this specific code change affects various market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

3.2.3 Compliance Software Updates

This proposal is anticipated to result in minimal adjustments to the compliance software since the main energy saving element (i.e., the airflow modulation requirement for large DOAS systems) is a mandatory requirement and is not able to be “traded” by energy modelers. The Statewide CASE Team can work with the compliance software team to determine what if any of the prescriptive changes need to be reflected in the compliance software.

3.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

Compliance costs are expected to be very minor for this measure mainly because this is simply a broadening of existing energy efficiency measures to additional HVAC system types. Raising awareness of the new measure requirements in advance is expected to reduce ongoing compliance costs. The statewide compliance improvement team can make a point of emphasizing which DOAS systems would be required to comply with the new measure.

3.3 Modulating DOAS - Market and Economic Analysis

3.3.1 Market Structure and Availability

3.3.1.1 Current Market Structure and Availability

DOAS is a mature technology with numerous installations in California and nationwide. The DOAS market is fundamentally a subset of the broader HVAC supply chain and manufacturer base.

The global dedicated outdoor air system (DOAS) market is valued at USD 5.2 billion in 2025 and is projected to reach USD 12.4 billion by 2035.[3] Growth is driven by the expanding commercial building sector, rising preference for energy-efficient ventilation

3 https://www.futuremarketinsights.com/reports/dedicated-outdoor-air-system-market.

solutions, and the need for optimized indoor air quality in high-occupancy environments. DOAS systems offer fresh air delivery capabilities, enhanced energy recovery opportunities, and independent ventilation control solutions, making them suitable for office buildings, healthcare facilities, educational institutions, and mixed-use commercial developments.

Nearly all commercial unitary HVAC manufacturers produce a 100 percent outdoor air version of their standard unitary air to air products. DOAS units are brought to the marketplace through distributors and manufacturer representatives, just like other pieces of HVAC equipment.

DCV and occupied standby are mature efficiency measures that have been in the energy code for over a decade. However, this code enhancement is needed because designers typically specify DOAS systems without airflow modulating controls which effectively results in constant air volume (CAV) systems, which are less efficient than systems that modulate airflow based on zone occupancy levels. However, this approach is cheaper and simpler to design and install, and therefore many designers favor it.

Many DOAS systems in the field today are specified with airflow modulating measures such as DCV and occupied standby. One example of a manufacturer that highlights the potential of this measure is the Trane CoolSense® Integrated Outdoor Air System catalog, which highlights the energy efficiency opportunity of including DCV with DOAS.[4] Page two of the catalog states: “The airflow-measuring damper in each terminal unit maintains the outdoor airflow required in each zone at any given time. Plus, demand-controlled ventilation (DCV) sequences (using either a CO2 sensor or occupancy sensor) are pre-engineered into the factory-mounted unit controller. All these features lead to efficient operation.” Another example comes from a DOAS manufacturer, which lists CO2 sensors in the duct or in the room as “optional accessories” for their equipment .[5]

3.3.1.2 Market Challenges and Solutions

Historically, a major challenge for occupied standby for HVAC has been the opacity around which zones and space types are required to comply with this measure. This challenge is broader than HVAC systems that use DOAS and apply to all nonresidential HVAC systems. A key aspect of this measure, intended to improve compliance rates with occupied standby requirements, is the inclusion of clearer and more explicit

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4 https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/equipment/terminal-devices/sensible-cooling/APP-PRC004E-EN.pdf

5 https://www.ventacity.com/products/ventilation-family/

language specifying the space types to which occupied standby applies. This will make it more obvious to the user whether a given space type needs to comply with occupied standby.

DOAS systems have traditionally been understood to be exempt from airflow modulation measures, though there is no inherent reason for this to be the case. This has resulted in inefficiently designed and installed DOAS systems which effectively function as CAV air distribution systems. Since the pandemic, nonresidential space usage patterns have changed significantly, with the trend toward lower nonresidential occupancy rates (i.e., greater rates of remote work by employees). This underscores the opportunity to design DOAS systems more efficiently by using airflow modulating strategies so that airflow rates can be reduced during periods of light or non-occupancy.

The Statewide CASE Team views the market challenges for the proposed modulating DOAS requirement to be very limited because this measure is simply broadening the scope of airflow limiting measures from mixed air distribution systems to DOAS systems. All necessary compliance tools are fully at the market's disposal. The only remaining step is the adoption of the code requirement to introduce these measures to DOAS systems moving forward. The prescriptive changes in this proposal also do not have market challenges because our measure is simply making some minor adjustments to the required supply air temperature and broadening zone delivery options to add flexibility for designers.

See Section 2.2 for a description of workforce training that may be needed to ensure effective design, installation, and commissioning.

3.3.2 Design and Construction Practices

3.3.2.1 Current Design and Construction Practices

In the 2025 edition of Title 24 Part 6, the typical DOAS system is designed to provide steady delivery of code minimum ventilation air to the zones during occupied periods. Occupied standby and DCV measures are typically interpreted to only apply to mixed air systems by most designers and other stakeholders.

DCV and occupied standby are measures that improve the building's energy efficiency performance during low or unoccupied time periods during times when the building is scheduled to be occupied. The measures are capable of benefiting both mixed air and DOAS systems.

As noted, the typical DOAS air distribution network today has no ability to sense and adjust the airflow rate being supplied to the zones. There are no air valves or dampers at the terminal units capable of limiting air delivery. This means that when there is an opportunity to reduce the amount of ventilation air delivered to the zones, the system cannot respond accordingly.

Although this practice is not particularly common today, some designers include airflow modulation in their DOAS system designs.

3.3.2.2 Health and Safety Considerations

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (DOSH). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.3.2.3 Design and Construction Challenges and Solutions

As described above, this measure is not commonly applied in California buildings. However, the Statewide CASE Team does not anticipate significant challenges or adjustments would be required to incorporate this measure into future designs, should it be adopted into code. This is because the strategies being promoted for this measure are commonly applied to mixed air VAV systems, which are familiar to all commercial HVAC designers. The adjustment needed for this measure would be the notion that this approach would now need to also be applied to in-scope DOAS systems.

See Table 14 in Section 3.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

3.3.3 Energy Equity and Environmental Justice

The Statewide CASE Team evaluated the potential impact on environmental and social justice (ESJ) communities, including impacts related to race, class, and gender.

This measure is expected to have no disproportionate impact on ESJ communities.

The Statewide CASE Team identified potential impacts of the proposed code change via research and stakeholder input. While the listed potential impacts should be comprehensive, they may not yet be exhaustive. Recognizing the importance of engaging ESJ communities and gathering their input to inform the code change process and proposed measures, the Statewide CASE Team is working to build relationships with community-based organizations (CBOs) to facilitate meaningful engagement. Please reach out to Bryan Boyce (bboyce@energy-solution.com) if you have input on how this proposal may impact ESJ communities or if you would like to offer your perspective.

3.3.4 Impacts on Jobs and Businesses

This section will be completed for the Final CASE Report

3.3.5 Economic and Fiscal Impacts

This section will be completed for the Final CASE Report.

3.4 Modulating DOAS - Cost Effectiveness

The cost-effectiveness analysis was only conducted for submeasure a, Air Valves.

3.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

Per California Law (Public Resources Code 25000), a measure is considered cost effective if its Benefit-Cost Ratio (BCR) is 1.0 or greater, amortized over the economic life of the structure. The Statewide CASE Team calculates BCR by dividing total dollar benefits by total dollar costs over a 30-year analysis period.

Benefits are based on Long-term System Cost (LSC), which assigns an hourly dollar value to energy use. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are valued more than off-peak hours. These factors are not utility rates, forecasts, or bill estimates. The CEC develops and publishes LSC hourly conversion factors for each code cycle.

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

3.4.2 Energy and Energy Cost Savings Results

EnergyPlus (and subsequently, CBECC) cannot model the modulating DOAS technology that comprises submeasure a. As a workaround, energy savings were calculated using a hybrid EnergyPlus and spreadsheet approach as follows:

1. The CBECC large office prototype was simulated in EnergyPlus with single zone heat pumps. This model has five zones per floor: four perimeter zones and one interior zone.
2. In both cases, the DOAS provides partial economizing benefits when ambient air is below the room temperature and the zone is in cooling mode. In the base case, this benefit is passively provided by CAV DOAS units because they always provide the outdoor fresh air at design airflow rates. In the measure case, this benefit would be

programmed into the controls logic to ensure that the supply fan is operated to provide partial economizer efficiency benefits.

3. The default schedules in the prototypes do not accurately reflect real-world conditions. Therefore, the Statewide CASE Team developed two new sets of occupancy, lighting, and plug load schedules:
    a. OS Schedule: to calculate the theoretical maximum potential savings from reducing ventilation to unoccupied zones, this schedule represents a zone that is always unoccupied. See Figure 4.
    b. DCV Schedule: this set of schedules represents realistic occupancy patterns in order to capture DCV savings. See Figure 6.
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 (link)
        ii. UC Berkeley Center for the Built Environment survey of hundreds of buildings found typical HW heating systems operate 130 hours/week (link)
5. The plug load (receptacle) schedule was used to capture the DOAS AHU fan energy savings. The fan energy consumption of the unitary heat pump object in the EnergyPlus model could have been changed rather than the plug load but this would have been extremely tedious and error-prone because then every zone in every climate for every case (high density, low density, etc.) would have to be adjusted to get it right. Adjusting the plug load schedules to include the DOAS fan power only had to be done twice: for the OS schedules and for the DCV schedule. This also accounts for the differences in fan energy cost and the impacts of the fan heat. Therefore, the OS Schedules and DCV Schedules were both split into Base Case and Proposed Case versions, with the only difference being the receptacle schedule. The average DOAS fan power for the 10 real buildings surveyed was 0.58 W/cfm. In the OS models the DOAS flow is 0.15 cfm/ft2. So, 0.58 x 0.15 = 0.087 W/ft2 was added to the plug loads in the base case. In the proposed case we made the conservative assumption that average DOAS fan speed would be 80% of full speed. Using the cube law of fan power, 80% speed corresponds to 51% power. So, 0.51 x 0.087 = 0.044 W/ft2 was added to the plug loads in the proposed case. In the DCV models the DOAS flow is 0.75 cfm/ft2. So, 0.58 x 0.75 = 0.44 W/ft2 was added to the plug loads in the base case and 0.44 x 0.51 = 0.22 W/ft2 is added in the proposed case.

6. All spaces were modeled as open office space (low density) and again as conference rooms (high density) to determine savings per square foot for low density and high-density space types. Low density has occupied standby savings. High density has occupied standby and DCV savings.
7. The proposed case single zone heat pump models included partial air-side economizers with maximum outside air flow rates matching the design ventilation rates, i.e., 0.15 cfm/ft2 for low density and 0.75 cfm/ft2 for high density. So, for occupied standby if the space is unoccupied the air valves do not have to bring in any outside air but can bring in between 0 and 0.15 cfm/ft2 if the space is in cooling and the outside air temperature is below the cooling setpoint. Full economizer free cooling is not required by the proposed measure but partial economizing is common practice for systems with modulating DOAS and is negligible cost (no additional hardware and minimal additional programming/commissioning once it becomes a standard feature of DOAS systems). Note that the base case also provides economizing benefits (in favorable conditions) due to the fact that it is always providing the same volume of air to the zones.
8. In addition to the low density occupied standby model and the high density occupied standby + DCV model, the model was also run with neither OS nor DCV, just with the modified plug loads representing the DOAS fan savings. This is used to represent the zones that require ventilation but are not required to have OS or DCV (e.g., storage, toilet rooms). The only difference between base case and proposed case is the plug load schedule representing the fan energy savings. Fan savings are applied for these zones because the DOAS fan serves all zones and will modulate accordingly.
9. As a parametric analysis, the heat pumps were also modeled with energy recovery ventilators to see if the measure is still cost effective for DOAS systems that include energy recovery.
10. The following cases were simulated in EnergyPlus in all climates, with each case having a baseline model and proposed model:
    a. low density spaces with OS in the proposed – always unoccupied – to achieve theoretical max OS savings for low density spaces.
    b. high density spaces with OS without DCV – always unoccupied – to achieve theoretical max OS savings for high density spaces.
    c. low density spaces without OS – to capture fan savings for spaces without OS or DCV.
    d. high density spaces with DCV without OS – to capture the DCV savings from realistic schedules.
    e. same as ‘a’ but with ERV
    f. same as ‘b’ but with ERV

g. save as ‘d’ but with ERV

11. The total annual hourly energy cost savings for each of the Cases above for each climate zone was exported to a spreadsheet.
12. The spreadsheet modifies and aggregates the simulated savings as follows:
    a. Separate analyses for each building type: Large office, primary school, and secondary school
    b. Surveys of 12 actual buildings of each of these types were used to determine the typical fraction of the building that is each of the following space types:
        i. Low density OS spaces (e.g., 70% for office buildings, 20% for schools)
        ii. High density DCV + OS spaces (e.g., 20% for office buildings, 70% for higher ed. schools)
        iii. High density DCV without OS spaces (e.g., K-12 classrooms are required to have DCV but not allowed to have OS, while higher education classrooms are required to have OS and DCV)
    c. The spreadsheet includes the ability to iterate on the following to determine under what assumptions the measure is cost effective:
        i. Low Density Occupancy Rate – 0% is the theoretical max savings from OS. 100% means the space is always occupied and there are no savings from OS. 70% means the space is occupied 70% of the time and unoccupied 30%. See Spreadsheet Results below for assumed values.
        ii. High Density Occupancy Rate – 0% means the space is always unoccupied and can go down to 0.15 cfm/ft2 if it has only DCV or down to 0 cfm/ft2 if it has both DCV and OS. 100% means the space is always occupied but still able to capture DCV savings using realistic schedules, i.e., not always at design occupancy. See Spreadsheet Results below for assumed values.
13. The spreadsheet also incorporates the cost data as follows:
    a. Adjustable building total area – this is needed for cost modeling because the DOAS AHU costs are per building, while the zone costs are per zone.
    b. Adjustable zone size – again this is needed to calculate zone costs per building. Surveys of each building type were used to determine average zone size for each building type.
    c. Both first costs and incremental O&M costs are included per building and per zone.

Figure 4. OS Schedules - Base Case

			Hour of Day																							
Description		Daily Sch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle (with fan heat)	Fraction	WD	0.03	0.03	0.03	0.03	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.03	0.03	0.03
		Sat	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.03	0.03	0.03	0.03	0.03
		Sun	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.03	0.03	0.03	0.03	0.03
HVAC Avail	OnOff	WD	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
		Sat	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
		Sun	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
HtgSetpt	Temperature	WD	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65
		Sat	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
		Sun	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
ClgSetpt	Temperature	WD	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80
		Sat	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
		Sun	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OACtrl Schedule	OnOff	WD	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Holiday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 5. OS Schedules - Proposed Case

			Hour of Day																							
Description		Daily Sch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle (with fan heat)	Fraction	WD	0.03	0.03	0.03	0.03	0.03	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03	0.03	0.03	0.03
		Sat	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03	0.03	0.03	0.03	0.03	0.03
		Sun	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.03	0.03	0.03	0.03	0.03	0.03
HVAC Avail	OnOff	WD	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
		Sat	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
		Sun	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
HtgSetpt	Temperature	WD	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65
		Sat	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
		Sun	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
ClgSetpt	Temperature	WD	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80
		Sat	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
		Sun	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OACtrl Schedule	OnOff	WD	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Holiday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

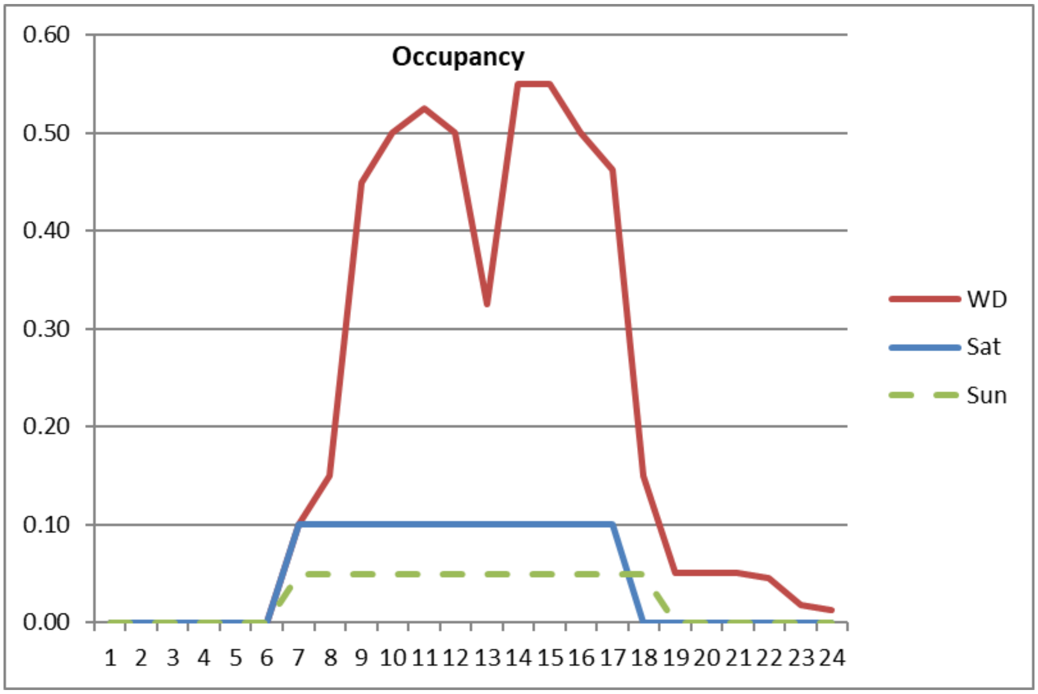
Figure 6. DCV Schedules - Base Case

			Hour of Day																							
Description		Daily Sch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.15	0.45	0.50	0.53	0.50	0.33	0.55	0.55	0.50	0.46	0.15	0.05	0.05	0.05	0.05	0.02	0.01
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.55	0.55	0.55	0.58	0.58	0.58	0.58	0.55	0.55	0.18	0.08	0.08	0.08	0.07	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.45	0.50	0.53	0.50	0.33	0.55	0.55	0.50	0.46	0.18	0.08	0.08	0.08	0.07	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle (with fan heat)	Fraction	WD	0.03	0.03	0.03	0.03	0.03	0.46	0.49	0.51	0.66	0.69	0.70	0.69	0.60	0.71	0.71	0.69	0.67	0.52	0.47	0.47	0.04	0.04	0.03	0.03
		Sat	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.49	0.59	0.59	0.59	0.59	0.51	0.51	0.51	0.51	0.51	0.46	0.03	0.03	0.03	0.03	0.03	0.03
		Sun	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.03	0.03	0.03	0.03	0.03	0.03
HVAC Avail	OnOff	WD	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
		Sat	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
		Sun	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
HtgSetpt	Temperature	WD	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65
		Sat	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
		Sun	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
ClgSetpt	Temperature	WD	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80
		Sat	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
		Sun	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OACtrl Schedule	OnOff	WD	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Holiday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 7. DCV Schedules - Proposed Case

			Hour of Day																							
Description		Daily Sch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupancy	Fraction	WD	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.15	0.45	0.50	0.53	0.50	0.33	0.55	0.55	0.50	0.46	0.15	0.05	0.05	0.05	0.05	0.02	0.01
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Lights	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.55	0.55	0.55	0.58	0.58	0.58	0.58	0.55	0.55	0.18	0.08	0.08	0.08	0.07	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle	Fraction	WD	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.15	0.45	0.50	0.53	0.50	0.33	0.55	0.55	0.50	0.46	0.18	0.08	0.08	0.08	0.07	0.05	0.05
		Sat	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.30	0.30	0.30	0.30	0.15	0.15	0.15	0.15	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Sun	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Receptacle (with fan heat)	Fraction	WD	0.03	0.03	0.03	0.03	0.03	0.25	0.28	0.30	0.45	0.48	0.49	0.48	0.39	0.50	0.50	0.48	0.46	0.31	0.26	0.26	0.04	0.04	0.03	0.03
		Sat	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.28	0.38	0.38	0.38	0.38	0.30	0.30	0.30	0.30	0.30	0.25	0.03	0.03	0.03	0.03	0.03	0.03
		Sun	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.03	0.03	0.03	0.03	0.03	0.03
HVAC Avail	OnOff	WD	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
		Sat	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
		Sun	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
HtgSetpt	Temperature	WD	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65
		Sat	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
		Sun	66	67	68	69	70	71	71	71	71	71	71	71	71	71	71	71	71	71	71	65	65	65	65	65
ClgSetpt	Temperature	WD	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80
		Sat	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
		Sun	80	80	78	76	75	74	73	73	73	73	73	73	73	73	73	73	73	73	80	80	80	80	80	80
Infiltration	Fraction	WD	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
		Sat	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00
		Sun	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OACtrl Schedule	OnOff	WD	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
		Sat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Holiday	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 8. Occupancy Profile from the DCV Schedules.



SPREADSHEET RESULTS:

Table 15 shows the spreadsheet result for several parametric analyses for each building type (office, K-12, Higher Ed.) For every row in the table the benefit-to-cost ratio exceeds 1.0 for every climate zone. The bold rows represent the default assumptions for each building type. For example, the bold Office row shows results for an office buildings large enough to have more than 3,000 cfm of outside, without ERV, with average zone size of 825 ft2, with Integrated Controls, with 70% of the building being low density occupied standby spaces (e.g., private office, open offices, corridors, etc.) and 20% of the building being high density DCV spaces (e.g., conference rooms, auditoria, break rooms, etc.) that the measure is cost effective even if all spaces are occupied 85% of the time the HVAC system is scheduled to operate. The second office rows shows it is cost effective under the same assumptions but with ERV. The third row shows it is cost effective with Non-integrated controls if the occupancy rate is 70% or lower.

Table 15. Modulating DOAS Results

					Space Types			Occupancy Rate	
Bldg Type	OA CFM	ERV	Zone ft2	Ctrl Option	O.S.	O.S.+DCV	Neither	O.S.	O.S.+DCV
Office	**>=3,000**	**No**	**825**	**Integrated**	**70%**	**20%**	**10%**	**85%**	**85%**
Office	>=3,000	Yes	825	Integrated	70%	20%	10%	85%	85%
Office	>=3,000	No	825	Non-Integr.	70%	20%	10%	70%	70%
Office	>=1,000	No	825	Integrated	70%	20%	10%	70%	70%
Office	>=3,000	No	300	Integrated	70%	20%	10%	70%	70%
Office	>=3,000	Yes	550	Integrated	70%	20%	10%	70%	70%
K-12 scho	**>=2,000**	**No**	**720**	**Integrated**	**10%**	**70%**	**20%**	**85%**	**85%**
K-12 scho	>=2,000	Yes	720	Integrated	10%	70%	20%	85%	85%
K-12 scho	>=2,000	No	720	Non-Integr.	10%	70%	20%	85%	85%
K-12 scho	>=2,000	Yes	720	Non-Integr.	10%	70%	20%	85%	85%
Hgher Ed.	**>=2,000**	**No**	**1200**	**Integrated**	**20%**	**70%**	**10%**	**90%**	**90%**
Hgher Ed.	>=2,000	Yes	1200	Integrated	20%	70%	10%	90%	90%
Hgher Ed.	>=2,000	No	1200	Non-Integr.	20%	70%	10%	85%	85%
Hgher Ed.	>=2,000	Yes	1200	Non-Integr.	20%	70%	10%	85%	85%
Hgher Ed.	>=3,000	Yes	800	Non-Integr.	20%	70%	10%	65%	60%

Research on actual occupancy rates shows that the measure is highly cost effective because actual occupancy rates are much lower than the ones in Table 15. The lower the occupancy rates the more cost effective the measure.

Table 16 shows the results of four studies conducted in 2025 on actual occupancy rates. The studies showed that typical zones are occupied 36-54% of normal business hours. The studies assumed normal business hours of 50-60 hours/week. Based on the research cited above, the HVAC hours in the models are 90 hours/week. Normalizing the studies to the 90 hours of HVAC operation indicates that typical zones are only occupied 20-36% of the time the HVAC is operating. Table 15 shows that the measure is cost effective even if zones are occupied 80-90% of the time so the measure is highly cost effective.

Table 16. Recent Research on Actual Occupancy Rates

Study / Source	Original study metric	Assumed office-hours window	Hours/wk in metric	HVAC-weighted occupancy
XY Sense – Workplace Utilization Index (Global, Q2–Q3 2025)	43% avg global utilization (business hours) [xysense.com]	08:00–18:00, Mon–Fri (assumed)	50 h	**23.9%**
XY Sense – Workplace Utilization Index (North America, Q2–Q3 2025)	36% avg utilization (North America) [xysense.com]	08:00–18:00, Mon–Fri (assumed)	50 h	**20.0%**
Density – Workplace Benchmark (Q1 2025)	47% avg daily peak floor utilization (busy-day peak, not all-day average) [density.io]	08:00–18:00, Mon–Fri (assumed)	50 h	**26.1%**
Kastle – Back-to-Work Barometer (Jan–Feb 2025)	54.2% of pre-pandemic attendance (weekly avg) [axios.com], [credaily.com]	07:00–19:00, Mon–Fri (badge/activity window, assumed)	60 h	**36.1%**

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 14 through

Table 19. Per-unit savings for the first year are expected to range from 0.24 to 1.51 kWh/yr depending upon climate zone. Demand reductions/increases are expected to range between 0.01 W and 0.28 W, depending on climate zone.

Table 20 presents total per-unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 17: First Year Electricity Savings (kWh) Per Square Foot – Modulating DOAS

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	2.93	2.79	2.15	2.95	2.08	1.69	1.66	2.09	2.07	2.41	2.70	2.47	2.54	2.64	3.14	3.96
Medium Office	2.93	2.79	2.15	2.95	2.08	1.69	1.66	2.09	2.07	2.41	2.70	2.47	2.54	2.64	3.14	3.96
Small Office	2.93	2.79	2.15	2.95	2.08	1.69	1.66	2.09	2.07	2.41	2.70	2.47	2.54	2.64	3.14	3.96
Large School	8.74	8.48	6.41	9.03	6.26	5.08	4.99	6.35	6.18	7.35	7.96	7.26	7.51	7.85	9.34	12.29
Small School	8.37	8.41	6.31	9.01	6.27	5.29	5.22	6.61	6.45	7.53	8.05	7.33	7.63	8.02	9.51	12.03

Table 18: First Year Peak Demand Reduction (W) Per Square Foot – Modulating DOAS

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.11	0.14	0.09	0.15	0.09	0.07	0.07	0.09	0.08	0.09	0.12	0.12	0.12	0.13	0.10	0.17
Medium Office	0.11	0.14	0.09	0.15	0.09	0.07	0.07	0.09	0.08	0.09	0.12	0.12	0.12	0.13	0.10	0.17
Small Office	0.11	0.14	0.09	0.15	0.09	0.07	0.07	0.09	0.08	0.09	0.12	0.12	0.12	0.13	0.10	0.17
Large School	0.33	0.42	0.26	0.47	0.26	0.21	0.21	0.26	0.23	0.27	0.33	0.33	0.33	0.37	0.28	0.44
Small School	0.32	0.41	0.26	0.46	0.26	0.21	0.21	0.26	0.23	0.26	0.32	0.32	0.32	0.35	0.27	0.43

Table 19: First Year Source Energy Savings (kBtu) Per Square Foot – Modulating DOAS

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	1.27	1.34	0.96	1.43	0.96	0.73	0.71	0.85	0.81	0.96	1.13	1.09	1.04	1.16	0.94	1.88
Medium Office	1.27	1.34	0.96	1.43	0.96	0.73	0.71	0.85	0.81	0.96	1.13	1.09	1.04	1.16	0.94	1.88
Small Office	1.27	1.34	0.96	1.43	0.96	0.73	0.71	0.85	0.81	0.96	1.13	1.09	1.04	1.16	0.94	1.88
Large School	3.86	4.12	2.92	4.38	2.92	2.21	2.15	2.59	2.34	2.92	3.25	3.12	2.99	3.31	2.75	5.89
Small School	3.76	4.05	2.90	4.31	2.88	2.24	2.18	2.60	2.36	2.92	3.20	3.07	2.97	3.24	2.78	5.70

Table 20: Total 30-Year LSC Savings (2029 PV$) Per Square Foot – Modulating DOAS

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	6.64	6.58	4.88	6.92	4.65	3.70	3.65	4.63	4.82	5.40	6.19	5.82	5.87	5.80	6.82	8.37
Medium Office	6.64	6.58	4.88	6.92	4.65	3.70	3.65	4.63	4.82	5.40	6.19	5.82	5.87	5.80	6.82	8.37
Small Office	6.64	6.58	4.88	6.92	4.65	3.70	3.65	4.63	4.82	5.40	6.19	5.82	5.87	5.80	6.82	8.37
Large School	18.86	18.82	13.76	19.94	13.16	10.36	10.18	13.06	13.32	15.36	17.14	15.99	16.20	16.23	18.92	24.72
Small School	16.90	17.29	12.62	18.39	12.21	9.93	9.79	12.47	12.80	14.48	16.14	14.97	15.28	15.50	17.90	22.76

3.4.3 Incremental First Cost

The content that follows applies to submeasure a, “Air Valves”.

The CASE Team consulted with Bay Area mechanical and controls contractors who have recently installed modulating zonal air valves, occupied standby controls, and demand control ventilation controls on many real buildings in Northern California. The costs provided by the contractors include equipment costs, labor costs, and costs for acceptance testing.

The incremental first costs include the following zone costs:

1) Delete manual volume dampers (the manual volume dampers in the base case are replaced by the modulating air valves in the proposed case)
2) Savings for not balancing the manual volume dampers
3) New modulating damper with air flow sensor, similar to Price RDV
4) New or modified zone controller with damper actuator and required programming. Pricing was provided for two scenarios:
    a) Non-integrated: if the air valve controller is standalone
    b) Integrated: if the air valve control function is integrated into the terminal unit controls (e.g. into a VRF fan coil unit controller)
5) Occupancy sensor for occupied standby zones. Again, pricing was provided for a non-integrated scenario (new standalone sensor) and integrated with existing zone HVAC or lighting controls.
6) CO2 sensor for DCV zones. Again, pricing was provided for a non-integrated scenario (new standalone sensor) and integrated with existing zone HVAC or lighting controls.

	Base Case	Proposed Case Non-Integrated	Proposed Case Integrated
Manual volume damper (MVD)	$150	$ -	$ -
Balancing per MVD	$250	$ -	$ -
Modulating air valve (e.g., Price RDV)	$ -	$600	$600
Controls (NI Occ or CO2 sensors)	$ -	$1,250	$500
Occ Sensor (per zone)	$ -	$600	$100
CO2 Sensor (per zone)	$ -	$1,000	$260

The incremental first costs include the following costs per DOAS air handler:

1) $6,000 for duct static pressure sensor and associated fan speed controls

The cost of a variable speed drive or electrically commutated motor on the supply fan is not included in the incremental cost due to the assumption that the current industry standard practice for DOAS equipment is to have this capability. The current prescriptive requirement for three speeds of fan control in Title 24, Part 6 at section 140.4(p)3 results in this capability being very frequently available in the market today as industry standard practice.

3.4.3.1 Manual Balancing

Manual balancing with manual volume balancing dampers is required in the baseline in order to measure airflow rates at steady state to allow zones to confirm they meet the design ventilation airflow rates. The system is constant volume and has no airflow measuring stations. Airflow is measured one time by the balancer during balancing.

In the proposed case manual volume balancing dampers are deleted because the zones all have airflow measuring stations to ensure the measured ventilation airflow rate is correct at all times. The required ventilation airflow is not constant but varies based on occupancy. Each zone damper modulates independently to maintain the airflow rate current required at each zone.

3.4.3.2 AFMS Calibration

The cost to field calibrate the AFMS is not included in the incremental cost. Field calibration of terminal unit AFMS is common but is not required by the California Mechanical Code or by Title 24. The Title 24 Acceptance Tests (e.g., NA7.5.x tests) say that outdoor air sensors or flow measuring devices must be either factory calibrated or field calibrated, and results documented on the acceptance test forms.

PG&E's Code Readiness Program Report CR24PGE0001 found that factory calibration provides accuracy within 10% of setpoint, which meets the accuracy requirements in Title 24 section 120.1(f).

ASHRAE Research Project 1353-TRP, compared factory calibration to field calibration of VAV box airflow controls and found that field calibration did not significantly improve accuracy relative to factory calibration.

Note that both the PG&E research and the ASHRAE research evaluated accuracy of VAV reheat boxes at minimum flows. Minimum flows depend on the minimum ventilation rate (e.g. 0.15 cfm/ft2) and the design cooling flow rate, typically in the range of 0.6 to 3.0 cfm/ft2. This means the minimum flow for a VAV reheat box can range from 5% to 25% of the maximum. As noted in both of these research reports, accuracy degrades at low flow. Accuracy will be better at 25% than at 5% and better at 100% than at 25%. This is because VAV box controllers use velocity pressure sensors for airflow measurement and velocity pressure goes down with the square root of the airflow. For example, at 25% flow the pressure is 6% of the max pressure and at 5% flow the pressure is at 0.25% of the maximum pressure.

The minimum flow rate on a modulating DOAS air valve is 100% for low density zones with occupied standby (e.g. open office space). For high density spaces (e.g. conference rooms) the minimum flow can be as low as 20%. So modulating DOAS AFMS will generally be more accurate than VAV box AFMS, even without field calibration.

3.4.4 Incremental Maintenance and Replacement Costs

The CASE Team consulted with Bay Area mechanical and controls contractors to collect the data for the incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, the expected useful life, frequency of replacement, and maintenance procedures related to the measure relative to the maintenance requirements for the baseline. Incremental maintenance and replacement costs were estimated based on the following expected useful lives:

- Damper and airflow probe: 30 years
- Damper actuator and controls: 20 years
- Occupancy sensor: 15 years
- CO_2 sensor: 10 years

The relevant costs are summarized in Table 21.

Table 21: Summary of Incremental Costs

	Actuator/controls	Occ sensor	CO2 sensor
Integrated Maintenance and Replace ($/yr/zone)	$14.34	$3.33	$17.48
Non-Integrated Maintenance and Replace ($/yr/zone)	$35.86	$19.95	$67.24

3.4.5 Cost Effectiveness

The results of the per-unit cost-effectiveness analyses are presented from Table 22 to Table 26 for new construction/additions. This entire section applies to submeasure a, Air Valves.

In the tables below, all values are presented in 2026 present value dollars (2029 PV$). Benefits represent 30-year LSC savings and other savings, including incremental first-cost savings if the proposed first cost is less than the current first cost, incremental maintenance cost savings if the proposed maintenance costs are less than the current maintenance costs, and incremental residual value if proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including equipment, replacement, and maintenance costs over the analysis period. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero, the benefit-cost ratio (BCR) is considered infinite. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate. If there are no total incremental PV costs, the BCR is infinite.

Table 22. 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – Large Office

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	6.64	1.96	3.39
2	6.58	1.96	3.35
3	4.88	1.96	2.49
4	6.92	1.96	3.53
5	4.65	1.96	2.37
6	3.70	1.96	1.88
7	3.65	1.96	1.86
8	4.63	1.96	2.36
9	4.82	1.96	2.46
10	5.40	1.96	2.76
11	6.19	1.96	3.15
12	5.82	1.96	2.97
13	5.87	1.96	2.99
14	5.80	1.96	2.96
15	6.82	1.96	3.48
16	8.37	1.96	4.27

Table 23. 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – Medium Office

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	6.64	1.96	3.39
2	6.58	1.96	3.35
3	4.88	1.96	2.49
4	6.92	1.96	3.53
5	4.65	1.96	2.37
6	3.70	1.96	1.88
7	3.65	1.96	1.86
8	4.63	1.96	2.36
9	4.82	1.96	2.46
10	5.40	1.96	2.76
11	6.19	1.96	3.15
12	5.82	1.96	2.97
13	5.87	1.96	2.99
14	5.80	1.96	2.96
15	6.82	1.96	3.48
16	8.37	1.96	4.27

Table 24. 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – Small Office

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	6.64	1.96	3.39
2	6.58	1.96	3.35
3	4.88	1.96	2.49
4	6.92	1.96	3.53
5	4.65	1.96	2.37
6	3.70	1.96	1.88
7	3.65	1.96	1.86
8	4.63	1.96	2.36
9	4.82	1.96	2.46
10	5.40	1.96	2.76
11	6.19	1.96	3.15
12	5.82	1.96	2.97
13	5.87	1.96	2.99
14	5.80	1.96	2.96
15	6.82	1.96	3.48
16	8.37	1.96	4.27

Table 25. 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – Large School

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	18.86	4.32	4.36
2	18.82	4.32	4.35
3	13.76	4.32	3.18
4	19.94	4.32	4.61
5	13.16	4.32	3.04
6	10.36	4.32	2.40
7	10.18	4.32	2.35
8	13.06	4.32	3.02
9	13.32	4.32	3.08
10	15.36	4.32	3.55
11	17.14	4.32	3.97
12	15.99	4.32	3.70
13	16.20	4.32	3.75
14	16.23	4.32	3.75
15	18.92	4.32	4.38
16	24.72	4.32	5.72

Table 26. 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions – Small School

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	16.90	2.70	6.25
2	17.29	2.70	6.39
3	12.62	2.70	4.67
4	18.39	2.70	6.80
5	12.21	2.70	4.52
6	9.93	2.70	3.67
7	9.79	2.70	3.62
8	12.47	2.70	4.61
9	12.80	2.70	4.73
10	14.48	2.70	5.35
11	16.14	2.70	5.97
12	14.97	2.70	5.54
13	15.28	2.70	5.65
14	15.50	2.70	5.73
15	17.90	2.70	6.62
16	22.76	2.70	8.42

3.5 Modulating DOAS - Statewide Impacts

Impacts have only been estimated for submeasure a, Air Valves.

3.5.1 Statewide Energy and Energy Cost Savings

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix C presents the assumptions on the percentage of the total construction forecast that the proposed measure would impact.

For more details on the methodology and context about estimating the current market share rate, as well as statewide energy and energy cost savings, see the 2028 CASE Methodology Report.

Table 27 presents first-year statewide savings from new construction, and additions.

Table 27: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV$)
1	20,157	0.03	0.00	0	0.04	$0.20
2	120,839	0.16	0.03	0	0.26	$1.19
3	532,262	0.48	0.07	0	0.73	$3.57
4	261,921	0.33	0.06	0	0.54	$2.53
5	56,692	0.05	0.01	0	0.09	$0.39
6	324,062	0.24	0.03	0	0.35	$1.71
7	243,998	0.20	0.03	0	0.29	$1.39
8	468,504	0.42	0.06	0	0.59	$3.06
9	858,790	0.74	0.10	0	0.97	$5.63
10	284,380	0.35	0.04	0	0.47	$2.53
11	81,402	0.12	0.02	0	0.17	$0.92
12	528,383	0.62	0.10	0	0.91	$4.71
13	169,590	0.24	0.04	0	0.33	$1.79
14	77,197	0.10	0.02	0	0.14	$0.69
15	46,009	0.06	0.01	0	0.06	$0.44
16	26,631	0.05	0.01	0	0.09	$0.38
Total	**4,100,818**	**4.20**	**0.60**	**0**	**6.04**	**$31.11**

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 28 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid metric tons of carbon dioxide equivalent (CO_2e) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

Table 28: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e)	Total Reduced GHG Emissions (Metric Ton CO2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	319.39	0.00	319.39	39331.91
Alterations	0.00	0.00	0.00	0.00
Total	**319.39**	**0.00**	**319.39**	**39331.91**

3.5.3 Statewide Water Use Impacts

The proposed code change will not result in water savings.

3.5.4 Statewide Material Impacts

This measure is not expected to result in a meaningful change to materials.

3.5.5 Environmental Impacts

This proposal would result in improved building energy efficiency and corresponding GHG emissions reductions.

There are no identified indirect adverse environmental impacts nor indirect environmental benefits from this code change proposal.

3.5.6 Other Non-Energy Impacts

This measure is not expected to result in any non-energy impacts.

3.6 Modulating DOAS - Proposed Code Language

3.6.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

3.6.2 Administrative Code (Title 24, Part 1)

There are no proposed changes to Title 24, Part 1.

3.6.3 Energy Code (Title 24, Part 6)

120.1 – REQUIREMENTS FOR VENTILATION AND INDOOR AIR QUALITY

(d) Operation and control requirements for minimum quantities of outdoor air.

5. Occupied Standby Zone Controls.

A. Space conditioning zones serving one or more of the following space types shall include occupied standby controls complying with Section 120.1(d)5B: ~~when all of the following are true:~~

> ~~i. All rooms served by the zone are permitted to have their ventilation air reduced to zero while in occupied-standby mode per Table 120.1-A; and~~
>
> ~~ii. Occupant sensors are required by Section 130.1(c)5 and 6; and~~
>
> ~~iii.~~ i. ~~The zone and ventilation system is not served by pneumatic controls.~~

1) Post-secondary classrooms
2) Lecture halls
3) Conference, meeting, or training rooms
4) Multipurpose rooms < 1,000 ft2
5) Breakrooms
6) Enclosed offices
7) Open-plan office areas
8) Corridors or stairwells

Exception to Section 120.1(d)5: Additions or alterations to existing ventilation systems served by pneumatic controls and permitted before 2029.

6. Modulating DOAS. DOAS systems in buildings with design outdoor airflow rates > 3,000 cfm shall meet all of the following:

A. Include modulating pressure independent air valves or other means of independently modulating outside air at each space conditioning zone

B. Disable ventilation to unoccupied space conditioning zones while maintaining measured outside air ventilation rates to occupied zones per 120.1(d)5
C. Include demand ventilation controls for high density spaces per 120.1(d)4
D. Modulate DOAS supply fan speed in accordance with 140.4(c)2

Exception to Section 120.1(d)6: Additions or alterations to existing DOAS systems permitted before 2029 that do not include modulating pressure independent air valves or other means of independently modulating outside air at each space conditioning zone.

(f) Design and control requirements for quantities of outdoor air.

1. All mechanical ventilation and space-conditioning systems shall be designed with and have installed ductwork, dampers and controls that allow design minimum outside air rates to be operated at no ~~less~~ more than the larger of (1) the minimum levels specified in Section 120.1(c)3; or (2) the rate required for make-up of exhaust systems that are required for a covered or non-covered process, for control of odors, or for the removal of contaminants within the space.

SECTION 120.2 – REQUIRED CONTROLS FOR SPACE-CONDITIONING AND VENTILATION SYSTEMS

(e) **Shut-off and reset controls for space-conditioning and ventilation systems**. Each space-conditioning system and each ventilation system shall be installed with controls that comply with the following:

1. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:

A. An automatic time switch control device complying with Section 110.9 with an accessible manual override that allows operation of the system for up to 4 hours; or

B. An occupancy sensor; or

C. A 4-hour timer that can be manually operated.

(f) **Dampers for air supply and exhaust equipment**. Outdoor air supply and exhaust equipment shall be installed with dampers that automatically close upon fan shutdown or during periods of non-occupancy.

Exception 1 to Section 120.2(f): Equipment that serves an area that ~~must operate~~ is continuously occupied.

Exception 2 to Section 120.2(f): Gravity and other nonelectrical equipment that has readily accessible manual damper controls.

Exception 3 to Section 120.2(f): At combustion air intakes and shaft vents.

Exception 4 to Section 120.2(f): Where prohibited by other provisions of law.

Section 120.5 – REQUIRED NONRESIDENTIAL MECHANICAL SYSTEM ACCEPTANCE

(a) Before an occupancy permit is granted, the following equipment and systems shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements.

5. Demand control ventilation systems required by Section ~~120.1(c)3~~120.1(d)4 or 120.1(d)6 shall be tested in accordance with NA7.5.5

18. Occupant sensing zone controls required by Section 120.1(d)5A or 120.1(d)6 shall be tested in accordance with NA7.5.17.

Section 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(p) Dedicated outdoor air systems (DOAS).

2. The DOAS ~~supply~~ outdoor air shall be delivered using one of the following options:

A. D~~d~~irectly to the occupied space ~~or~~

B. A~~a~~t the outlet of any terminal heating or cooling coils and shall cycle off any zone heating and cooling equipment fans, circulation pumps and terminal unit fans when there is no call for heating or cooling in the zone.

C. At the inlet to zonal terminal heating or cooling coils. When there is no call for heating or cooling in the zone, the zone heating and cooling equipment, circulation pumps, and terminal unit fans shall either:

i. cycle off if there is a path for the outside air to reach the space, such as a return grille, or

ii. be controlled to reduce supply airflow to no more than the required outdoor air

~~Exception 1 to Section 140.4(p)2: Active chilled beam systems.~~

~~Exception 2 to Section 140.4(p)2: Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.~~

3. DOAS supply and exhaust fans not required to modulate by 120.1(d)6 shall have a minimum of three speeds to facilitate system balancing.

4. DOAS ~~with mechanical cooling~~ providing ventilation to multiple zones and operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above ~~60~~55°F ~~when representative building loads or outdoor air temperature indicates that the majority of zones require cooling~~ and shall not use mechanical cooling to cool supply air below 75°F. DOAS units serving zonal systems without latent cooling capability may mechanically cool supply air below 75°F when the outdoor dewpoint temperature is above 55°F.

3.6.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

3.6.5 Compliance Manuals

The Statewide CASE Team will provide the CEC with recommended revisions to compliance manuals after the 45-Day Language is published.

3.6.6 ACM Reference Manual

Changes to the ACM Reference Manual are being researched and recommendations will be provided in the final report.

3.6.7 Compliance Forms

As discussed in Section 3.1.4.5, the NRCC-MCH-E compliance form would be updated to reflect the proposed change. Additionally, NRCA-MCH-06-A (DCV) and NRCA-MCH-19-A (occupied standby) may need modifications. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

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Appendix A: Assumptions for Cost-Effectiveness Analysis

PVAV Turndown

Key Assumptions for Energy Savings Analysis

- The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-zone-specific LSC hourly factors when calculating energy and energy cost impacts.
- To model the energy savings for PVAV turndown, the Statewide CASE Team used the Medium Office prototype. Medium offices, large schools, and laboratories are the buildings that typically use PVAV systems. The CEC has not yet released the 2025 large school prototype; it will be modeled once available.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 29 presents the prototype buildings used in the analysis.

Table 29: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR-0.33

The Standard Design was modified to reflect realistic conditions:

- Occupancy, lighting, and plug loads are lower than those reflected in CBECC as shown in Table 30 to
-
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- Table 33.
- The maximum supply air temperature reset was reduced from 60ºF to 58ºF as it is rare that 60ºF is achieved.
- For parallel fan-powered VAV boxes, the fan on flow fraction was changed from zero to 30 percent to mimic single-duct VAV boxes, as parallel boxes are rarely used.

Table 30: New Occupancy Weekday Schedule

Hour of Day	CBECC Default Schedule	New Schedule
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.10	0.10
8	0.20	0.15
9	0.95	0.45
10	0.95	0.50
11	0.95	0.53
12	0.95	0.50
13	0.50	0.33
14	0.95	0.55
15	0.95	0.55
16	0.95	0.50
17	0.95	0.46
18	0.30	0.15
19	0.10	0.05
20	0.10	0.05
21	0.10	0.05
22	0.10	0.05
23	0.05	0.02
24	0.05	0.01

Table 31: New Occupancy Saturday Schedule

Hour of Day	CBECC Default Schedule	New Schedule
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.10	0.10
8	0.10	0.10
9	0.30	0.10
10	0.30	0.10
11	0.30	0.10
12	0.30	0.10
13	0.10	0.10
14	0.10	0.10
15	0.10	0.10
16	0.10	0.10
17	0.10	0.10
18	0.05	0.00
19	0.05	0.00
20	0.00	0.00
21	0.00	0.00
22	0.00	0.00
23	0.00	0.00
24	0.00	0.00

Table 32: New Lighting Weekday Schedule

Hour of Day	CBECC Default Schedule	New Schedule
1	0.05	0.05
2	0.05	0.05
3	0.05	0.05
4	0.05	0.05
5	0.05	0.05
6	0.10	0.05
7	0.10	0.10
8	0.30	0.15
9	0.65	0.55
10	0.65	0.55
11	0.65	0.55
12	0.65	0.58
13	0.65	0.58
14	0.65	0.58
15	0.65	0.58
16	0.65	0.55
17	0.65	0.55
18	0.35	0.18
19	0.30	0.08
20	0.30	0.08
21	0.20	0.08
22	0.20	0.07
23	0.10	0.05
24	0.05	0.05

Table 33: New Plug Load Weekday Schedule

Hour of Day	CBECC Default Schedule	New Schedule
1	0.05	0.05
2	0.05	0.05
3	0.05	0.05
4	0.05	0.05
5	0.05	0.05
6	0.10	0.05
7	0.10	0.10
8	0.30	0.15
9	0.90	0.45
10	0.90	0.50
11	0.90	0.53
12	0.90	0.50
13	0.90	0.33
14	0.90	0.55
15	0.90	0.55
16	0.90	0.50
17	0.90	0.46
18	0.50	0.18
19	0.30	0.08
20	0.30	0.08
21	0.20	0.08
22	0.20	0.07
23	0.10	0.05
24	0.05	0.05

The Proposed Design is identical to the revised Standard Design in all ways except for the revisions that represent the proposed changes to the code. The low-speed airflow of the two-stage VAV units was reduced from 50 percent of design flow to 25 percent. The team could not model 15 percent, as the limitation of the two-stage object in EnergyPlus resulted in unrealistically high fan power. The team is working on remodeling the variable-speed compressor object, which will result in higher energy savings. The minimum zone airflow fractions were reduced from 30 percent to 15 percent.

Table 34 presents the parameters modified and the values used in the Standard Design and Proposed Design.

Table 34: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeMedium	All	Coil:Cooling:DX:TwoSpeed	Low Speed Rated Air Flow Rate {m3/s}	50% of design flow	25% of design flow
OfficeMedium	All	AirTerminal:SingleDuct:ParallelPIU:Reheat	Minimum Primary Air Flow Fraction	0.3	0.15
OfficeMedium	All	AirTerminal:SingleDuct:ParallelPIU:Reheat	Fan On Flow Fraction	0.3	0.15
OfficeMedium	All	AirTerminal:SingleDuct:VAV:Reheat	Constant Minimum Air Flow Fraction	0.3	0.15

The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

Modulating DOAS

Key Assumptions for Energy Savings Analysis

- The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and energy cost impacts.
- To model the energy savings for MODULATING DOAS, the Statewide CASE Team used applicable building prototypes provided by the Energy Commission. These prototypes include assembly, medium office, large office, small school, and large school.
- The impacted space types include offices and conference rooms. However, the CBECC prototypes are simplified "box" models consisting of one core zone and four perimeter zones. To estimate per-unit energy savings for each impacted prototype, the Statewide CASE Team applied the estimated composition of different functional space types from Table 15 of the 2025 Daylighting CASE Report.

- The default schedules in the prototypes do not accurately reflect real-world conditions. Therefore, the Statewide CASE Team revised the occupancy, lighting, and plug load schedules provided by Taylor Engineers as shown in the previous section for PVAV turndown, and adjusted the plug load from 1.5 W/ft² to 0.5 W/ft² to better represent typical building usage.

Energy Savings Methodology per Prototypical Building

The 2028 CASE Methodology Report provides details on estimating energy savings per prototypical building and unit. The CEC directed the Statewide CASE Team to model energy impacts using specific prototypical building models that represent typical building geometries for different building types. Table 35 presents the prototype buildings used in the analysis.

Table 35: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
OfficeLarge	12	498,589	12 story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR-0.40
OfficeMedium	3	53,628	3 story office building with 5 zones and a ceiling plenum on each floor. WWR-0.33
OfficeSmall	1	5,502	1 story, 5 zone office building with pitched roof and unconditioned attic. WWR- 0.24 210,866
SchoolSmall	1	24,413	Elementary school with WWR of 0.36
SchoolLarge	2	210,866	High school with WWR of 35% and SRR 1.4%

The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 36 presents the parameters modified and the values used in the Standard Design and Proposed Design.

Table 36: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeLarge	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.15 cfm/ft2	0 cfm/ft2
OfficeMedium	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.15 cfm/ft2	0 cfm/ft2
OfficeSmall	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.15 cfm/ft2	0 cfm/ft2
SchoolSmall	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.15 cfm/ft2	0 cfm/ft2
SchoolLarge	All	Controller:OutdoorAir	Economizer Control Type	NoEconomizer	FixedDryBulb
OfficeLarge	All	Controller:OutdoorAir	Economizer Control Type	NoEconomizer	FixedDryBulb
OfficeMedium	All	Controller:OutdoorAir	Economizer Control Type	NoEconomizer	FixedDryBulb
OfficeSmall	All	Controller:OutdoorAir	Economizer Control Type	NoEconomizer	FixedDryBulb
SchoolSmall	All	Controller:OutdoorAir	Economizer Control Type	NoEconomizer	FixedDryBulb
SchoolLarge	All	Controller:OutdoorAir	Economizer Maximum Limit Dry-Bulb Temperature {C}	NA	23.9 °C
OfficeLarge	All	Controller:OutdoorAir	Economizer Maximum Limit Dry-Bulb Temperature {C}	NA	23.9°C
OfficeMedium	All	Controller:OutdoorAir	Economizer Maximum Limit Dry-Bulb Temperature {C}	NA	23.9°C
OfficeSmall	All	Controller:OutdoorAir	Economizer Maximum Limit Dry-Bulb Temperature {C}	NA	23.9°C

SchoolSmall	All	Controller:OutdoorAir	Economizer Maximum Limit Dry-Bulb Temperature {C}	NA	23.9°C
SchoolLarge	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.75 cfm/ft2	0 m/ft2
OfficeLarge	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.75 cfm/ft2	0 m/ft
OfficeMedium	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.75 cfm/ft2	0 m/ft
OfficeSmall	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.75 cfm/ft2	0 m/ft
SchoolSmall	All	DesignSpecification: OutdoorAir	Outdoor Air Flow per Zone Floor Area	0.75 cfm/ft2	0 m/ft
SchoolLarge	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeOccupancyWD
OfficeLarge	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeOccupancyWD
OfficeMedium	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeOccupancyWD
OfficeSmall	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeOccupancyWD
SchoolSmall	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeOccupancyWD
SchoolLarge	All	Schedule:Week:Daily	Saturday Schedule:Day Name	NewOfficeOccupancySat	NewOfficeOccupancySat

OfficeLarge	All	Schedule:Week:Daily	Saturday Schedule:Day Name	NewOfficeOccupancySat	NewOfficeOccupancySat
OfficeMedium	All	Schedule:Week:Daily	Saturday Schedule:Day Name	NewOfficeOccupancySat	NewOfficeOccupancySat
OfficeSmall	All	Schedule:Week:Daily	Saturday Schedule:Day Name	NewOfficeOccupancySat	NewOfficeOccupancySat
SchoolSmall	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeLightsWD	NewOfficeLightsWD
SchoolLarge	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeLightsWD	NewOfficeLightsWD
OfficeLarge	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeLightsWD	NewOfficeLightsWD
OfficeMedium	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeLightsWD
OfficeSmall	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeLightsWD
SchoolSmall	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeReceptacleWD
SchoolLarge	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday Schedule:Day Name	NewOfficeOccupancyWD	NewOfficeReceptacleWD
OfficeLarge	All	Schedule:Week:Daily	Monday/Tuesday/Wednesday/Thursday/Friday	NewOfficeOccupancyWD	NewOfficeReceptacleWD

			Schedule:Day Name		
OfficeMedium	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thurs day/Friday Schedule:Day Name	NewOfficeOcc upancySat	NewOfficeRe ceptacleWD
OfficeSmall	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thurs day/Friday Schedule:Day Name	NewOfficeOcc upancySat	NewOfficeRe ceptacleWD
SchoolSmall	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thurs day/Friday Schedule:Day Name	NewOfficeOcc upancySat	NewOfficeRe ceptacleWD
SchoolLarge	All	Schedule:Week:Daily	Monday/Tuesday/ Wednesday/Thurs day/Friday Schedule:Day Name	NewOfficeOcc upancySat	NewOfficeRe ceptacleWD

The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

Appendix B: Purpose and Necessity of Proposed Code Changes

Introduction

The sections below provide the purpose and necessity of proposed changes to Title 24, Part 1; Title 24, Part 6; and the reference appendices. This section intends to provide the CEC with the information needed for the Initial Statement of Reasons.

See Sections 2.6 and 3.6 of this report for marked-up code language.

PVAV Turndown

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: Section 140.4(m)

Purpose: The purpose of this change is to strengthen the current multizone packaged VAV fan turndown capabilities from the current required minimum of 50 percent of design airflow down to 15 percent of design airflow. Furthermore, a new requirement to limit compressor lockout at airflow rates above 15 percent of design airflow is being added to improve system efficiency and occupant comfort.

Necessity: This change is necessary to improve the energy efficiency performance of multizone packaged VAV system designs in nonresidential buildings. Currently, there is no requirement that compressors remain active down to low part load airflow rates. There are a variety of measures throughout Title 24, Part 6 that require airflow turndown capabilities in response to occupancy or part load conditions, and the cumulative impact of these requirements is that PVAV systems frequently are put into low part load airflow conditions. This measure would ensure that PVAV equipment can efficiently deliver space conditioning in low airflow conditions.

Purpose and Necessity of Changes to the Reference Appendices

Section: NA7.5.6

Purpose: The purpose of this change is to ensure that PVAV equipment complies with the new requirements regarding fan airflow turndown and elimination of compressor lockout at low airflow settings.

Necessity: This change is necessary to verify that the equipment can meet the required airflow turndown and compressor lockout limitation requirements in the field.

Modulating DOAS

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1.

Purpose and Necessity of Changes to Title 24, Part 6

Section: 120.1(d)

Purpose: The purpose of this change is to improve the clarity and specificity of occupied standby controls requirements for both DOAS and mixed-air system types. Additionally, this change will explicitly include the requirement that certain DOAS systems be capable of achieving airflow modulation to zones based on dynamic primary air requirements, accounting for real time changes to occupancy rates.

Necessity: The change or exception is necessary to cost-effectively improve the energy efficiency performance of DOAS systems in settings where there is a wide range of occupancy patterns. Current Title 24 Part 6 language is not explicit in stating that DOAS systems are required to modulate airflow and this measure addresses this gap. Furthermore, the ventilation occupied standby requirements are difficult to understand and these changes improve clarity and enforceability.

Section: 120.5(a)

Purpose: The purpose of this change is to reference the new sections of 2025 Title 24, Part 6 that trigger acceptance testing for DCV and occupied standby measures so that in-scope DOAS systems can be tested for DCV and occupied standby compliance.

Necessity: This change is necessary to ensure that wherever DOAS systems are triggered to modulate airflow capabilities to individual zones, they also trigger the appropriate acceptance testing requirements. The acceptance test ensures that the system has been installed correctly.

Section: 140.4(p)2

Purpose: The purpose of this change is to allow for greater flexibility in options to provide outside air to the zone.

Necessity: This change is necessary to ensure that designers of DOAS equipment are allowed to prescriptively specify efficient airflow delivery strategies.

Section: 140.4(p)4

Purpose: The purpose of this change is to revise the prescriptive DOAS supply air temperature setpoint requirements to further discourage simultaneous cooling and heating of the same airstream.

Necessity: This change is necessary to ensure that DOAS equipment does not excessively re-heat or re-cool ventilation air.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

Appendix C: Assumptions for Statewide Savings Estimates

The Statewide CASE Team is anticipating updated construction forecasts to be released by the California Energy Commission in March 2026. This will impact statewide energy savings but not the cost effectiveness of the proposal. The final CASE Report will present the updated savings based on the new forecasts.

PVAV Turndown

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts provided by the CEC. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates consider the current market share rate. The Statewide CASE Team estimated that the current market share for the proposed code change is 50 percent in the new-construction market. This is lower than the historical market share rate of 80 percent because updates to Title 24-2025 encourage the use of systems other than packaged multi-zone VAV.

Table **37** presents the projected nonresidential new construction that the proposed code change will impact in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 39 shows the assumed percentage of affected floor space by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings.

Table 40 represents the assumed percentage of affected floorspace by climate zone.

Table 37: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Medium Office	0.07	0.24	0.69	0.37	0.19	0.60	0.40	0.82	1.59	0.59	0.13	1.40	0.29	0.17	0.13	0.05	7.73
Total	**0.07**	**0.24**	**0.69**	**0.37**	**0.19**	**0.60**	**0.40**	**0.82**	**1.59**	**0.59**	**0.13**	**1.40**	**0.29**	**0.17**	**0.13**	**0.05**	**7.73**

Table 38: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Medium Office	2.70	24.79	63.03	33.82	10.66	38.25	35.10	47.29	69.07	53.35	13.55	81.36	20.14	10.66	8.20	3.25	515.23
Total	**2.70**	**24.79**	**63.03**	**33.82**	**10.66**	**38.25**	**35.10**	**47.29**	**69.07**	**53.35**	**13.55**	**81.36**	**20.14**	**10.66**	**8.20**	**3.25**	**515.23**

Table 39: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2026, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
Medium Office	50%	80%

Table 40: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	50%	80%
2	50%	80%
3	50%	80%
4	50%	80%
5	50%	80%
6	50%	80%
7	50%	80%
8	50%	80%
9	50%	80%
10	50%	80%
11	50%	80%
12	50%	80%
13	50%	80%
14	50%	80%
15	50%	80%
16	50%	80%

MODULATING DOAS

The Statewide CASE Team estimated statewide impacts for the first year by multiplying per-unit savings estimates by statewide construction forecasts provided by the CEC. The 2028 CASE Methodology Report includes additional information about the methodology and assumptions used to calculate statewide energy impacts.

The statewide savings and cost estimates consider the current market share rate. The Statewide CASE Team estimated that the current market share rate for the proposed code change is 9.36 percent for the new construction market. The current market share rate is estimated based on the 2018 Commercial Buildings Energy Consumption Survey (CBECS).

Table 41

Table 41 presents the projected nonresidential new construction that the proposed code change will impact in 2026. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floorspace that the proposed code change would impact. Table 43 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. represents the assumed percentage of affected floorspace by climate zone.

The 2018 Commercial Buildings Energy Consumption Survey (CBECS) includes 5,918 buildings with a total floor space of 96,423 million square feet. Among these buildings, there are 249 buildings with total floor space of 9,027 million square feet served by DOAS. Therefore, CBECS indicates that 9.36 percent of commercial floorspace is served by DOAS systems in 2018.

Table 41: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2026, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	2.03	0.99	0.00	0.89	0.52	1.44	2.61	0.25	0.07	0.36	0.00	0.13	0.01	0.03	9.32
Medium Office	0.09	0.33	0.96	0.52	0.26	0.84	0.56	1.15	2.23	0.82	0.19	1.96	0.41	0.24	0.18	0.07	10.83
Small Office	0.01	0.30	0.13	0.01	0.04	0.10	0.16	0.11	0.25	0.29	0.06	0.38	0.27	0.03	0.07	0.02	2.25
Large Retail	0.00	0.00	0.77	0.38	0.10	0.49	0.26	0.58	1.16	0.44	0.21	0.91	0.25	0.10	0.13	0.04	5.83
Medium Retail	0.06	0.24	0.56	0.31	0.06	0.42	0.20	0.60	1.00	0.58	0.10	0.44	0.27	0.13	0.09	0.06	5.10
Strip Mall	0.00	0.11	0.35	0.16	0.01	0.39	0.34	0.69	0.75	0.94	0.05	0.41	0.23	0.22	0.07	0.04	4.77
Mixed-Use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.00	0.08	0.54	0.27	0.02	0.37	0.38	0.56	0.88	0.53	0.22	0.71	0.38	0.10	0.05	0.04	5.13
Small School	0.05	0.19	0.32	0.16	0.10	0.22	0.21	0.25	0.46	0.24	0.07	0.54	0.21	0.07	0.03	0.03	3.15
Non-refrigerated Warehouse	0.04	0.26	1.51	0.78	0.12	0.95	0.50	1.36	2.11	0.95	0.44	1.99	0.57	0.25	0.26	0.10	12.21
Hotel	0.03	0.15	0.72	0.37	0.08	0.39	0.34	0.55	0.83	0.40	0.11	0.56	0.18	0.10	0.09	0.03	4.91
Assembly	0.01	0.28	1.11	0.39	0.04	0.55	0.56	1.00	1.28	0.80	0.12	0.99	0.21	0.17	0.08	0.06	7.64
Hospital	0.02	0.12	0.57	0.29	0.05	0.22	0.37	0.30	0.53	0.55	0.10	0.56	0.18	0.10	0.08	0.03	4.08
Laboratory	0.01	0.13	0.90	0.50	0.05	0.29	0.19	0.32	0.59	0.24	0.09	0.30	0.08	0.06	0.03	0.02	3.81
Restaurant	0.01	0.06	0.23	0.12	0.02	0.24	0.14	0.35	0.57	0.29	0.05	0.22	0.10	0.07	0.03	0.02	2.52
Enclosed Parking Garage	0.00	0.01	1.28	0.87	0.00	1.81	0.49	1.59	1.07	0.04	0.00	0.03	0.00	0.01	0.00	0.01	7.21
Open Parking Garage	0.00	0.08	1.73	1.18	0.04	2.55	0.84	2.24	1.51	0.46	0.01	0.37	0.03	0.14	0.03	0.07	11.28
Grocery	0.00	0.03	0.07	0.04	0.01	0.03	0.01	0.04	0.06	0.03	0.01	0.03	0.02	0.01	0.01	0.00	0.41
Refrigerated Warehouse	0.00	0.00	0.04	0.04	0.01	0.02	0.00	0.00	0.01	0.03	0.00	0.05	0.08	0.01	0.01	0.00	0.29
Controlled-Environment Horticulture	0.06	0.05	0.22	0.03	0.14	0.18	0.00	0.02	0.02	0.19	0.21	0.21	0.06	0.01	0.03	0.00	1.46
Vehicle Service	0.00	0.05	0.38	0.25	0.02	0.39	0.24	0.56	1.27	0.40	0.02	0.27	0.17	0.14	0.04	0.03	4.23
Manufacturing	0.00	0.01	0.15	0.05	0.01	0.01	0.04	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34

Unassigned	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Total	0.4	2.5	14.6	8.0	1.2	11.4	6.3	13.8	19.2	8.5	2.1	11.3	3.7	2.1	1.3	0.7	107.1

Table 42: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2026 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.10	2.48	111.84	57.88	1.47	79.63	58.17	130.08	242.48	46.78	2.09	62.89	7.41	16.22	3.55	3.73	826.79
Medium Office	2.70	24.79	63.03	33.82	10.66	38.25	35.10	47.29	69.07	53.35	13.55	81.36	20.14	10.66	8.20	3.25	515.23
Small Office	3.34	10.20	17.75	9.06	6.00	10.58	6.81	10.62	16.70	19.54	8.48	35.15	17.18	3.99	4.94	2.14	182.51
Large Retail	0.80	6.93	46.94	21.52	3.36	25.57	20.27	34.77	53.22	42.65	9.12	46.53	18.01	8.73	7.52	2.57	348.51
Medium Retail	0.94	10.49	35.62	20.59	4.35	35.42	27.73	53.38	86.56	53.51	8.30	48.40	19.32	12.42	7.02	4.14	428.17
Strip Mall	2.67	7.87	29.94	14.74	4.08	32.18	22.63	44.61	66.96	53.54	9.80	38.70	19.34	12.22	6.96	3.67	369.90
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.61	6.42	27.86	11.16	1.66	22.70	18.03	34.33	58.86	44.81	8.10	42.70	21.13	9.65	6.10	2.87	316.98
Small School	1.78	8.90	20.46	7.98	4.85	20.55	11.97	27.55	43.45	26.42	10.80	33.66	18.75	6.98	3.40	2.92	250.43
Non-refrigerated Warehouse	2.66	16.18	86.64	42.74	7.84	71.98	41.18	102.72	165.84	146.16	26.98	118.64	40.86	31.10	23.24	9.30	934.08
Hotel	1.42	8.42	38.48	19.78	4.01	24.39	26.13	33.58	52.81	29.67	5.77	32.42	10.46	6.40	4.70	1.95	300.40
Assembly	3.46	14.54	73.07	36.05	5.28	45.80	32.72	71.31	96.16	73.40	13.08	55.78	24.10	15.16	9.46	5.15	574.53
Hospital	1.49	8.87	38.66	19.74	4.04	22.60	21.72	32.62	55.90	31.68	8.89	42.54	17.99	7.04	4.03	2.59	320.41
Laboratory	0.14	3.21	29.54	22.45	1.22	9.77	13.75	12.49	15.45	8.65	0.54	9.71	3.52	1.38	0.31	0.46	132.59
Restaurant	0.49	2.89	11.78	6.00	1.24	13.17	8.58	19.02	32.00	25.93	2.81	13.56	6.19	5.49	2.76	1.52	153.42
Enclosed Parking Garage	0.01	0.43	32.57	24.75	0.24	23.32	16.54	46.73	58.02	2.14	0.28	2.47	0.39	0.68	0.13	0.35	209.06
Open Parking Garage	0.18	5.62	44.02	33.46	3.09	32.91	28.14	65.95	81.92	27.66	3.57	31.97	5.05	8.84	1.72	4.49	378.59
Grocery	0.08	1.36	4.70	2.85	0.60	2.73	1.67	3.21	5.56	3.21	0.52	2.99	1.16	0.75	0.43	0.31	32.12
Refrigerated Warehouse	0.00	0.36	0.73	0.17	0.31	0.37	0.02	0.34	0.63	0.52	0.21	1.72	3.13	0.15	0.16	0.12	8.92

Controlled-Environment Horticulture	0.56	0.37	2.10	0.86	5.06	6.61	0.86	0.59	1.28	2.89	2.01	3.63	4.29	0.37	0.52	0.19	32.17
Vehicle Service	0.73	4.95	26.92	12.78	2.38	26.98	18.46	39.62	65.42	45.23	5.04	30.66	14.59	12.07	4.94	2.83	313.61
Manufacturing	3.28	13.51	49.54	63.64	4.47	58.66	26.62	98.16	134.48	39.66	10.29	45.61	20.78	13.58	4.12	7.42	593.83
Unassigned	0.29	5.26	7.22	5.05	0.18	2.06	0.62	3.02	6.29	2.04	2.69	11.48	2.35	0.62	0.32	0.82	50.31
Total	**27.7**	**164.1**	**799.4**	**467.1**	**76.4**	**606.2**	**437.7**	**912.0**	**1409.1**	**779.5**	**152.9**	**792.6**	**296.1**	**184.5**	**104.5**	**62.8**	**7,272.55**

Table 43: Percentage of Nonresidential Floorspace Impacted by Proposed Code Change in 2029, by Building Type

Building Type	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
Large Office	9.36%	9.36%
Medium Office	9.36%	9.36%
Small Office	9.36%	9.36%
Large Retail	0%	0%
Medium Retail	0%	0%
Strip Mall	0%	0%
Mixed-Use Retail	0%	0%
Large School	9.36%	9.36%
Small School	9.36%	9.36%
Non-refrigerated Warehouse	0%	0%
Hotel	0%	0%
Assembly	0%	0%
Hospital	0%	0%
Laboratory	0%	0%
Restaurant	0%	0%
Enclosed Parking Garage	0%	0%
Open Parking Garage	0%	0%
Grocery	0%	0%
Refrigerated Warehouse	0%	0%
Controlled-Environment Horticulture	0%	0%
Vehicle Service	0%	0%
Manufacturing	0%	0%
Unassigned	0%	0%

Table 44: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	100%	0%
2	100%	0%
3	100%	0%
4	100%	0%
5	100%	0%
6	100%	0%
7	100%	0%
8	100%	0%
9	100%	0%
10	100%	0%
11	100%	0%
12	100%	0%
13	100%	0%
14	100%	0%
15	100%	0%
16	100%	0%

Appendix D: Environmental Analysis

PVAV Turndown

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including—but not limited to—an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

This measure is expected to result in energy savings (and corresponding GHG emission reductions) due to improved packaged VAV system efficiency. The estimated impact of these benefits has been quantified in this report.

Direct Adverse Environmental Impacts

This measure is expected to not result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

This measure represents a straightforward building energy efficiency enhancement in buildings with multizone packaged VAV systems and as such, is not expected to result in any indirect environmental benefits.

Indirect Adverse Environmental Impacts

This measure represents a straightforward building energy efficiency enhancement in buildings with multizone packaged VAV systems and as such, is not expected to result in any indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine whether this measure would result in significant direct or indirect adverse environmental impacts and therefore, did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts on water quality or water use.

Modulating DOAS

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of its proposal, including—but not limited to—an evaluation of factors contained in the California Code of Regulations, Title 14, section 15064, and has determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

This measure is expected to result in energy savings (and corresponding GHG emission reductions) due to improved airflow turndown capabilities in DOAS systems. The estimated impact of these benefits has been quantified in this report.

Direct Adverse Environmental Impacts

This measure is expected to not result in any direct adverse environmental impacts.

Indirect Environmental Impacts

Indirect Environmental Benefits

This measure represents a straightforward building energy efficiency enhancement for buildings with DOAS systems and as such, is not expected to result in any indirect environmental benefits.

Indirect Adverse Environmental Impacts

This measure represents a straightforward building energy efficiency enhancement for buildings with DOAS systems and as such, is not expected to result in any indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors" (Cal. Code Regs., tit. 14, § 15021). The Statewide CASE Team did not determine whether this measure would result in significant direct or indirect adverse environmental impacts and therefore did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect.

Water Use and Water Quality Impacts Methodology

There are no impacts on water quality or water use.

Appendix E: Summary of Stakeholder Engagement

Introduction to Stakeholder Engagement

Collaborating with stakeholders who may be affected by proposed code changes is a core component of the Statewide CASE Team's process. The Statewide CASE Team engages interested parties to identify and address issues related to the proposals, with the goal of submitting recommendations to the CEC in this Draft CASE Report that reflect broad support. Public stakeholders provide valuable feedback on draft analyses and help identify and address adoption challenges, including cost effectiveness, market and technical barriers, compliance and enforcement, and potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations.

PVAV Turndown

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and analysis results
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted one stakeholder meeting for PVAV Turndown via webinar, as described in Table 45. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

Table 45: Utility-Sponsored Stakeholder Meeting

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of HVAC Air Distribution Utility-Sponsored Stakeholder Meeting	Tuesday September 23, 2025	• Introduced the fundamentals of the measure • Fielded questions from stakeholders on the measure

The first round of utility-sponsored stakeholder meetings began in September 2025 and served as an early forum to promote transparency and gather stakeholder feedback on measures under consideration by the Statewide CASE Team.

The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the full Title 24 Stakeholders listserv, which includes over 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from diverse industries and trades, such as manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was announced on the Title 24 Stakeholders LinkedIn page and cross-promoted on the CEC LinkedIn page approximately two weeks in advance to engage individuals, organizations, and broader channels outside the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers, individual comments, and results from live attendee polls to help evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 46. Manufacturer engagement is critical to understand the challenges of complying with the PVAV airflow turndown measure. As this CASE initiative continues, additional manufacturer stakeholders will be consulted for this measure's development.

Table 46: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Daikin Applied/Skip Ernst	Manufacturer	No
AAON/Kevin Teakell	Manufacturer	No
Carrier/Richard Lord	Manufacturer	No

Modulating DOAS

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2025 code cycle. The goal of these meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To promote transparency in the development of code change proposals, the Statewide CASE Team uses stakeholder meetings to solicit feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and analysis results
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted one stakeholder meeting for Modulating DOAS via webinar, as described in Table 47. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

Table 47: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of HVAC Air Distribution Utility-Sponsored Stakeholder Meeting	Tuesday September 23, 2025	• Introduced the fundamentals of the measure • Fielded questions from stakeholders on the measure

The first round of utility-sponsored stakeholder meetings began in September 2025 and served as an early forum to promote transparency and gather stakeholder feedback on measures under consideration by the Statewide CASE Team.

The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2025 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented the initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred from September 2025 and provided updated details on proposed code changes. These meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com. One email was sent to the full Title 24 Stakeholders listserv, which includes over 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from diverse industries and trades, such as manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was announced on the Title 24 Stakeholders LinkedIn page and cross-promoted on the CEC LinkedIn page approximately two weeks in advance to engage individuals, organizations, and broader channels outside the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers, individual comments, and results from live attendee polls to help evaluate stakeholder participation and support.