Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

Nonresidential HPWH Ventilation Clean-Up

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Executive Summary

This proposal describes specific code changes to simplify ventilation requirements for heat pump water heaters (HPWHs) that the Statewide Codes and Standards Enhancement (CASE) Team submits to the California Energy Commission (CEC) for potential inclusion in the 2028 California Energy Code (Title 24, Part 6). To be adopted, measures must be cost-effective and technically feasible. This proposal would make unitary HPWH installation decision making simpler, mitigate potential problems, and improve consumer-sized HPWH performance in nonresidential buildings.

Stakeholder engagement included workshops, surveys of installers and designers, and input from manufacturers and subject matter experts, ensuring the proposal reflects real-world practices and industry feedback. The proposal incorporates feedback from a public stakeholder meeting held on October 23, 2025 that included survey questions, multiple online surveys, and interviews with plumbers, HVAC and plumbing designers, HVAC installers, contractors, subject matter experts (SMEs), and the compliance improvement team.

The Statewide CASE Team recognizes ongoing systemic inequities in environmental and social justice (ESJ) communities and is developing code change proposals with careful consideration of potential unintended impacts. Each measure was evaluated, and those considerations are documented in the CASE Report.

Proposed Code Change

This proposal would simplify existing ventilation compliance pathways for consumer integrated HPWHs in nonresidential buildings. The measure would apply to nonresidential buildings with one or more consumer-sized HPWHs, such as small offices and cafes. The measure would eliminate select single-duct and louver-only ventilation configurations when connected to the outdoors and instead emphasize balanced ventilation approaches. The proposal would retain flexibility by allowing multiple compliant configurations while improving clarity and consistency in code language and adjusting to reflect new research.

Benefits of Proposed Change

The proposed change would reduce risk of both moisture damage and poor indoor air quality by avoiding pressure imbalances caused by improper ventilation configurations. According to a survey of 27 industry professionals, improper HPWH ventilation practices lead to moisture damage in about one percent of HPWH installations with ducts (see Appendix F for more details). By discouraging single-duct systems that cross the building pressure boundary, the measure would improve system performance and reduce unintended heating and cooling loads. These improvements support California's long-term energy efficiency and greenhouse gas (GHG) reduction goals while enhancing occupant health and safety in nonresidential buildings.

Compliance and Enforcement

The proposal builds on the existing 2025 compliance framework, requiring minimal updates to existing compliance forms without introducing significant new administrative burden. Both the certificate of compliance form in NRCC-PLB-E (element 22 in Table F) and the certificate of installation form in NRCI-PLB-E (Electric Ready Requirements) would be updated to reflect the updated ventilation compliance options. Compliance is expected to be high, as multiple pathways remain available and the changes primarily refine existing requirements. Some training and outreach will be needed to support designers, installers, and enforcement officials in understanding updated ventilation requirements.

Market Assessment

The market for unitary HPWHs in nonresidential buildings is growing, supported by electrification and decarbonization policies. For example, U.S. HPWH sales are projected to increase from 190,000 HPWHs shipped in 2023 to millions annually starting in 2029 as a result of the DOE requirement for all electric tank water heaters over the size of 35 gallons to be HPWHs starting in 2029 (Advanced Water Heating Initiative 2026). Products and installation materials are widely available and already used in practice. The proposal is technically feasible and aligns with current installation practices, although it may require incremental adjustments for some designers and installers that have not adopted the two-duct design practice yet. Economic impacts are expected to be minimal, with low incremental costs and no significant disruption to jobs or businesses. This measure may slightly support market growth by improving confidence in HPWH performance.

Cost Effectiveness

The proposed code change is cost-effective across all applicable California climate zones. Benefit-to-cost ratios[1] range from 0.3 to 24.7 depending on building type, climate zone, and configuration. Incremental costs are low, and long-term system cost savings are achieved through improved efficiency and reduced operational impacts.

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[1] The benefit-to-cost ratio (BCR) compares benefits or cost savings to costs over the 30-year period of analysis. Proposed code changes with a BCR of 1.0 or greater are cost effective.

Statewide Impacts

Statewide savings are driven by reduced HPWH energy use and improved system efficiency.

Table 1: Summary of Statewide Impacts

Metric [a]	Total Statewide Impacts
Annual Electricity Savings (GWh)	0.01
Peak Demand Reduction (MW)	0.002
Annual Natural Gas Savings (Million Therms)	0.00
Annual Source Energy Savings (Million kBtu)	0.02
30-Year Long-term System Cost Savings (Million 2029 PV$)	$0.10
Annual Avoided GHG (Metric Tons CO2e/yr)	1.28

a. Values represent impacts from buildings permitted during the first year the code is in effect. Positive values indicate savings or reductions.

Acronyms

Table 2 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a glossary of terms.

Table 2: List of Acronyms

Acronym	Definition
ACM	Alternative Calculation Method
ADA	Americans with Disabilities Act
AHJ	Authority Having Jurisdiction
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
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
CalEPA	California Environmental Protection Agency
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
CBO	Community-Based Organization
CCDEH	California Conference of Directors of Environmental Health
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFM	Cubic Feet Per Minute
CFR	Code of Federal Regulations
CO2e	Carbon Dioxide Equivalent
COP	Coefficient of Performance
CPUC	California Public Utilities Commission
CSE	California Simulation Engine
CTF	Conduction Transfer Functions
CZ	Climate Zone
DAC	Disadvantaged Community

Acronym	Definition
DGS	California Department of General Services
DOAS	Dedicated Outdoor Air System
DOE	Department of Energy
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
FRED	Federal Reserve Economic Data
FSOR	Final Statement of Reasons
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
HPWH	Heat Pump Water Heater
IAQ	Indoor Air Quality
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISOR	Initial Statement of Reasons
kBtu	Kilo British Thermal Unit
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LED	Light Emitting Diode
LPD	Lighting Power Density
LSC	Long-term System Cost
MAEDbS	Modernized Appliance Efficiency Database System
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
MW	Megawatt
NFA	Net Free Area
NPDI	Net Private Domestic Investment
NRCC	Nonresidential Certificate of Compliance
NRCI	Nonresidential Certificate of Installation
PEP	Public Engagement Plan
PLB	Plumbing

Acronym	Definition
PM	Particulate Mass
PV	Present Value
SB	Senate Bill
SDD	Standards Data Dictionary
SME	Subject Matter Expert
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
UEF	Uniform Energy Factor
UL	Underwriters Laboratories
W	Watt

1. Introduction

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 jointly sponsored this effort. Where the term "Statewide CASE Team" is used in this report, it refers to the authors and State Building Codes Advocacy activities supported through the Codes and Standards program.

1.3 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 the California Energy Commission (CEC), utilities (PGE, SCE, and SDG&E), plumbers, HVAC and plumbing designers, HVAC installers, contractors, subject matter experts (SMEs), and the compliance improvement team. This proposal incorporates the following:

- On October 23, 2025, the Statewide CASE Team held a public stakeholder workshop that included survey questions.
- From September 20, 2025, through November 3, 2025, the Statewide CASE Team distributed an online survey to plumbers and program managers.

- From October 30, 2025, through December 12, 2025, the Statewide CASE Team distributed an online survey to public stakeholders via email, LinkedIn, the Title 24 Stakeholder website, stakeholder webinars, and targeted personal outreach. Maintenance personnel, engineers, and designers provided survey feedback.
- In January of 2026, the Statewide CASE Team subject matter experts working with heat pump water heaters (HPWHs) in food service applications shared HPWH implementation feedback.
- In April of 2026, the Statewide CASE Team surveyed HPWH installers about installation practices.
- In April and May of 2026, the Statewide CASE Team gathered feedback from manufacturers on the proposed code language.

In addition, the Statewide CASE Team interviewed or received written input from nine stakeholders and SMEs to help define the proposed measures, estimate incremental costs, and better understand industry concerns.

Key takeaways from stakeholder outreach and stakeholder meetings include:

1) The HPWH ventilation clean-up topic is a high priority HPWH topic.
2) A maximum duct length requirement is needed if there is a minimum duct diameter requirement for HPWH's with axial fans.
3) There will be minimal new compliance implementation cost by the state for this measure since it is a small change to 2025 code requirements. This update will be included as part of the standard new code roll out education.
4) Without the proposed code change, there may be negative impacts to the uptake of HPWHs in nonresidential buildings as a result of moisture and indoor air quality (IAQ) issues caused by a only a single HPWH duct connected to the outdoors while the other side of the HPWH vents into a conditioned HPWH room.
5) The survey of plumbers and program directors indicates that water heaters are typically being installed indoors. These water heaters are typically HPWHs installed without ducts. Installing HPWHs with ducts in new construction is almost always feasible, but retrofits are only sometimes feasible. Survey findings indicate that the percentage of HPWHs installed in rooms less than 700 square feet varies significantly across installers. Some installers report that five to ten percent of HPWHs are being installed in small rooms, while others indicate that more than 75 percent of HPWHs are being installed in small rooms.
6) Survey questions presented during the stakeholder meeting on October 23, 2025, indicate that approximately five percent of newly constructed small office buildings will install a HPWH with either an intake duct or an exhaust duct.

7) Subject matter experts working with HPWHs in food service applications indicate that it is very uncommon (less than one percent) for water heater installations in new quick-service restaurant buildings to include consumer integrated HPWHs with an intake or exhaust duct.
8) Nine responses from a group of operation and maintenance personnel, engineers, and designers also indicate that it is uncommon for water heater retrofits to be a HPWH with either an intake duct or an exhaust duct. Responses from this this same group indicate that it is also uncommon for water heater retrofits to have both intake and exhaust ducts.
9) Eight responses from HPWH installers indicate that installing ducts takes about 1.9 hours for the first duct and 1.6 hours for the second duct, but six responses from design professionals, and energy advocates expect that installations will take approximately four times longer. This is an opportunity to educate designers and consultants about the cost of implementation for HPWH ventilation ducts which will result in broader adoption of ducting for HPWHs.
10) All stakeholders agree that building pressure balance is important and that a single HPWH ventilation duct crossing the building pressure boundary (connecting the building's conditioned space with outdoor air) will disrupt this pressure balance. This feedback resulted in the Statewide CASE Team disallowing single intake and single exhaust ventilation duct configurations that cross the building pressure boundary.
11) All stakeholders acknowledge that the cold air exhausted from HPWHs increases condensation potential. Discussions emphasized the importance of keeping this exhaust air away from already cold surfaces and that ducting this air with an insulated duct is a reliable way to direct this cold exhaust air away from cool surfaces. This feedback resulted in the Statewide CASE Team focusing code language around managing HPWH exhaust air with an insulated duct through an outlet near the ceiling of a communicating space or to outside.
12) Several stakeholders mentioned the importance of flexibility in ventilation code requirements to accommodate unique HPWH locations in buildings.
    a. It was discussed that HPWHs installed in unconditioned closets with exterior-facing doors should be allowed to use a single exhaust duct and a louvered door or vent to allow makeup air into the space for the HPWH intake. This feedback led the Statewide CASE Team to allow a louver/grille for makeup air in exterior-facing closets when paired with an exhaust duct.
    b. Several stakeholders mentioned that rooms with regularly operating heat sources should have fewer ventilation requirements. This feedback led the

Statewide CASE Team to allow calculations for the space to determine whether ducting is necessary.

13) Several stakeholders mentioned that there is an AHRI working group for HPWH ventilation that is developing Guideline U. Guideline U may add information to product literature that details manufacturer approved HPWH installation methods. This feedback resulted in keeping the manufacturer-approved HPWH ventilation compliance approach defined in the 2025 code language in the 2028 code language proposal.

14) Several stakeholders mentioned that adding minimum requirements for duct diameter and maximum length restrictions for HPWHs with axial fans will not solve heat transfer issues caused by airflow limitations because each manufacturer uses different fans. The AHRI working group may address fan performance in Guideline U. This feedback resulted in removing the newly proposed language around adding minimum duct diameter requirements and maximum length restrictions for HPWHs with axial fans.

See Appendix F for details on the Statewide CASE Team's stakeholder engagement.

1.4 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in environmental and social justice (ESJ) communities.[2] These issues persist today. To minimize the risk of perpetuating inequity, code change proposals were developed with intentional consideration of the unintended consequences on ESJ communities.

When analyzing impacts for nonresidential buildings, the Statewide CASE Team reviewed each nonresidential building type through the lens of the four criteria: cost, health, resiliency, and comfort. The Statewide CASE Team examined which building types are used by ESJ communities most frequently and evaluated the allocation of impacts related to the following areas among all populations. Some building types have

[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 five 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).

unique environmental justice concerns due to their common uses, location, or other factors.

The Statewide CASE Team will continue to build relationships with CBOs and other stakeholders to improve the identification of potential impacts for future code cycles and is open to additional resources that can contribute to this effort.

2. Measure Description

2.1 Proposed Code Change

This proposed code change would simplify the four existing consumer integrated HPWH ventilation compliance pathways implemented in the 2025 code to make unitary HPWH installation decision making simpler, as well as improving consumer-sized HPWH performance in nonresidential buildings. This measure applies only to nonresidential buildings where one or more consumer-sized HPWHs gets installed, such as small offices and cafes.

Under the 2025 code, allowed methods of providing ventilation air included those approved by the manufacturer, installing the HPWH in a large unvented room of minimum size, installing in a closet with minimum ventilation area to adjacent spaces via louvers or a duct, and directly ducting the unit to the outdoors or to an adjacent space. The Statewide CASE Team recommends improvements to this code language for clarity, and adjustments to requirements to reflect new research and better align with other codes in development.

This proposal also recommends eliminating the following from the 2025 code:

- Two ducting configurations:
    - Intake air ducted from outside with no exhaust duct to outside, and
    - Exhaust air ducted to outside with no intake duct to outside when the HPWH is installed inside the building in conditioned space; but if the HPWH is installed outside the building or in an unconditioned space this is allowed.
- Two louvered wall/door ventilation configurations:
    - Louvered door/wall for the exhaust of the HPWH to the outdoors, and
    - Louvered door/wall for the exhaust of the HPWH to a communicating space.

Table 3 summarizes the scope of the proposed code change.

Table 3: 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 500.3.3.7 [Section 110.3(c)7] Part 6 Section 100.1	NRCC-PLB-E Table F element 22 NRCI-PLB-E	N/A

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

2.2 Benefits of Proposed Change

The proposed code change will decrease moisture damage risk, air quality issues, and space conditioning load impacts for HPWHs installed in a conditioned space.

Typical unitary HPWH's installed and vented within conditioned spaces provide minimal impact on space conditioning loads when the space is 450 cubic feet or larger. However, ducting only the HPWH intake or exhaust to outside can negatively impact IAQ and increase heating and cooling load (ENERGY STAR n.d., Klein 2025).

A HPWH with minimal airflow restrictions typically moves 176 CFM of air across the evaporator coil,[3] but some models can bring in as much as 475 cfm (C. Colon 2013). This HPWH airflow would depressurize or pressurize the HPWH room depending on whether the HPWH has only one exhaust duct or one intake duct connected to the outdoors (Bradford White Corporation, USA 2025). In addition, some installation practices can increase the risk of moisture damage, which is a health and safety concern. These installation practices include placing the outlet of the HPWH too close to other surfaces, inappropriately sized and uninsulated ducting, and using a louvered

[3] Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023

door/wall for the exhaust of HPWHs. Updated code language in this measure would reduce the risk of moisture damage, IAQ issues, and health and other safety concerns.

2.3 Background Information

Consumer integrated heat pump water heaters are defined under U.S. DOE CFR 431 as HPWHs with storage volumes of 120 gallons or less with an electrical input of less than 24 amps at less than 250 volts. The 2025 California energy code defines an integrated heat pump water heater as “a HPWH that has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.” This report will use the generic HPWH term, but the proposed code language will use the more formal “consumer integrated HPWH” terminology.

HPWHs are an efficient water heating appliance utilizing a refrigeration cycle (compressor, heat exchangers, working fluid, and a fan). The fan pulls in air (either from the surrounding environment or from a duct) to transfer heat to the refrigeration system, which heats water inside the storage tank. HPWH compressor operation is two to three times more efficient than using the resistive electric element (common to 208/240V HPWHs to provide supplemental heating, as needed). Maximizing HPWH compressor operation is the goal to increase HPWH efficiency in accordance with California Title 24, Part 6 code. In addition, maximizing HPWH compressor operation results in lower peak winter-morning electrical demand, as the compressor draws one-eighth the demand of an electric resistive element.

The fan used to pull air across the condenser heat exchanger in HPWHs can be an axial fan or a centrifugal fan. Axial fans look like a propeller with fan blades extending from the center of the fan. Centrifugal fans look like a hamster wheel with fan blades that extend away from a back plate; see Figure 1. Axial fans can move large volumes of air efficiently, but they are not ideal for ducted applications with higher static pressure, as airflow decreases quickly with increasing back pressure.[4] Centrifugal fans are good for high static pressure duct applications and are quieter than axial fans but are less efficient and typically more expensive (AS Engineers n.d.).

[4] (Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023)

Figure 1: Example of an axial style fan (left) and a centrifugal style fan (right).

Source: (CFM Continental Fan n.d., PBM n.d.)

HPWHs are installed in different configurations with either no ducts, one duct, or two ducts (i.e., “fully ducted”), as shown in Figure 2. Ducts are used to connect the intake and/or exhaust of the HPWH to the outside (duct crosses the building pressure boundary) OR connect to a larger interior space within the building (duct connects to a communicating interior space within the same pressure boundary).

If no ducts are used during installation, the room must be larger than a certain size (450 to 700 cubic feet depending on the compressor size) to prevent the room from being excessively cooled by the HPWH exhaust air. HWPH efficiency decreases by 6 to 54 percent in these small closet cases without proper ventilation; see Appendix A for more information.

Figure 2: Example of a HPWH with no ducts (left), one duct (center) and two ducts (right) also known as fully ducted.

Source: (Home Depot n.d., San Jose Clean Energy n.d., Arctic Heat Pumps n.d.)

The 2025 Multifamily Domestic Hot Water CASE Report involved updating Section 110.3 (now Section 500.3.3.7.2) of the 2025 Energy Code to include ventilation requirements for HPWHs. Allowed methods of providing adequate ventilation include those approved by the manufacturer, installing the HPWH without any additional ducting in an unvented room larger than a defined minimum size, installing the HPWH in a room less than the defined size mentioned above with the addition of louvers in the wall or door large enough to provide the minimum net free area (NFA) for ventilation, and installing the HPWH with ventilation ducts on the intake or exhaust side of the heat pump. With this proposal, the Statewide CASE Team recommends improvements to existing code language for clarity, better reflecting new research and align with other codes in development.

This Statewide CASE measure proposal for the 2028 code cycle recommends elimination of two currently allowed ducting configurations and two louvered wall/door configurations:

- Two ducting configurations:
    - Intake air ducted from outside with no exhaust duct to outside, and
    - Exhaust air ducted to outside with no intake duct to outside, when the HPWH is installed inside the building in conditioned space; but if the HPWH is installed outside the building or in an unconditioned space, this is allowed.
- Two louvered wall/door ventilation configurations:
    - Louvered door/wall for the exhaust of the HPWH to the outdoors, and
    - Louvered door/wall for the exhaust of the HPWH to a communicating space.

The two ducting configurations interfere with the operation of balanced and central indoor ventilation systems and increase space-conditioning loads. The two louvered wall/door ventilation configurations cause a risk of moisture damage.

2.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 7: Proposed Language of this report for detailed revisions to code language.

2.4.1 Energy Code Change Summary

Modifications to Title 24, Part 6 are summarized in this section.

SECTION 500.3 [Section 110.3] – MANDATORY REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

Subsection 500.3.3.7.2 [Section 110.3(c)7B]: The proposed regulations have been separated into Residential (including Group R Occupancy, and Common or Public Use Areas serving that Occupancy) and Nonresidential to keep the requirements clear for each. Subsection 500.3.3.7.2 [Section 110.3(c)7B] maintains the same code language that was implemented in 2025 for residential buildings.

Subsection 500.3.3.7.3 [Section 110.3(c)7C]: Subsection 500.3.3.7.3 [Section 110.3(c)7C]: is a modified version of 500.3.3.7.2 [Section 110.3(c)7B] that is proposed to be added below the residential section. This new section would clarify ventilation options for consumer integrated HPWHs installed in nonresidential buildings. This language would require both intake and exhaust ducts instead either an intake duct OR an exhaust duct that crosses pressure boundary to the outdoors. This requirement cost-effectively increases the stringency of the Energy Code, thereby minimizing the energy use of nonresidential buildings and maintains the pressure balance and indoor air quality (IAQ) of the room that the HPWH is located, which in turn improves the state's economic and environmental health. For HPWHs installed in condition space, intake and exhaust duct configurations or exhaust only duct configurations where the duct connects to another space can still be used if there are louvers in the room that connect it to a communicating space, but the single duct cannot be used when connected to the outdoors. Similarly, for HPWHs installed in unconditioned space can use intake and exhaust duct configurations or exhaust only duct configurations where the duct connects to another space can still be used if there are louvers in the room that connect it to outdoors, but the single intake duct cannot be used when connected to the outdoors.

2.4.2 Reference Appendices Change Summary

There are no proposed changes to the reference appendices.

2.4.3 Compliance Manuals Change Summary

There are no proposed changes to the compliance manuals.

2.4.4 Alternative Calculation Method Reference Manual Change Summary

There are no proposed changes to the alternative calculation method reference manual.

2.4.5 Compliance Forms Change Summary

Two compliance forms would be updated to align with the proposed code language changes including NRCC-PLB-E and NRCI-PLB-E.

The check box in Table F and element 22 of the NRCC-PLB-E compliance form would be updated with the new ventilation options to reflect updates to section **Subsection 500.3.3.7 [Section 110.3(c)7]** for nonresidential buildings, see Figure 3.

CALIFORNIA ENERGY COMMISSION

DOMESTIC WATER HEATING SYSTEM

CEC-NRCC-PLB-E

Multifamily Water Heating Equipment Serving Individual Dwelling Units- §170.2(d)1, §180.2(b)3C

Equipment Type (select all that apply):		
System Name:		
16	☐	Gas/propane instantaneous water heater with input rating ≤ 200,000 BTUH and no storage tank. Note: Cannot comply using the prescriptive path with a storage tank per Exception 1 §170.2(d)1 (New Construction and Additions Only)
	☐	A single 240-volt heat pump water heater serving the dwelling unit. (New Construction and Additions Only, §170.2(d)1A)
	☐	A single 120-volt heat pump water heater serving a dwelling unit with 1 bedroom or less. (New Construction and Additions Only, Exception 2 to §170.2(d)1)
	☐	A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher (§170.2(d)1B or §180.2(b)3).
	☐	A single heat pump water heater with storage tank located in the garage or conditioned space and be placed on an incompressible, rigid insulated surface with minimum R-10. The water heater shall be installed with a communication interface that meets either the requirements of 110.12(a) or has an ANSI/CTA-2045-B communication port. (Alterations Only)
	☐	If the existing water heater is an electric resistance water heater, a consumer electric water heater. (Alterations only, §180.2(b)3)
17	☐	Replacement or altered gas or propane water heater (Alterations only, §180.2(b)3ci)

Water Heating Equipment All Occupancies - §110.3(c)3, §140.5(a)

	Yes	No	NA	Requirement
System Name:				
18	☐	☐	☐	Unfired storage tank insulation shall have Internal + External ≥ R-16 OR External ≥ R-3.5. Label required per §110.3(c)3
19	☐	☐	☐	New state buildings 60% of energy for service water heating from site solar energy or recovered energy per §110.3(c)5
20	☐	☐	☐	Isolation valves for instantaneous water heater with input rating > 6.8 kBTUH or 2 kW has been specified per §110.3(c)6
21	☐	☐	☐	School buildings < 25,000ft² and < 4 stories must install a heat pump water heating system per §140.5(a)1. Water heating systems serving an individual bathroom space may be an instantaneous electric water heater.
22	Air-Source Heat Pump Water Heaters (HPWHs) (§110.3(c)7)			
	☐	☐	☐	Backup heat is required when inlet air is unconditioned unless the compressor cut-off temperature is below the Heating Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2.
	☐	☐	☐	Consumer integrated HPWHs shall meet one of the following ventilation requirements:
				Dropdown

Figure 3: NRCC-PLB-E compliance form section for water heating equipment, all occupancies. Table F and the check box in element 22 require that the ventilation option for consumer integrated HPWH installation to be selected.

The Electric Ready section of the NRCI-PLB-E installation compliance form should be updated with a new ventilation options list proposed for the 2028 code to reflect updates to section **Subsection 500.3.3.7 [Section 110.3(c)7]** for nonresidential buildings, see Figure 4 for the 2025 form. The proposed changes to the NRCI-PLB-E compliance form include updates to align with the proposed code change where an exhaust duct is required in small rooms that are vented. This includes updating the minimum NFA to half of the listed value for a fully louvered door.

Domestic Water Heating System

CALIFORNIA ENERGY COMMISSION

CEC-NRCI-PLB-E

Electric Ready Requirements

System Name:	
A condensate drain that is no more than 2 inches higher than the base of the installed water heater, and allows natural draining without pump assistance	
A ventilation method meeting one of the following: - The designated space for the future heat pump water heater shall have a minimum volume of 700 cubic feet; or - The designated space for the future heat pump water heater shall vent to a communicating space in the same pressure boundary via permanent openings with a minimum total NFA of 250 square inches., so that the total combined volume connected via permanent openings is 700 cubic feet or larger. The permanent openings shall be: - Fully louvered doors with fixed louvers; or - Two permanent fixed openings located within 12 inches from the enclosure top and bottom; - The designated space for the future heat pump water heater shall include two 8 inches capped ducts, venting to the building exterior: - All ducts, connections, and building penetrations shall be sealed. - Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to a minimum insulation level of R-6. - Airflow from termination points shall be diverted away from each other.	
Space shall be reserved for a Heat Pump. The minimum space reserved shall include space for service clearances and air flow clearances and shall meet one of the following: - The space reserved shall be the space required for a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project; or - The space reserved shall meet the requirements specified in Joint Appendix JA15.2.1.	
Space shall be reserved for Tanks. The minimum space reserved shall include space for service clearances and shall meet one of the following: - The space reserved shall be the space required for a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project; or - The space reserved shall meet the requirements specified in Joint Appendix JA15.2.2.	
Ventilation shall be provided by meeting one of the following: - Physical space reserved for the heat pump shall be located outside; or - A pathway shall be reserved for future routing of supply and exhaust air via ductwork from the reserved heat pump location to a suitable outdoor location. Penetrations through the building envelope for louvers and ducts shall be planned and identified for future use. The reserved pathway and penetrations through the building envelope shall be sized to meet one of the following: - The reserved pathway and penetrations shall be sized to serve a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project. - The reserved pathway and penetrations shall be sized to meet the requirements specified in Joint Appendix JA15.2.3.	
Condensate drainage piping. An approved receptacle that is sized per the California Plumbing Code for condensate drainage shall be installed within 3 feet of the reserved heat pump location, or piping shall be installed from within 3 feet of the reserved heat pump location to an approved discharge location that is sized in accordance with the California Plumbing Code, and meet one of the following: - Condensate drainage shall be sized to serve a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project. - Condensate drainage piping shall be sized to meet the requirements specified in Joint Appendix JA15.2.4.	

Figure 4: NRCI-PLB-E compliance form section for the Domestic Water Heating System which is applicable to nonresidential, hotel/motel and high-rise residential occupancies. The Electric Ready Requirements section requires that the ventilation option for consumer integrated HPWH installation to be selected.

2.5 Measure Context

This measure would clarify requirements for nonresidential HPWH ventilation in small spaces within nonresidential buildings by removing the single-duct installation option for outdoor connections. Comparable codes or standards that specify HPWH ducting configurations are limited in detail and do not provide mandatory requirements specific to HPWHs; See section 2.5.1. This proposal addresses installation and ventilation practices and would not interfere with other codes and standards.

2.5.1 Comparable Model Codes or Standards

As of April 2026, there are no relevant model codes or standards that prescribe HPWH ducting for nonresidential spaces, but Air-Conditioning, Heating, and Refrigeration Institute (AHRI) is developing Guideline U to address HPWH ventilation documentation requirements for manufacturers. ASHRAE 62.1 establishes space-level IAQ and ventilation criteria but does not prescribe equipment-specific HPWH ducting (ASHRAE 2022).

Nonregulatory guidance aligned with this measure includes ENERGY STAR®'s "Heat Pump Water Heater Design Considerations," which warns against ducting only the intake or exhaust due to pressure imbalances: "Do not duct only the Heat Pump Water Heater intake air or exhaust air to the outside. Doing so will create a pressure imbalance that will lead to air infiltration or exfiltration, increasing the load on the space heating and cooling systems" (ENERGY STAR n.d.). The proposed changes are consistent with this guidance in that they prohibit single-duct configurations that cross the pressure boundary to outdoors.

2.5.2 Interactions with Other Regulations

There are no federal, state, or local regulatory requirements that explicitly require or prohibit HPWH ducting and ventilation requirements in small nonresidential spaces.

3. Compliance and Enforcement

3.1 Compliance Considerations

The compliance forms for water heaters were updated in the 2025 code to provide ventilation compliance path options for HPWH implementation. Under this 2028 code change proposal, both the certificate of compliance form in NRCC-PLB-E and the certificate of installation form in NRCI-PLB-E would be updated to reflect the updated ventilation compliance options for HPWHs in nonresidential buildings established in this document. The compliance form process has not changed from the 2025 code cycle; therefore, there is minimal extra burden on the compliance team.

Designers are required to fill out the NRCC-PLB-E form, which includes element 22 of Table F, where the HPWH ventilation configuration is selected. Plans examiners verify that the NRCC form and design drawing (plumbing, mechanical, and architectural) agreement. Plumbing designs should describe the ventilation specifications, while the mechanical drawings include ducting and wall grilles/vents as part of the building ventilation design drawings, and wall grilles/vents should also be called out in architectural drawings. Contractors/Installers pull a permit and install the HPWH with the ventilation approach per the plumbing, mechanical, and architectural design drawings. Contractors/Installers complete the NRCI-PLB-E form after installation and then have the installation inspected. Inspection ensures that the installation is equal to or better than the design.

The feasibility of compliance is high because multiple compliance approaches can be selected for the specific HPWH installation space type and project type. Installations that would have used one duct to comply with the 2025 code would require two ducts to comply with this 2028 code change proposal, and with minimal effect on the feasibility of installation. Feasibility will decrease slightly for installations that would have used a fully louvered door, upper and lower louver, and upper louver with a door undercut because these will now require an exhaust duct to be installed. Installing an exhaust duct requires enough space to run the duct, making a hole in the wall, and having free space for the exhaust air to travel before reaching nearby surfaces if this exhaust enters a communicating space.

3.2 Impact on Market Actors

Market actors were introduced to the idea of HPWH ducting in the 2025 code. This proposal aims to further refine the 2025 code to improve efficiency, reduce space conditioning load impact, and improve IAQ. The most impacted market actors are designers and installers. Builders and code officials are less impacted. Table 4 summarizes impacts on market actors and suggests outreach and education that may help support them as they prepare for the effective date of the requirements.

Table 4: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Owner/ Developer [a]	Makeup air grilles and ducts need to be kept unobstructed to ensure proper HPWH operation.	Send a newsletter/email announcement of new requirements and/or webinar/video on best practices, need for the proposed change, and estimated cost for updated HPWH ventilation compliance options. Ongoing communication could also be used to share this information via trade organizations and publications.
Design Professional [b]	Require plans to include exhaust ducts with a grille for makeup intake air in small spaces or two ducts in small spaces. Coordination with multiple contractors may be needed to ensure ventilation requirements are properly met. Plumbing designs should describe the ventilation sizing, while the mechanical drawings include ducting and wall grilles/vents as part of the building ventilation design drawings and wall grilles/vents should also be called out in architectural drawings.	Send a newsletter/email announcement of new requirements and/or webinar to educate affected design professionals (including but not limited to mechanical, plumbing and architects) to raise awareness of installation best practices for updated HPWH ventilation compliance options, associated benefits, updated forms, and need for coordination with multiple contractors.
Construction Team [c]	Require installations of exhaust ducts in with a grille for makeup intake air or dual ducts in small spaces. Coordination with multiple contractors may be needed to ensure ventilation requirements are properly met during installation.	Send a newsletter/email announcement of new installation requirements and/or webinar to educate the contractor, plumber and installer on installation practices, installation responsibilities, and forms for updated HPWH ventilation compliance options.
Building Department [d]	Being aware of updated HPWH ventilation requirements as part of plumbing, mechanical and architectural plan reviews to ensure alignment.	Send a newsletter/email announcement of new requirements and/or webinar to educate on updated HPWH ventilation requirements and forms for plan reviews.
Verification Tester [e]	No changes from 2025 code cycle	No changes from 2025 code cycle
Manufacturer and Distributor	Being aware of code change and updating installation options in product literature to align with CA requirements.	Provide publicly available updated requirements and send a newsletter/email announcement of new requirements and/or

Market Actor	Impact(s)	Suggested Outreach and Education
		webinar to communicate best practices and need for the proposed change.

a. Owner/Developer is funding the project and is the primary decision-maker.
b. Design professionals include architects, 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 third-party plan review and inspection.
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, energy consultants, and building owners and occupants. While the analysis in the Methodology Report is not specific to the code change(s) presented in this report, this measure focuses on designers, installers, building departments, and building owners, since these market actors are expected to experience the most direct impacts from requiring more HPWH ventilation ducts in small spaces to improve HPWH performance and reduce condensation risks. 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.

This code change is not expected to change the workflow of current market actors, compliance processes, or additional skills required to achieve compliance.

Builder. The proposed change would likely affect firms engaged in the construction or retrofitting of commercial or industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers equally; instead, it would primarily affect specific subsectors within the industry. Table 5 shows the commercial building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Building occupants (owners and tenants). The proposed code change would have incremental costs and would reduce building owners' utility bills throughout the measure's lifetime. See the 2028 CASE Methodology Report for a description of how LSC savings relate to occupant utility bill savings.

Table 5: Specific Subsectors of the California Commercial and Industrial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions $)
Commercial Building Construction	5,491	87,450	$10.6
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	$5.8
Nonresidential Siding Contractors	32	735	$0.1
Other Nonresidential Exterior Contractors	234	2,259	$0.1
Nonresidential Drywall Contractors	593	19,328	$1.8
Nonresidential Painting Contractors	501	9,225	$0.7
Nonresidential Finish Carpentry Contractors	313	3,697	$0.3

Source: Analysis by the Title 24 Statewide CASE Team of QCEW data from the California Employment Development Department

*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. U.S. Bureau of Labor Statistics, Handbook of Methods.

3.3 Compliance Software Updates

This code change in California Building Energy Code Compliance Software (CBECC) is low priority compared to prescriptive and high energy impact measures. CBECC could be updated and would need additional functionality to quantify pressure imbalances for single duct HPWH systems and additional analysis nodes are needed to quantify airflow, HPWH inlet and outlet temperatures, and IAQ parameters.

3.4 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.

The process for Plans Examiners to review forms and drawings may not change, but some training would be required to ensure understanding of the measure and to verify the design information on the NRCC-PLB-E form. The process for inspection review would ensure that the information on the NRCI-PLB-E form is consistent with the NRCC-PLB-E form, and matches what is actually installed. The process would not be new, but training may be required for inspectors to understand the requirements of the proposed measure.

4. Market and Economic Analysis

4.1 Market Structure and Availability

4.1.1 Current Market Structure and Availability

HPWH shipments in the United States (U.S.) have increased at a rate of 8,900 per year from 2011 to 2021, then increased to 39,000 per year from 2021 to 2023. Then, in 2024 it is estimated that California installed 43,000 HPWHs of the 214,000 shipped to the U.S. HPWH sales are projected to increase rapidly as a result of the DOE requirement for all electric tank water heaters over the size of 35 gallons to be HPWHs starting in 2029. United States HPWH sales are project to increase from 190,000 per year in 2023 to millions per year in 2029 and beyond (Advanced Water Heating Initiative 2026).

As mentioned in the 2025 Multifamily DHW Title 24 CASE Report, the consumer integrated HPWH market comprises about 100 HPWH models certified by the CEC (and listed in the MAEDbS). These models can be ducted, and their minimum ventilation requirements are defined in their specification sheets. HPWHs and components for ducting these HPWHs are commonly stocked at local retailers like Home Depot, Lowe's, and HD Supply, and warehouses like Supply House and Grainger. Commonly stocked products include 6- to 10-inch flexible ventilation ducts, band clamps or duct tape, couplers, and duct hanger straps. Couplers that connect HPWH ducts are available from major HPWH manufacturers and are typically in stock at suppliers.[5] Four manufacturers provide integrated couplers for quick duct implementation. In addition to market actors listed in Section 2.2.2, manufacturers and suppliers of ducts, hanger brackets, couplers, tape, and vents are affected by this code change.

4.1.2 Market Challenges and Solutions

The primary market challenges for HPWH ducts include added cost, unfamiliarity with ducting, code clarity, coordination among designers/plan checkers/inspectors, coordination among contractor/trades/subcontractors, product fit, and market acceptance. Each challenge is described below.

- **Cost.** Adding a second duct or building a vented enclosure can add labor and material costs for building owners. The solution to this market challenge is to require more duct installations, which will increase product sales and reduce material cost. Installers will become more familiar with installing ducts, which will lead to reduced installation time and cost. See section 5 about installation costs.

[5] Installers mentioned using Keller Supply and Pace Supply

- **Unfamiliarity.** Many installers have limited experience with dual-duct configurations or the 2025 ventilation requirements. The solution to this market challenge is to educate installers and designers via existing channels such as Energy Code Ace – a well-established, no-cost tool for builders, installers, code enforcement agencies, and others. This tool, overseen by the Statewide Codes and Standards program, offers webinars, fact sheets, and a helpline to assist the industry in understanding existing code requirements as well as to recent changes to ensure that the installation of ducting is familiar. The difference between single-duct and dual-duct installation primarily involves accommodating the added duct and wall penetrations.
- **Code Clarity.** Some 2025 language has been interpreted inconsistently. In Title 24, Part 6: 110.3(c)7B4iv says: "With a ducted inlet, the minimum NFA shall be equal to the cross-sectional area of the duct. With a ducted exhaust, the minimum NFA shall be the larger of 20 square inches or the minimum NFA provided by the manufacturer for this method." The duct selection options are confusing because the language can lead to three different net free area targets.

  The solution to this market challenge is additional education for installers and designers via existing channels such as Energy Code Ace – a well-established tool for builders, installers, code enforcement agencies, and others. This tool, overseen by the Statewide Codes and Standards program, offers webinars, fact sheets, and a helpline to assist the industry in understanding existing code requirements in addition to recent changes to clarify terms like communicating space, NFA, and pressure boundary, to remove the single-duct options that drive infiltration, and to clarify the requirements for both connection sealing and insulation in the updated code language.
- **Coordination Between Designers/Plan Checkers/Inspectors.** HPWH ventilation specifications and locations are sometimes overlooked in plumbing and mechanical drawings. The solution is to standardize the drawing documentation process so that designers (plumbing, mechanical, architectural), plan set reviewers (plumbing, mechanical, architectural), and inspectors know where to look for information. In nonresidential buildings, there are three sets of drawings where HPWH ventilation information should be listed, including plumbing, mechanical, and architectural. Plumbing designs should describe the ventilation specification to comply with this measure, which may include ducts or no ducts, the diameter of duct location of wall penetration, grille/louvers/door undercut, and NFA for grille/louvers/door undercut. Mechanical drawings should include location of ducting and wall grilles/louvers/vents, callouts in the drawing for the components, airflow direction to identify intake and exhaust air, detail drawing of wall mounted ventilation components (grilles, vent caps, etc.) with dimensions, product numbers, and a description for the components listed in a

table as part of the building ventilation design drawings. Wall grilles/louvers/vents should also be called out in architectural drawings.

- **Coordination Between Trades/Subs.** HPWH ventilation specifications and locations are sometimes overlooked during installation. The solution is to standardize the installation process so that installers (plumbers, mechanical, general contractors, and electricians) and inspectors know who is responsible for each part of the installation. See the "Coordination Between Designers/Plan Checkers/Inspectors" section above for drawing types and information in each drawing. During new construction, mechanical subcontractors should cut wall penetrations, install wall vents, HPWHs, ducts, and condensate drains. Plumbers and general contractors can also do this work, but plumbers are responsible for water hookups and connecting the condensate lines to the HPWH. Electricians are responsible for running power to the room and connecting power to the HPWH and the breaker panel. In a retrofit, the plumber will typically complete all tasks above other than the electricians' tasks.
- **Product Fit.** Many consumer integrated HPWHs are not shipped with dual-duct accessories by default. The solution to this market challenge is to review manufacturer and retailer offerings to understand available kits, axial vs. centrifugal fan airflow delivery capabilities, and recommended duct sizes, thereby streamlining the procurement process. Four manufacturers offer HPWH product lines with integrated ventilation duct couplers. Axial versus centrifugal fans are not advertised, but the typical ventilation duct diameter is eight inches.
- **Market Acceptance.** Market acceptance of HPWHs may be impacted due to air quality, room pressure imbalance, and condensation issues with single-duct installations that cross the building pressure boundary, which is allowed in the 2025 code. Single-duct configurations can result in moisture damage to small rooms over time and negative user experiences with HPWHs as a technology. The solution for this market challenge is to share lab and field findings on airflow, pressure balance, and IAQ with designers, engineers, installers, manufacturers, and raters via a newsletter/email announcement with a link to a webinar/video summarizing how the updated code reduces these issues using the dual duct approach when connecting the HPWH to the outdoors. Lab testing indicates higher indoor PM2.5 when using single-ducted HPWH ventilation approaches than with dual ducts or no ducts, and HPWH exhaust air temperatures have been shown to reduce below the dew point, which necessitates exhaust duct insulation to prevent condensation on the exterior of HPWH exhaust ducts. See Appendix H for more details.

HPWHs have been widely available in the market for over a decade. As a result of programs like TECH Clean California, Home Electrification, and Appliance Rebates

(HEEHRA) rebates, SMUD Home Performance Program (HPP), and the Golden State Rebates program, which have been developed to increase adoption and provide education of HPWHs, market awareness of the technology is growing.

See Section 3 for a description of workforce training that may be needed to ensure effective design, installation, and commissioning.

4.2 Design and Construction Practices

This section details design and implementation practices, health and safety considerations, and other implementation challenges associated with HPWHs and HPWH ventilation ducts in 2025.

4.2.1 Current Design and Construction Practices

Current design and construction practices include installing the HPWH in a room larger than the minimum volume (450 cubic feet to 700 cubic feet depending on the compressor size), installing a HPWH in a small room with louvered doors, ventilation grills, and door undercuts with a minimum NFA for air to pass through from the HPWH room to another connecting space, and installing the HPWH in a room of any size with either an intake duct, exhaust duct or both. Based on feedback collected during the October 23, 2025 stakeholder meeting, a three-person survey of utility program managers and installers, and a survey of 27 interested professionals, more than 78 percent of HPWH installations in nonresidential buildings in the past 12 months were installed without ducts and only nine percent with a single duct. This equates to one percent of all water heater installations being a HPWH with a single duct and closer to two percent implementing a HPWH with dual ducts. Because the 2025 code language went into effect four months before this report, it is assumed that a limited number of HPWHs were installed with ducts before 2026. An unducted HPWH performs well when the HPWH is installed in a room larger than the recommended minimum (450 to 700 cubic feet). It is possible for a HPWH to deliver energy-efficient performance when properly installed in small rooms if connected to an adjacent space with adequate volume using one duct or via louvers doors or walls; however, locating the outlet of the HPWH's exhaust too close to nearby surfaces can cause condensation and resulting water damage.

4.2.2 Health and Safety Considerations

The proposed code change is expected to improve the health and safety of HPWH installations in small rooms by preventing outside air from being drawn into the HPWH room due to pressure imbalances (Klein 2025). Outdoor air can carry moisture, particulates, gases, and bacteria into the building.

By requiring a second HPWH duct when connecting a HPWH in conditioned space to outside, the outdoor air is exhausted to the outdoors instead of indoors. Condensation can form on the outside of ducts that are not insulated, which can lead to increased risk of moisture damage (Hoeschele 2022). Condensation that forms inside the ventilation duct can be controlled and drained into the HPWH housing and through the condensate line either by sloping the exhaust duct toward the HPWH outlet port or another technique, which may involve drains from the lowest portion of the duct.

The dual duct configuration will keep the indoor air quality of the room as consistent as possible relative to a room without the HPWH. The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) working group is establishing Guideline U, which may address condensation requirements. In addition, the dual duct configuration maintains neutral room pressure, minimizing air transfer between the HPWH room and connected rooms and outdoors.

One consideration is that wall intake and exhaust vents and couplers exiting the building envelope will need to be sealed to prevent air and water ingress from the outdoors. In addition, HPWHs without an exhaust duct discharge cool exhaust air into the HPWH room. In small spaces with or without a louvered wall/door for ventilation, this cold exhaust air blown onto other surfaces or permanently installed equipment creates an increased risk of condensation if not properly managed, leading to various issues, including mold growth, structural damage, corrosion, and reduced equipment life, particularly in environments with low surface temperatures.

Proper exhaust air routing, such as directing it away from adjacent surfaces by rotating the HPWH to change the exhaust port direction, using an insulated exhaust port ventilation elbow to redirect airflow, and providing adequate clearance, reduces condensation potential.[6]

4.2.3 Design and Construction Challenges and Solutions

Design and construction challenges may increase relative to the 2025 energy code due to differences in code language between nonresidential and residential installations of the same HPWH.

It is important to consider intake and exhaust port locations when locating the HPWHs in the room to minimize bends in the ductwork, as bends can cause significant pressure drops. Manufacturers provide guidance on acceptable equivalent duct lengths for different HPWH duct diameters and types (flexible and rigid) because flexible ducts, elbows, and tight bends increase pressure drops more than rigid ducts. Restricting HPWH airflow across the coil can significantly impact COP, as detailed in Appendix A.

[6] From Attachment 5 of Draft UMC Public Comment – January 6th, 2025.

In addition, it is important to maintain access for servicing, repair, and replacement of the evaporator coil, blower, compressor, anode rod, air filters, control panels, and thermostats. The solution is to locate the water heater at a sufficient distance from the top and sides to allow the air filter to be replaced and to provide access for removing the components above. This requires water pipe and ventilation duct placement such that they do not cover any of these components.[7]

See Table 4 in Section 3.2 for a description of workforce training that could support effective design, installation, and commissioning.

4.3 Energy Equity and Environmental Justice

Each measure in this CASE Report was evaluated for ESJ impacts using 4 criteria: cost, health, resiliency, and comfort. The details of that evaluation can be found in Section 1.4 and the 2028 CASE Methodology Report.

Installing dual-duct HPWHs will improve the health, safety, and comfort of low-income nonresidential buildings and reduce the likelihood of unexpected costs for moisture damage, estimated at $789 (April, 2026), resulting from implementing HPWHs with improper ventilation, such as a single intake duct to the outdoors. Installing a second duct or an exhaust duct instead of using grilles or louvers for exhaust air management results in higher first costs, which may negatively affect low-income communities (see Appendix F for survey feedback from installers), but the more frequent implementation of dual duct systems will lead to lower costs over time. Nonresidential building owners and tenants will also benefit from reduced electricity bills.

Although installing a duct instead of using grilles or louvers for exhaust air management will increase the first cost for a HPWH installation, there are other less expensive ventilation strategies that can be implemented to provide adequate ventilation to a HPWH for great HPWH efficiency with minimal effect on building HVAC electricity costs.

One low-cost approach for ventilating a HPWH installed in a closet in a conditioned space is to cut the bottom of the door to create a door undercut. This door undercut allows air to be pulled into the HPWH room from the communicating space to supply the intake air for the HPWH. Door undercuts can typically be completed in less than half an hour, and as installers gain experience through more frequent installations, the process becomes even more efficient. Then the exhaust air can be directed from the room to the communicating space via a single duct or other approved method provided by the manufacturer. Another consideration that can help reduce costs is selecting a HPWH with a built-in duct coupler.

[7] From Attachment 5 of Draft UMC Public Comment – January 6th, 2025.

The American Lung Association study titled "State of Air 2025" indicates that disadvantaged communities are also more susceptible to health impacts (American Lung Association 2025). Ingress of this polluted outdoor air into buildings can have negative health effects.

Several California cities rank among the top 25 most polluted areas in the United States in three different categories: (1) Ozone, where 8 of 25 locations are in California; (2) Daily Particulate Mass (PM), where 8 of 25 locations are in California; and (3) Annual PM, where 7 of 25 locations are in California (American Lung Association 2025). According to data from the CalEnviroScreen website and California Environmental Protection Agency (CalEPA) Senate Bill (SB) 535 Disadvantaged Communities interactive map tool, most of these California locations are classified as disadvantaged communities. These sources indicate that buildings in disadvantaged communities, in general, are more likely to be in areas of low air quality, which means they are more likely to benefit from the improvements associated with dual HPWH ducts than other populations.

4.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 6, Table 7 and Table 8 outline the statewide implications for these job categories. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

The Statewide CASE Team does not anticipate that the proposed changes would lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, the Statewide CASE Team's proposed change would not result in economic disruption to any sector of the California economy. Rather, it would lead to modest changes in the employment of existing jobs.

Table 6: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector

Type of Economic Impact	Employment (Jobs)	Labor Income (Millions)	Total Value Added (Millions)	Output (Millions)
Direct Effects (Additional spending by Commercial Builders)	0.30	$0.02	$0.03	$0.07
Indirect Effect (Additional spending by firms supporting Commercial Builders)	0.14	$0.01	$0.02	$0.03
Total Economic Impacts	0.44	$0.04	$0.05	$0.10

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[8]

Table 7: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building designers and energy consultants)	0.05	$5,030	$4,980	$7,871
Indirect Effect (Additional spending by firms supporting building designers and energy consultants)	0.02	$1,498	$2,082	$3,351
Total Economic Impacts	**0.06**	**$6,528**	**$7,062**	**$11,222**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

Table 8: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors

Type of Economic Impact	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effects (Additional spending by building inspectors)	0.01	$683	$810	$984
Indirect Effect (Additional spending by firms supporting building inspectors)	0.00	$63	$99	$172
Total Economic Impacts	**0.01**	**$746**	**$908**	**$1,156**

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.

The proposed change represents a modest adjustment that is not expected to excessively burden or competitively disadvantage California businesses, nor is it expected to lead to a competitive advantage for California businesses. Therefore, the

[8] IMPLAN® model, 2020 Data, IMPLAN Group LLC, IMPLAN System (data and software), 16905 Northcross Dr., Suite 120, Huntersville, NC 28078 www.IMPLAN.com

Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[9] Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have an advantageous or an adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling estimated a $8,874 increase in California business income from the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.[10]

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[11] As Table 9 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID-19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of incremental income that business owners would reinvest into expanding their capital stock.

[9] Gov. Code, §§ 11346.3(c)(1)(C), 11346.3(a)(2); 1 CCR § 2003(a)(3) Competitive advantages or disadvantages for California businesses currently doing business in the state.

[10] 23 percent of proprietor income was assumed to be allocated to net business investment (investment that expands the capital stock, rather than updates or replaces existing capital stock); see Table 9.

[11] Net private domestic investment is the total amount of investment in capital by the business sector that is used to expand the capital stock, rather than maintain or replace due to depreciation. Corporate profit is the money left after a corporation pays its expenses.

Table 9: Net Domestic Private Investment and Corporate Profits, U.S.

Year	Net Domestic Private Investment by Businesses, Billions of Dollars	Corporate Profits After Taxes, Billions of Dollars	Ratio of Net Private Investment to Corporate Profits (Percent)
2020	389	2,212	18
2021	545	2,888	19
2022	825	2,951	28
2023	836	3,069	27
2024	885	3,441	26
5-Year Average	**Intentionally blank**	**Intentionally blank**	23

Source: (Federal Reserve Economic Data (FRED) n.d.)

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a $2,083 increase in net private investment by California businesses.

4.5 Economic and Fiscal Impacts

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to a significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. The proposed change would not result in economic disruption to any sector of the California economy. For more information on the Statewide CASE Team's economic and fiscal impacts methodology, see the 2028 CASE Methodology Report.

Adoption of this code change proposal would result in relatively modest economic impacts through the additional direct spending by those in the commercial building industry, architects, energy consultants, and building inspectors. The Statewide CASE Team does not anticipate that money saved by commercial building owners or other organizations affected by the proposed 2028 code cycle regulations would result in additional spending by those businesses.

4.5.1 Effects on the State General Fund, State Special Funds, and Local Governments

The Statewide CASE Team does not expect the proposed code changes to have a measurable impact on California's General Fund, any state special funds, or local government funds.

Cost to State: The state government already has a budget for code development, education, and compliance enforcement. While the state government would be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs for the state government are small when compared to the overall cost savings and policy benefits associated with the code change proposals.

This measure only applies to nonresidential buildings where one or more consumer-sized HPWHs gets installed, like small offices and cafes. Some small office buildings can be funded through the California General Fund or State Special Fund and some of these buildings will have HPWHs, so the State General Fund could be affected by this HPWH ventilation code change, but the impact will be small because the measure is cost-effective. Cafes are typically not funded through the California General Fund or State Special Fund, so these funds will not be impacted.

Cost to Local Governments: All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2028 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the Compliance Improvement Program (such as Energy Code Ace). As noted in Section 3.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

4.5.2 Mandates on Local Agencies or School Districts

The proposed change would mandate local agencies or school districts where consumer-sized HPWHs are installed. This measure applies to small nonresidential buildings like small offices and cafes which are a part of some local agencies or school districts so they will need to comply with this proposed measure.

4.5.3 Costs to Local Agencies or School Districts

The proposed changes would impose a modest increase in cost due to installing one or more HPWH ventilation ducts, but these costs have been found to be cost-effective.

4.5.4 Costs or Savings to Any State Agency

The proposed changes would impose a modest increase in cost due to installing one or more HPWH ventilation ducts, but these costs have been found to be cost-effective.

4.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

There are no added non-discretionary costs or savings to local agencies.

4.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state.

5. Cost Effectiveness

5.1 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 B 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.

5.2 Energy and Energy Cost Savings Results

Energy and energy cost savings were calculated for this measure using CBECC models that were minimally compliant with the 2025 Title 24 requirements. These models were adjusted to include a HPWH, then modified and analyzed using EnergyPlus software.

The Statewide CASE Team selected the following parameters for the HPWH used in the small office building model in CBECC for Climate Zone 12:

- HPWH type: Integrated
- HPWH Capacity: One 50-gallon tank for small offices[12]
- UEF:[13] 3.62

[12] The Statewide CASE team identified that two 80 gallon tanks are necessary for Café buildings within the quick service restaurant building category, but the savings associated with different ducting configurations are conservatively being estimated by the savings found form the small office building.

[13] Uniform Energy Factor is a ratio of how much useful energy the HPWH heats versus how much energy it uses.

- Power: 380W
- First Hour Rating: 63 gallons for small office building

A review of ENERGY STAR Certified HPWHs and the MAEDbS provided average values used to define the model criteria listed above, see Table 10.

Table 10: Summary of Average HPWH Storage Tank Size, First Hour Rating and UEF for Given HPWH Tank Size Filter Criteria for HPWHs on the ENERGY STAR Certified List and MAEDbS Database

Source	HPWH Storage Tank Range Filter (Gal)	HPWH Storage Tank size (Gal)	Average [Median] First Hour Rating (Gal)	Average [Median] UEF
ENERGY STAR Certified HPWHs	46 to 53	50	63.5 [66.0]	3.51 [3.46]
MAEDbS Database	46 to 53	50	63.2 [65.0]	3.46 [3.68]
ENERGY STAR Certified HPWHs	59 to 74	65	78.7 [80.0]	3.77 [3.90]
MAEDbS Database	59 to 74	65	78.2 [80.0]	3.70 [3.70]
ENERGY STAR Certified HPWHs	75 to 83	80	90.6 [91.0]	3.62 [3.48]
MAEDbS Database	75 to 83	80	91.3 [92.0]	3.70 [3.88]
ENERGY STAR Certified HPWHs	36 to 82	All	72.4 [69.00]	3.62 [3.68]
MAEDbS Database	36 to 82	All	72.2 [70.0]	3.67 [3.75]

Source: (ENERGY STAR n.d., CALIFORNIA ENERGY COMMISSION n.d.)

A UEF of 3.62 was chosen as a conservative value relative to the average for all HPWHs. In addition, the first-hour ratings used in the analysis are slightly lower than the average in the table, which will result in slightly more energy consumption than the average HPWH. A 380-watt compressor correlates to approximately 160 CFM of airflow across the evaporator coil in the CBECC version 2.0 Release Candidate (RC which is the newest testing version of CBECC) model, which is in line with ventilation studies (Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023). The small office building was analyzed using the CBECC model for one climate zone (CZ 12), then exported as an IDF file to be analyzed in EnergyPlus.

EnergyPlus version 25 was used to import building configurations, HPWH details, and weather data from the CBECC IDF file. Then the models were modified to include two analysis nodes, and the weather files from all 16 California climate zones were updated to run 16 different calculations as a batch run. One node represented the intake air for the HPWH, and the other node represented the exhaust for the HPWH. Two ventilation configurations were modeled in EnergyPlus including:

1. Dual Ducts to Communicating Space - Keep both intake and exhaust nodes for the HPWH connected to the indoor zone (temperature, humidity, latent gains, etc.), which is modeled as an unducted HPWH.
2. Dual Ducts (intake and exhaust to outside) - Set both the HP intake node and exhaust air to match outdoor air conditions (temperature, humidity, latent gains, etc.).

The building electrical energy use for the following two single duct ventilation configurations were calculated based on the results above:

1. Single Duct (intake only) – Building energy was calculated using the results from the Dual Ducts EnergyPlus model, where the HPWH intake air node for the intake duct matches the outdoor air conditions (temperature, humidity, latent gains, etc.), but instead of exhausting the air outside, this air is exhausted into the building's conditioned space. Using equation five below the total energy impact on the building's space conditioning load is calculated as a result of the cold air exhausted from the HPWH at ten degrees Fahrenheit below the outdoor temperature. It is then assumed that the building conditioning system will run to make up this energy difference at the rated system efficiency, and the total electrical energy associated with that is added to the building electrical energy associated from the Dual Duct EnergyPlus model results. This single intake duct ventilation is the standard design for comparing to the proposed intake and exhaust duct configuration.
2. Single Duct (exhaust only) – Building energy was calculated using the results from the Dual Ducts to Communicating Space EnergyPlus model where the HPWH intake air node for the intake duct matches the indoor air conditions (temperature, humidity, latent gains, etc.) but instead of exhausting this air indoors, this air is exhausted outdoors. The pressure imbalance of the building caused by the HPWH airflow is balanced with air entering the building from outdoors at outdoor air conditions (temperature, humidity, latent gains, etc.). Using equation 6 below the total energy impact on the buildings space conditioning load is calculated as a result of the outdoor air making up the air displaced by the HPWH at the outdoor temperature and exhausting the cold HPWH air outdoors instead of inside the building. It is then assumed that the building conditioning system will run to makeup this difference in energy to maintain the HVAC heating/cooling setpoint at the rated HVAC system efficiency and the total electrical energy associated with that is summed with the building

electrical energy associated with the Dual Duct EnergyPlus model results. This single exhaust duct ventilation is the standard design for comparing to the proposed Dual Ducts ventilation configuration.

$$eq\ 1{:}\ E_{HVAC} = \frac{E_{HVAC\_for\_HPWH}}{COP_{HVAC}}$$

$$eq\ 2{:}\ E_{HVAC\_for\_HPWH} = E_{Outdoor\_to\_Indoor} + E_{HPWH\_Exhaust}$$

$$eq\ 3{:}\ E_{Outdoor\_to\_Indoor} = 1.08\ x\ CFM\ x\ \Delta T_{Outdoor\_to\_Indoor}\ x\ \Delta t$$

$$eq\ 4{:}\ \Delta T_{Outdoor\_to\_Indoor} = T_{Inside} - T_{Outside}$$

$$eq\ 4{:}\ E_{HPWH\_Exhaust} = 1.08\ x\ CFM\ x\ \Delta T_{Outdoor\_to\_HPWH\_Exhaust}\ x\ \Delta t$$

$$Eq\ 6{:}\ \Delta T_{HPWH\_Exhaust} = -10°F$$

$$eq\ 5{:}\ E_{HVAC\_for\_HPWH\_Single\_Intake\_Duct} = \frac{1.08\ x\ CFM\ x\ [T_{Inside} - T_{Outside} + 10°F]\ x\ \Delta t}{COP_{HVAC}}$$

$$eq\ 6{:}\ E_{HVAC\_for\_HPWH\_Single\_Exhaust\_Duct} = \frac{1.08\ x\ CFM\ x\ [\ T_{Inside} - T_{Outside} - 10°F]\ x\ \Delta t}{COP_{HVAC}}$$

Where, during cooling days it is assumed that the coefficient of performance (COP) assumptions for building HVAC systems is as follows: $COP_{HVAC} = 4.08$ and during heating days it is assumed that the COP for building HVAC systems is as follows: $COP_{HVAC} = 3.53$. These are conservative COPs based on the rated system performance for the small office building HVAC systems which means that installed energy savings may be larger than the savings calculated in this report.

Equations above only account for mixing load impacts to the conditioning system. This is a conservative approach because outdoor air is likely to have a higher humidity than the building ambient humidity in each climate zone, which may result in additional conditioning savings to account for these latent gains.

In addition, the building electrical energy use for the following two louvered door- or grille-ventilated configurations were calculated based on the results above, assuming 130 square inches of net free area for both the intake louvers or grilles and the exhaust louvers or grilles:

1. Dual Grilles to Outside – Building energy was calculated using the results from the Dual Ducts EnergyPlus model, but the energy consumed by the HPWH was scaled by the COP of a HPWH ventilated with two grilles divided by the COP of a HPWH ventilated with an exhaust duct and an 18 square inch NFA grille for intake makeup air. This ratio of COP is assumed to be the average of three HPWH lab test results for each climate zone which ranges from 0.98 to 1.13

where numbers above one indicate that the exhaust duct installation results in electrical energy savings (Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023). It is assumed that there is no effect on the building's conditioning system, but the additional energy consumption of a HPWH ventilated with grilles is added to the Dual Duct EnergyPlus model results. This Dual Grilles to Outside ventilation is the standard design for comparing to the proposed exhaust duct to outside with an 18-square-inch NFA intake grille, which is assumed to operate with the same performance as the dual-duct ventilation configuration.

2. Dual Grilles to Indoor Communicating Space – Building energy was calculated using the results from the Dual Ducts to Communicating Space EnergyPlus model, but the energy consumed by the HPWH was scaled by the COP of a HPWH ventilated with two grilles divided by the COP of a HPWH ventilated with an exhaust duct and an 18 square inch NFA grille for intake makeup air. This ratio of COP is assumed to result in one percent HPWH electrical energy use savings. This one percent value is based on the average of two ventilation configurations with two grilles (84 cubic foot room and 200 cubic foot room), in Appendix A relative to a single exhaust duct in an 84 cubic foot room. It is assumed that this value is constant over the year at a ratio of 1.01 where numbers above one indicate that the exhaust duct installation results in electrical energy. It is assumed that there is no effect on the building conditioning system, but the added energy consumption of a HPWH ventilated with grilles is added to the Dual Ducts to Communicating Space EnergyPlus model results. This Dual Grilles to Indoor Communicating Space ventilation is the standard design for comparing to the proposed exhaust duct to a communicating space with an 18-square-inch NFA intake grille, which is assumed to operate with the same performance as the Dual Ducts to communicating space duct configuration.

Non-energy benefits associated with this code change include reduced moisture damage risk inside when ducts are used for HPWH exhaust ventilation. When both intake and exhaust ventilation ducts are used instead of a single intake duct to outdoors benefits include improved indoor air quality by removing the ingress risk of airborne particulates, gases, and bacteria originating outdoors and exhausting into the room, and neutral pressure balance in the room where the HPWH is installed. More details on the non-energy benefits are provided in Section 6.6.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 11 through Table 14. Per-square-foot savings for the first year are expected to range from -0.09 to 0.45 kWh/yr, depending upon climate zone and building type. Demand reductions are expected to range between -

0.01 and 0.07 watts per square foot for small office buildings and Cafés. No natural gas savings were expected, as the measure primarily impacts electricity usage.

Table 15 presents total per-square-foot 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$) from electricity and natural gas cost savings for the prototypical building.

Table 11: First Year Electricity Savings (kWh) Per Square Foot

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
Small Office **(Single Intake Duct vs Dual Duct)**	0.25	0.20	0.19	0.16	0.18	0.13	0.12	0.11	0.11	0.11	0.15	0.16	0.13	0.13	0.12	0.15
Small Office **(Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)**	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
Small Office **(Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)**	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
Small Office **(Single Exhaust Duct vs Dual Duct)**	0.00	-0.03	-0.04	-0.01	-0.01	-0.01	-0.01	0.00	-0.04	-0.04	-0.01	0.00	0.03	-0.02	0.07	-0.04
Small Office **(Single Exhaust Duct vs Dual Ducts to Communicating Space)**	0.05	0.02	0.02	0.02	0.02	0.00	0.00	0.01	0.02	0.02	0.05	0.02	0.04	0.04	0.06	0.05
Small Office **(Weighted Average)**	0.04	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.03	0.02	0.03	0.02	0.04	0.03
Quick Service Restaurant **(Single Intake Duct vs Dual Duct)**	0.55	0.44	0.42	0.35	0.40	0.30	0.26	0.24	0.25	0.24	0.33	0.36	0.28	0.28	0.27	0.33
Quick Service Restaurant **(Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)**	-0.01	0.02	0.00	0.03	0.01	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.05
Quick Service Restaurant	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

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
(Dual Grilles to Indoor Communicating Space Outdoors vs Exhaust Duct with Intake Grille to Communicating Space)																
Quick Service Restaurant (Single Exhaust Duct vs Dual Duct)	0.00	-0.07	-0.09	-0.01	-0.02	-0.03	-0.03	-0.01	-0.09	-0.09	-0.03	0.00	0.06	-0.04	0.15	-0.09
Quick Service Restaurant (Single Exhaust Duct vs Dual Ducts to Communicating Space)	0.12	0.05	0.04	0.05	0.04	0.01	0.01	0.02	0.04	0.04	0.10	0.05	0.10	0.10	0.14	0.12
Quick Service Restaurant (Weighted Average)	0.09	0.06	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.06	0.06	0.07	0.05	0.08	0.06

Table 12: First Year Peak Demand Reduction (kW) Per Square Foot

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
Small Office **(Single Intake Duct vs Dual Duct)**	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.03	0.01
Small Office **(Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)**	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
Small Office **(Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)**	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
Small Office **(Single Exhaust Duct vs Dual Duct)**	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Small Office **(Single Exhaust Duct vs Dual Ducts to Communicating Space)**	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Small Office **(Weighted Average)**	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00
Quick Service Restaurant **(Single Intake Duct vs Dual Duct)**	0.06	0.04	0.05	0.04	0.05	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.07	0.03
Quick Service Restaurant **(Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)**	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	0.01
Quick Service Restaurant	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

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
(Dual Grilles to Indoor Communicating Space Outdoors vs Exhaust Duct with Intake Grille to Communicating Space)																
Quick Service Restaurant (Single Exhaust Duct vs Dual Duct)	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	-0.01
Quick Service Restaurant (Single Exhaust Duct vs Dual Ducts to Communicating Space)	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Quick Service Restaurant (Weighted Average)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 13: First Year Natural Gas Savings (kBtu) Per Square Foot

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
Small Office (Single Intake Duct vs Dual Duct)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Small Office (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Small Office (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Small Office (Single Exhaust Duct vs Dual Duct)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Small Office (Single Exhaust Duct vs Dual Ducts to Communicating Space)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Small Office (Weighted Average)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Quick Service Restaurant (Single Intake Duct vs Dual Duct)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Quick Service Restaurant (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Quick Service Restaurant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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
(Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)																
Quick Service Restaurant (Single Exhaust Duct vs Dual Duct)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Quick Service Restaurant (Single Exhaust Duct vs Dual Ducts to Communicating Space)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Quick Service Restaurant (Weighted Average)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 14: First Year Source Energy Savings (kBtu) Per Square Foot

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
Small Office (Single Intake Duct vs Dual Duct)	0.38	0.34	0.32	0.28	0.32	0.23	0.20	0.22	0.23	0.23	0.28	0.30	0.26	0.23	0.34	0.18
Small Office (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	0.00	0.01	0.00	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.04
Small Office (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)	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
Small Office (Single Exhaust Duct vs Dual Duct)	0.07	0.04	0.00	0.02	0.01	0.00	0.00	0.01	0.00	-0.01	0.03	0.02	0.04	0.04	0.05	-0.08
Small Office (Single Exhaust Duct vs Dual Ducts to Communicating Space)	0.10	0.08	0.06	0.09	0.07	0.03	0.03	0.05	0.06	0.06	0.09	0.08	0.09	0.10	0.07	0.10
Small Office (Weighted Average)	0.07	0.06	0.05	0.06	0.05	0.04	0.03	0.04	0.04	0.04	0.06	0.06	0.06	0.06	0.06	0.04
Quick Service Restaurant (Single Intake Duct vs Dual Duct)	0.83	0.74	0.71	0.61	0.71	0.51	0.45	0.48	0.51	0.51	0.61	0.66	0.57	0.51	0.74	0.40
Quick Service Restaurant (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	-0.01	0.03	0.00	0.05	0.02	0.05	0.04	0.05	0.05	0.05	0.07	0.04	0.06	0.07	0.06	0.08
Quick Service Restaurant	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

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
(Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)																
Quick Service Restaurant (Single Exhaust Duct vs Dual Duct)	0.16	0.10	0.01	0.04	0.02	0.00	0.00	0.03	0.00	-0.02	0.06	0.04	0.09	0.08	0.11	-0.18
Quick Service Restaurant (Single Exhaust Duct vs Dual Ducts to Communicating Space)	0.23	0.18	0.12	0.20	0.15	0.08	0.07	0.11	0.13	0.13	0.20	0.18	0.20	0.22	0.16	0.23
Quick Service Restaurant (Weighted Average)	0.16	0.14	0.11	0.12	0.12	0.08	0.07	0.09	0.09	0.09	0.13	0.12	0.13	0.12	0.14	0.09

Table 15: Total 30-Year LSC Savings (2029 PV$) Per Square Foot

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
Small Office (Single Intake Duct vs Dual Duct)	2.09	1.67	1.64	1.33	1.56	1.13	0.96	0.88	0.94	0.92	1.23	1.36	1.10	0.99	1.23	1.11
Small Office (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	-0.02	0.08	0.00	0.11	0.06	0.13	0.11	0.12	0.13	0.13	0.17	0.10	0.15	0.17	0.16	0.18
Small Office (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Small Office (Single Exhaust Duct vs Dual Duct)	0.13	-0.12	-0.21	0.03	-0.06	-0.08	-0.04	0.05	-0.19	-0.17	-0.02	0.07	0.28	-0.02	0.53	-0.31
Small Office (Single Exhaust Duct vs Dual Ducts to Communicating Space)	0.49	0.28	0.22	0.31	0.20	0.08	0.08	0.16	0.23	0.25	0.44	0.30	0.43	0.43	0.53	0.45
Small Office (Weighted Average)	0.36	0.25	0.21	0.24	0.22	0.15	0.14	0.16	0.15	0.16	0.26	0.24	0.27	0.23	0.34	0.21
Quick Service Restaurant (Single Intake Duct vs Dual Duct)	4.60	3.68	3.61	2.92	3.43	2.48	2.12	1.93	2.07	2.03	2.72	3.00	2.41	2.19	2.71	2.44
Quick Service Restaurant (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)	-0.05	0.18	0.00	0.25	0.12	0.29	0.24	0.27	0.28	0.28	0.37	0.23	0.34	0.37	0.35	0.39
Quick Service Restaurant	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

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
(Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)																
Quick Service Restaurant **(Single Exhaust Duct vs Dual Duct)**	0.29	-0.25	-0.46	0.06	-0.12	-0.17	-0.09	0.10	-0.42	-0.38	-0.05	0.15	0.61	-0.04	1.16	-0.68
Quick Service Restaurant **(Single Exhaust Duct vs Dual Ducts to Communicating Space)**	1.08	0.61	0.47	0.68	0.44	0.17	0.18	0.35	0.50	0.55	0.97	0.66	0.96	0.94	1.18	0.99
Quick Service Restaurant **(Weighted Average)**	0.79	0.55	0.46	0.52	0.49	0.34	0.30	0.34	0.33	0.35	0.56	0.53	0.60	0.50	0.74	0.47

5.3 Incremental First Cost

Incremental first costs for installing HPWH ducts are provided for labor and equipment costs. Labor cost estimates were collected from commercial mechanical or plumbing contractors and commercial builders via email and phone surveys. Equipment costs were gathered from an average of retailer and distributor costs (including Menards, Supply House, Home Depot, and Grainger) for each component required for the HPWH ventilation duct. The incremental first cost for the duct equipment and labor is expected to be higher for retrofits than new construction/additions. This is due to the need to cover existing wall/door vents used for existing gas water heaters and added cost of ventilation duct elbows used to direct air away from walls/ceiling close to the retrofit HPWH exhaust port.

Installing a ventilation duct for a Heat Pump Water Heater (HPWH) involves several components and steps, including:

- **Wall Vent/Outdoor Grill/Termination Kit**: Connects the duct in the room where the HPWH is located to the outdoors.
- **Boot**: Connects the duct to the wall vent/outdoor grille when there is no round connector integrated into the wall vent/outdoor grille.
- **Coupler**: Connects to the intake or exhaust port on the HPWH.
- **Band Clamps or Tape**: Secures the flexible duct to the coupler.
- **Flexible Ventilation Duct**: Facilitates airflow between the HPWH and the connected space.
- **Duct Hanger Straps**: Attaches the duct to the ceiling for stability.

The installer (plumber, general contractor, or mechanical subcontractor) must cut a hole in the wall of the HPWH room to connect to the outdoors, and both sides of the wall vent shall be sealed to prevent air and water leakage. Once sealed, the boot, duct, hanger straps, and coupler are installed to complete the ventilation setup. The wall vent shall include a bug screen and rain/snow shield when installed outdoors to prevent water and bug ingress. The NFA of the wall vent and a bug screen shall also meet the NFA required in the proposed code language.

The incremental cost for adding a second 24 foot long, 8-inch diameter HPWH ventilation duct is $257 in materials and $233 in labor for a single HPWH ventilation duct or $202 in labor when installing a second duct.[14] These cost estimates are within the range of $125 to $315 for labor and $235 to $575 (December 2023) for components

[14] Based on an average of eight installers estimated time to install only one duct and time to install a second duct for the same HPWH in hours multiplied by the hourly fully loaded labor rate for California Plumbers, Pipefitters, and Steamfitters (July 2025) please see Appendix F for details on installation time.

identified in Table 9 of "The Amazing Shrinking Room" report (Larson and Larson, Heat Pump Water Heaters in Small Spaces Lab Testing: "The Amazing Shrinking Room" 2022). The total material and installation cost estimate of $490 for a single HPWH duct and $459 for a second duct is also consistent with page 365 of the 2025 Multifamily Domestic Hot Water CASE Report where material costs are estimated at $195 and labor costs are estimated at $200 per duct (August 2023).

The $257 material cost is a conservative estimate because this number was derived from retail pricing (April 2026) rather than wholesale pricing and it includes the cost of ducting kits from three manufacturers and no cost from four manufacturers because they provide built-in duct couplers as part of all shipped products. Installers with a contractor's license will purchase materials from a wholesaler or have a discounted retailer pricing.

There are incremental cost savings when choosing to implement a HPWH exhaust duct instead of a grille in new construction. This cost savings is assumed to be a total material and labor savings of $99 based on one half of the cost associated with installing two grilles defined in the 2025 Multifamily Domestic Hot Water CASE Report (August 2023). The total implementation cost for an exhaust duct instead of a grille in new construction is a total of $490 ($233 in labor for only one duct and $257 for materials) minus the cost savings from not having to install the grille in the baseline case which was defined earlier as $99 for a total exhaust duct cost of $391 (July 2025).

In retrofit applications, an additional cost includes covering any existing wall/door vents with a wood, metal, or plastic panel to prevent airflow between the water heater closet and the outdoors. This one-time installation cost is estimated to be $147 (April 2026). This cost includes one hour of labor at $124 per hour;[15] the labor includes cutting out the panel to cover the louvers, nailing, or screwing it into place, and sealing it with adhesive. Material costs are estimated at $15[16] for the panel and $8[17] of adhesive.

An additional $82 (April 2026) cost in retrofit applications is required to attach an elbow to the exhaust side of the HPWH to make room for the ventilation duct to be attached when the HPWH is installed in a very small room or located close to a wall. This cost includes half an hour of labor at $124 per hour[18] to attach the elbow to the HPWH duct coupler with a band clamp and aluminum duct tape, then wrap the elbow in insulation

[15] Based on the hourly fully loaded labor rate for California Plumbers, Pipefitters, and Steamfitters (July 2025), please see Appendix F for details on the time estimates.

[16] Based on the price of a six inch wide by eighteen inch long 22 gauge aluminum sheet metal from Home Depot (April 2026).

[17] Based on the price of exterior window, door and siding sealant from Home Depot (April 2026).

[18] Based on the hourly fully loaded labor rate for California Plumbers, Pipefitters, and Steamfitters (July 2025), please see Appendix F for details on the time estimates.

taken from the extra length of duct purchased above. The material cost is estimated at $13[19] for the elbow and $8[20] for a zip tie or band clamp to connect the duct.

5.4 Incremental Maintenance and Replacement Costs

A description of the incremental maintenance and replacement costs, as well as an estimation of present value of maintenance and replacement costs, are provided in the 2028 CASE Methodology Report.

The incremental maintenance and replacement costs, as well as estimation of present value of maintenance and replacement costs, are provided for HPWH ducts assuming that they have a longer life than HVAC distribution ducts, which is ten or more years,[21] because the HPWH ventilation ducts are not exposed to the high temperature of the attic space like HVAC ventilation ducts typically are. Given this assumption, the CASE authors are assuming no incremental maintenance or duct replacement costs during the 30-year analysis period. The HPWH will be replaced during the 30-year horizon, but the ducts can be re-used.

Two other assumptions were applied as maintenance costs. Incremental maintenance costs include drywall damage from moisture and exterior vent re-sealing with adhesive.

An intake duct connected to the outdoors without an exhaust duct to the outdoors (HPWH exhausts air into the small room) could result in moisture damage, which has a maintenance cost associated with it. It is assumed that a $781 drywall replacement will be required once every ten years (April 2026). This cost includes six hours of labor at $117 per hour[22] to cut out drywall, inspect, size new drywall, install, texture, and paint. The drywall cost is estimated at $42[23] plus $47[24] for texture and paint. It is assumed that this will occur only in one percent of single-duct installations based on survey feedback (see Appendix F for details).

The exterior vent will require additional adhesive to prevent water ingress. Since one duct would already be present at the building, only five minutes of time is necessary to

[19] Based on the price of an eight inch diameter round adjustable elbow from Home Depot (April 2026).

[20] Based on the price of using two band clamps with a three to five inch diameter or a partial bag of plenum rated HVAC cable zip ties from Home Depot (April 2026).

[21] Environmental Heating & Air Solutions n.d.

[22] Based on the hourly fully loaded labor rate for California Carpenters (July 2025).

[23] Based on the price of two mold-resistant and moisture-resistant sheets of drywall, both one-half inch thick by four feet by eight feet, from Home Depot (April 2026).

[24] Based on the price of a quart of paint, container of wall texture, joint tape, joint compound, and paint roller from Home Depot (April 2026).

apply the new adhesive at a rate of $124 per hour[25] and the adhesive will cost $8[26] of adhesive will be used per HPWH duct vent. The new adhesive is expected to need to be applied every 15 years.

5.5 Cost Effectiveness

Cost effectiveness is determined by the net energy savings over time, incremental first cost, and incremental maintenance costs over a 30-year period. Assumptions were discussed with subject matter experts, stakeholders and data was collected in surveys of contractors between September 28 and November 3.

Results of the per-unit cost-effectiveness analyses are presented in Table 19 through Table 21 represent new construction/additions in small office buildings and quick service restaurants while Table 22 through Table 27 represents new alterations in small office buildings and quick service restaurants.

In the tables below, all values are presented in 2029 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 the proposed residual value is greater than the current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including incremental equipment, replacement, and maintenance costs over the period of analysis. The analysis treats a negative incremental maintenance cost as a positive benefit. If total incremental costs are zero, the benefit-to-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.

[25] Based on the hourly fully loaded labor rate for California Plumbers, Pipefitters, and Steamfitters (July 2025), please see Appendix F for details on the time estimates.

[26] Based on the price of exterior window, door and siding sealant from Home Depot (April 2026).

Table 16: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Single Intake Duct vs Dual Duct)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	2.10	0.09	24.59
2	1.68	0.09	19.57
3	1.66	0.09	19.01
4	1.38	0.09	14.82
5	1.56	0.09	18.35
6	1.15	0.09	12.89
7	1.05	0.11	9.92
8	0.90	0.09	10.04
9	0.96	0.09	10.85
10	0.95	0.09	10.38
11	1.25	0.09	14.36
12	1.38	0.09	15.84
13	1.10	0.09	12.85
14	1.01	0.09	11.47
15	1.25	0.09	14.25
16	1.12	0.09	12.89
Total	**1.20**	**0.09**	**13.69**

Table 17: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	-0.02	0.15	-0.17
2	0.08	0.15	0.56
3	0.00	0.15	0.00
4	0.12	0.15	0.79
5	0.06	0.15	0.38
6	0.13	0.15	0.92
7	0.12	0.15	0.82
8	0.13	0.15	0.86
9	0.13	0.15	0.89
10	0.13	0.15	0.90
11	0.17	0.15	1.15
12	0.11	0.15	0.72
13	0.15	0.15	1.05
14	0.17	0.15	1.17
15	0.16	0.15	1.09
16	0.18	0.15	1.22
Total	**0.11**	**0.15**	**0.77**

Table 18: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.01	0.07	0.14
2	0.01	0.07	0.14
3	0.01	0.07	0.14
4	0.01	0.08	0.13
5	0.01	0.07	0.14
6	0.01	0.07	0.13
7	0.01	0.09	0.12
8	0.01	0.08	0.13
9	0.01	0.07	0.13
10	0.01	0.08	0.13
11	0.01	0.07	0.14
12	0.01	0.07	0.14
13	0.01	0.07	0.13
14	0.01	0.07	0.13
15	0.01	0.07	0.13
16	0.01	0.07	0.14
Total	**0.01**	**0.07**	**0.13**

Table 19: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Single Exhaust Duct vs Dual Ducts)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.13	0.17	0.77
2	-0.12	0.17	-0.68
3	-0.21	0.17	-1.23
4	0.03	0.17	0.17
5	-0.06	0.17	-0.32
6	-0.08	0.17	-0.46
7	-0.04	0.17	-0.26
8	0.05	0.17	0.28
9	-0.19	0.17	-1.13
10	-0.18	0.17	-1.04
11	-0.03	0.17	-0.15
12	0.07	0.17	0.40
13	0.28	0.17	1.62
14	-0.02	0.17	-0.10
15	0.54	0.17	3.13
16	-0.31	0.17	-1.82
Total	**-0.04**	**0.17**	**-0.23**

Table 20: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Single Exhaust Duct vs Dual Ducts to Communicating Space)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.49	0.08	5.83
2	0.28	0.08	3.28
3	0.22	0.09	2.53
4	0.32	0.09	3.51
5	0.20	0.08	2.41
6	0.08	0.09	0.89
7	0.09	0.10	0.86
8	0.16	0.09	1.86
9	0.23	0.09	2.66
10	0.26	0.09	2.85
11	0.44	0.09	5.18
12	0.30	0.09	3.52
13	0.44	0.08	5.16
14	0.43	0.09	5.00
15	0.54	0.09	6.25
16	0.45	0.09	5.28
Total	**0.27**	**0.09**	**3.13**

Table 21: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – New Construction and Additions (Weighted Average)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.36	0.10	4.16
2	0.25	0.10	2.95
3	0.21	0.10	2.60
4	0.25	0.10	2.59
5	0.22	0.10	2.64
6	0.16	0.10	1.74
7	0.15	0.11	1.41
8	0.16	0.10	1.71
9	0.15	0.10	1.83
10	0.16	0.10	1.83
11	0.26	0.10	2.92
12	0.24	0.10	2.73
13	0.27	0.10	2.93
14	0.23	0.10	2.56
15	0.34	0.10	3.50
16	0.21	0.10	2.60
Total	**0.21**	**0.10**	**2.34**

Table 22: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Single Intake Duct vs Dual Duct)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	2.09	0.13	16.51
2	1.68	0.13	13.17
3	1.65	0.13	12.80
4	1.34	0.13	10.36
5	1.56	0.13	12.30
6	1.14	0.13	8.69
7	0.98	0.13	7.44
8	0.90	0.13	6.71
9	0.96	0.13	7.19
10	0.94	0.13	7.11
11	1.24	0.13	9.71
12	1.37	0.13	10.71
13	1.10	0.13	8.62
14	1.01	0.13	7.68
15	1.24	0.13	9.67
16	1.12	0.13	8.65
Total	**1.24**	**0.13**	**9.53**

Table 23: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	-0.02	0.27	-0.09
2	0.08	0.27	0.31
3	0.00	0.27	0.00
4	0.11	0.27	0.43
5	0.06	0.27	0.21
6	0.13	0.27	0.50
7	0.11	0.27	0.42
8	0.13	0.27	0.47
9	0.13	0.27	0.49
10	0.13	0.27	0.49
11	0.17	0.27	0.63
12	0.11	0.27	0.40
13	0.15	0.27	0.58
14	0.17	0.27	0.64
15	0.16	0.27	0.60
16	0.18	0.27	0.67
Total	**0.11**	**0.27**	**0.42**

Table 24: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.01	0.13	0.08
2	0.01	0.13	0.08
3	0.01	0.13	0.08
4	0.01	0.13	0.07
5	0.01	0.13	0.07
6	0.01	0.14	0.07
7	0.01	0.14	0.07
8	0.01	0.14	0.07
9	0.01	0.14	0.07
10	0.01	0.14	0.07
11	0.01	0.13	0.07
12	0.01	0.13	0.07
13	0.01	0.13	0.07
14	0.01	0.14	0.07
15	0.01	0.13	0.07
16	0.01	0.13	0.08
Total	**0.01**	**0.13**	**0.07**

Table 25: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Single Exhaust Duct vs Dual Ducts)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.13	0.25	0.51
2	-0.12	0.25	-0.45
3	-0.21	0.25	-0.83
4	0.03	0.25	0.11
5	-0.06	0.25	-0.22
6	-0.08	0.25	-0.31
7	-0.04	0.25	-0.16
8	0.05	0.25	0.19
9	-0.20	0.25	-0.77
10	-0.18	0.25	-0.69
11	-0.02	0.25	-0.10
12	0.07	0.25	0.27
13	0.28	0.25	1.09
14	-0.02	0.25	-0.06
15	0.53	0.25	2.09
16	-0.31	0.25	-1.22
Total	**-0.01**	**0.25**	**-0.05**

Table 26: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Single Exhaust Duct vs Dual Ducts to Communicating Space)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.49	0.13	3.89
2	0.28	0.13	2.20
3	0.22	0.13	1.69
4	0.31	0.13	2.45
5	0.20	0.13	1.61
6	0.08	0.13	0.60
7	0.08	0.13	0.64
8	0.16	0.13	1.24
9	0.23	0.13	1.76
10	0.25	0.13	1.95
11	0.44	0.13	3.49
12	0.30	0.13	2.37
13	0.44	0.13	3.45
14	0.43	0.13	3.34
15	0.54	0.13	4.23
16	0.45	0.13	3.53
Total	**0.29**	**0.13**	**2.22**

Table 27: 30-Year Cost-Effectiveness Summary Per Nonresidential Building/Square Foot – Alterations (Weighted Average)

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.36	0.16	2.78
2	0.25	0.16	1.97
3	0.21	0.16	1.74
4	0.24	0.16	1.79
5	0.22	0.16	1.75
6	0.15	0.16	1.15
7	0.14	0.16	1.03
8	0.16	0.16	1.12
9	0.16	0.16	1.19
10	0.16	0.16	1.23
11	0.26	0.16	1.95
12	0.24	0.16	1.82
13	0.27	0.16	1.94
14	0.23	0.16	1.69
15	0.34	0.16	2.34
16	0.21	0.16	1.72
Total	**0.22**	**0.16**	**1.63**

6. Statewide Impacts

6.1 Statewide Energy and Energy Cost Savings

To determine the annual number of units that would be affected by the proposed code change, the Statewide CASE Team first surveyed industry professionals to estimate the percentage of hot water heaters in nonresidential buildings that shall be subjected to the proposed code change and the portion of that market that is already compliant with the proposed code change. Statewide energy and cost impacts were determined by applying both intake and exhaust ventilation ducts or exhaust duct and a grille within the same pressure boundary to ventilate HPWHs in small office buildings and quick service restaurants.

The number of applicable new construction buildings affected by the proposed HPWH ventilation code change is based on the 2028 Construction Forecast from the 2028 Code cycle MeasureSET Excel document. The square footage of small office buildings was divided by 5500 square feet, and the square footage of restaurant building stock was divided by 2500 square feet to determine the number of available buildings with water heaters. This number of available buildings with water heaters is scaled by the percentage of the buildings expected to implement a HPWH with ducts in the next year. This weighted number is used to estimate statewide energy and energy cost savings per HPWH.

Stakeholders indicated that eight percent of water heaters installed in new construction will be HPWHs with either an intake or an exhaust duct. It is assumed that these eight percent of water heaters would need to implement either dual ducts or a combination of an exhaust duct and a grille with the proposed updates to the 2028 code language. Because the next stakeholder survey question indicated that there are likely two times the amount of quick service restaurant installations for these HPWHs than small offices, the eight percent implementation rate gets split into five percent of small offices and ten percent of quick service restaurant where water heater retrofits will implement the proposed requirement for either dual ducts or a combination of an exhaust duct and a grille ventilation system.

After discussions with other researchers working on an updated sizing guideline for water heaters in food service applications, the quick service restaurant implementation rate was identified as being too high due to the 2020 California Conference of Directors of Environmental Health (CCDEH) Guideline for Sizing Water Heaters. This guideline focuses on the heating energy delivered by the electric resistive heating element in HPWHs, not the combined electric resistive heating element and heat pump. It is more conservative to say that it is very uncommon (much less than one percent) for new quick service restaurants to install consumer integrated HPWHs with ducts following the

San Francisco Department of Public Health Technical Bulletin titled "Heat Pump Plan Review for Food Facilities."

A similar process was used to estimate the number of retrofit water heaters that will implement the newly required dual duct HPWH ventilation system in existing buildings. The existing stock square footage data for small offices were divided by 5500 square feet and restaurant building stock square footage was divided by 2500 square feet to determine the number of available buildings where water heaters are used. This assumes that all buildings have at least one hot water heater.

It is assumed the commercial building water heaters are replaced every ten years, so ten percent of the water heaters in the existing floor space will be replaced during the first year that the code is implemented. Then, stakeholders indicated that it would be uncommon (two percent on average) for retrofit water heaters to implement a HPWH with either an intake or an exhaust duct which would require either dual ducts or a combination of an exhaust duct and a grille with the proposed updates to the 2028 code language.

Because the next survey question indicated that there are likely two times the amount of quick service restaurant installations for these HPWHs than small offices, the two percent implementation rate is split into one percent of small offices and three percent of quick service restaurant water heater retrofits. Next, the ten percent derating was applied to these values to account for a typical ten year life for water heaters (Gromicko n.d.), which results in one-tenth of all water heaters being replaced annually.

After applying the ten percent derating, much less than one percent of small office water heater replacements and less than one percent of quick service restaurant water heater replacements would implement the proposed either dual ducts or a combination of an exhaust duct and a grille dual ducting HPWH ventilation system. Following the guidance from other researchers working on an updated sizing guideline for water heaters in food service applications, the number of quick service restaurant water heater replacements that would implement the proposed dual duct HPWH ventilation system is very uncommon, which updated the adoption percent to much less than one percent.

See the 2028 CASE Methodology Report for details on how statewide savings are calculated. Appendix D 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.

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 28 through and Table 33) alterations (Table 34 through Table 39) by climate zone.

Table 28: Statewide Energy and LSC Impacts – New Construction and Additions (Single Intake Duct vs Dual Duct)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	258	65	7	N/A	97	$541
2	805	161	14	N/A	272	$1,355
3	1,631	316	39	N/A	533	$2,708
4	287	48	5	N/A	82	$395
5	597	109	13	N/A	192	$933
6	1,176	161	20	N/A	276	$1,348
7	147	19	2	N/A	33	$155
8	1,591	175	27	N/A	352	$1,427
9	3,477	403	62	N/A	816	$3,321
10	1,051	119	19	N/A	253	$999
11	479	73	9	N/A	134	$597
12	2,025	338	38	N/A	615	$2,791
13	1,785	232	36	N/A	463	$1,967
14	491	63	7	N/A	117	$496
15	253	31	8	N/A	86	$316
16	230	35	3	N/A	43	$257
Total	**16,284**	**2,347**	**311**	**N/A**	**4,364**	**$19,607**

Table 29: Statewide Energy and LSC Impacts – New Construction and Additions (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	258	-1	0	N/A	-1	-$6
2	805	8	1	N/A	12	$66
3	1,631	-1	0	N/A	0	$0
4	287	4	0	N/A	6	$33
5	597	4	0	N/A	6	$33
6	1,176	19	2	N/A	28	$158
7	147	2	0	N/A	3	$18
8	1,591	24	3	N/A	37	$201
9	3,477	55	6	N/A	84	$455
10	1,051	17	2	N/A	26	$139
11	479	10	1	N/A	15	$81
12	2,025	25	3	N/A	40	$214
13	1,785	33	4	N/A	51	$275
14	491	10	1	N/A	17	$84
15	253	5	1	N/A	8	$40
16	230	5	1	N/A	8	$41
Total	**16,284**	**219**	**25**	**N/A**	**338**	**$1,832**

Table 30: Statewide Energy and LSC Impacts – New Construction and Additions (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	1,033	1	0	N/A	2	$11
2	3,221	3	0	N/A	6	$32
3	6,523	5	1	N/A	11	$66
4	1,149	1	0	N/A	2	$12
5	2,387	2	0	N/A	4	$23
6	4,704	4	1	N/A	8	$46
7	590	0	0	N/A	1	$6
8	6,364	5	1	N/A	11	$62
9	13,909	10	2	N/A	24	$137
10	4,202	3	1	N/A	7	$42
11	1,914	1	0	N/A	3	$19
12	8,100	6	1	N/A	14	$81
13	7,140	5	1	N/A	12	$70
14	1,966	1	0	N/A	3	$19
15	1,012	1	0	N/A	2	$10
16	920	1	0	N/A	2	$9
Total	**65,137**	**49**	**8**	**N/A**	**110**	**$644**

Table 31: Statewide Energy and LSC Impacts – New Construction and Additions (Single Exhaust Duct vs Dual Duct)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	258	0	2	N/A	19	$34
2	805	-27	5	N/A	35	-$93
3	1,631	-65	4	N/A	6	-$344
4	287	-2	1	N/A	6	$8
5	597	-6	0	N/A	5	-$33
6	1,176	-18	1	N/A	-1	-$93
7	147	-2	0	N/A	0	$7
8	1,591	-5	4	N/A	23	$77
9	3,477	-151	14	N/A	-3	-$674
10	1,051	-43	3	N/A	-10	-$186
11	479	-6	4	N/A	14	-$12
12	2,025	-3	7	N/A	42	$140
13	1,785	50	10	N/A	76	$496
14	491	-8	2	N/A	18	-$8
15	253	17	1	N/A	13	$136
16	230	-9	-1	N/A	-19	-$72
Total	**16,284**	**-278**	**58**	**N/A**	**225**	**-$633**

Table 32: Statewide Energy and LSC Impacts – New Construction and Additions (Single Exhaust Duct vs Dual Ducts to Communicating Space)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	517	28	4	N/A	54	$253
2	1,611	37	11	N/A	135	$448
3	3,262	66	15	N/A	183	$710
4	575	15	6	N/A	54	$185
5	1,194	21	5	N/A	80	$242
6	2,352	6	8	N/A	82	$185
7	295	1	1	N/A	10	$26
8	3,182	28	17	N/A	161	$521
9	6,954	114	44	N/A	404	$1,608
10	2,101	43	13	N/A	129	$542
11	957	45	9	N/A	88	$425
12	4,050	102	37	N/A	332	$1,224
13	3,570	160	35	N/A	321	$1,561
14	983	45	9	N/A	100	$427
15	506	32	4	N/A	38	$274
16	460	25	4	N/A	49	$208
Total	**32,568**	**767**	**223**	**N/A**	**2,220**	**$8,842**

Table 33: Statewide Energy and LSC Impacts – New Construction and Additions (Sum)

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	2,324	93	14	N/A	171	$833
2	7,247	181	32	N/A	460	$1,808
3	14,678	322	60	N/A	733	$3,140
4	2,585	66	12	N/A	150	$634
5	5,372	129	19	N/A	287	$1,198
6	10,584	172	32	N/A	393	$1,644
7	1,326	21	4	N/A	47	$199
8	14,319	227	51	N/A	583	$2,287
9	31,294	431	128	N/A	1324	$4,846
10	9,456	139	37	N/A	405	$1,536
11	4,308	122	23	N/A	255	$1,110
12	18,225	468	85	N/A	1042	$4,450
13	16,065	480	85	N/A	923	$4,367
14	4,422	111	21	N/A	255	$1,018
15	2,277	86	15	N/A	147	$776
16	2,070	57	7	N/A	82	$444
Total	**146,557**	**3,104**	**625**	**N/A**	**7,258**	**$30,292**

Table 34: Statewide Energy and LSC Impacts – Alterations (Single Intake Duct vs Dual Duct)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	715	179	20	N/A	269	$1,496
2	1,991	397	34	N/A	671	$3,341
3	3,152	609	76	N/A	1,027	$5,216
4	1,455	235	25	N/A	406	$1,953
5	1,125	205	25	N/A	362	$1,757
6	2,137	291	36	N/A	499	$2,440
7	1,368	166	21	N/A	281	$1,337
8	2,147	237	37	N/A	475	$1,927
9	3,593	419	64	N/A	848	$3,450
10	3,993	447	72	N/A	947	$3,743
11	1,708	258	32	N/A	475	$2,116
12	6,565	1088	123	N/A	1,983	$8,997
13	3,649	474	74	N/A	946	$4,014
14	903	115	13	N/A	214	$911
15	1,188	145	39	N/A	402	$1,473
16	475	71	6	N/A	88	$529
Total	**36,162**	**5336**	**696**	**N/A**	**9,892**	**$44,701**

Table 35: Statewide Energy and LSC Impacts – Alterations (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	715	-2	0	N/A	-3	-$17
2	1,991	19	2	N/A	29	$162
3	3,152	-1	0	N/A	0	$0
4	1,455	19	2	N/A	31	$165
5	1,125	7	1	N/A	11	$62
6	2,137	35	4	N/A	51	$287
7	1,368	19	2	N/A	27	$154
8	2,147	33	4	N/A	50	$271
9	3,593	57	6	N/A	87	$473
10	3,993	63	7	N/A	97	$522
11	1,708	34	4	N/A	54	$286
12	6,565	82	10	N/A	128	$690
13	3,649	67	8	N/A	103	$560
14	903	18	2	N/A	31	$154
15	1,188	22	3	N/A	35	$188
16	475	11	1	N/A	17	$85
Total	**36,162**	**482**	**56**	**N/A**	**747**	**$4,041**

Table 36: Statewide Energy and LSC Impacts – Alterations (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	2,860	2	0	N/A	5	$29
2	7,964	6	1	N/A	14	$80
3	12,608	10	2	N/A	21	$127
4	5,820	4	1	N/A	10	$58
5	4,499	3	1	N/A	8	$44
6	8,547	6	1	N/A	14	$83
7	5,472	4	1	N/A	9	$53
8	8,587	6	1	N/A	14	$84
9	14,371	11	2	N/A	24	$142
10	15,971	12	2	N/A	27	$157
11	6,831	5	1	N/A	12	$68
12	26,262	20	3	N/A	45	$259
13	14,595	10	2	N/A	24	$142
14	3,612	3	0	N/A	6	$36
15	4,751	3	1	N/A	8	$46
16	1,899	1	0	N/A	3	$19
Total	**144,647**	**108**	**18**	**N/A**	**245**	**$1,426**

Table 37: Statewide Energy and LSC Impacts – Alterations (Single Exhaust Duct vs Dual Duct)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	715	0	6	N/A	53	$94
2	1,991	-67	13	N/A	86	-$230
3	3,152	-125	9	N/A	11	-$663
4	1,455	-8	5	N/A	29	$41
5	1,125	-12	0	N/A	10	-$62
6	2,137	-32	2	N/A	-1	-$169
7	1,368	-16	2	N/A	3	-$57
8	2,147	-7	5	N/A	31	$104
9	3,593	-157	15	N/A	-4	-$701
10	3,993	-161	11	N/A	-36	-$699
11	1,708	-23	14	N/A	50	-$42
12	6,565	-9	21	N/A	134	$452
13	3,649	102	19	N/A	156	$1,011
14	903	-15	5	N/A	34	-$15
15	1,188	80	7	N/A	60	$631
16	475	-19	-2	N/A	-40	-$148
Total	**36,162**	**-468**	**132**	**N/A**	**578**	**-$452**

Table 38: Statewide Energy and LSC Impacts – Alterations (Single Exhaust Duct vs Dual Ducts to Communicating Space)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	1,430	78	12	N/A	150	$700
2	3,982	91	28	N/A	333	$1,105
3	6,304	128	29	N/A	352	$1,368
4	2,910	73	27	N/A	265	$914
5	2,249	40	10	N/A	151	$455
6	4,273	10	15	N/A	149	$334
7	2,736	8	11	N/A	88	$229
8	4,294	38	23	N/A	218	$704
9	7,185	118	45	N/A	419	$1,671
10	7,986	160	48	N/A	484	$2,032
11	3,416	158	32	N/A	313	$1,508
12	13,131	327	118	N/A	1071	$3,947
13	7,297	327	72	N/A	655	$3,186
14	1,806	82	17	N/A	183	$785
15	2,375	151	19	N/A	179	$1,277
16	949	52	8	N/A	100	$429
Total	**72,324**	**1842**	**514**	**N/A**	**5,109**	**$20,643**

Table 39: Statewide Energy and LSC Impacts – Alterations (Sum)

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2029 (Square Feet)	First-Year Electricity Savings (kWh)	First-Year Peak Electrical Demand Reduction (W)	First-Year Natural Gas Savings (Therms)	First-Year Source Energy Savings (kBtu)	30-Year Present Valued LSC Savings (2029 PV$)
1	6,435	258	38	N/A	474	$2,302
2	17,919	446	79	N/A	1,133	$4,457
3	28,368	620	115	N/A	1,411	$6,048
4	13,095	324	60	N/A	740	$3,130
5	10,123	243	36	N/A	541	$2,256
6	19,231	311	58	N/A	712	$2,975
7	12,312	180	36	N/A	409	$1,717
8	19,322	307	69	N/A	788	$3,090
9	32,335	448	133	N/A	1,375	$5,034
10	35,936	520	139	N/A	1,519	$5,756
11	15,371	433	82	N/A	904	$3,935
12	59,088	1,508	275	N/A	3,360	$14,346
13	32,839	980	174	N/A	1,884	$8,913
14	8,127	204	38	N/A	468	$1,871
15	10,690	401	69	N/A	683	$3,615
16	4,273	117	14	N/A	169	$914
Total	**325,457**	**7,299**	**1415**	**N/A**	**16,569**	**$70,359**

6.2 Statewide Greenhouse Gas Emissions Reductions

Table 40 through Table 45 present the estimated first-year reduction in GHG emissions resulting from the proposed code change in small office buildings and quick service restaurants. In this initial year, the Statewide CASE Team expects to avoid 1.22 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 40: First-Year Statewide GHG Emissions Impacts (Single Intake Duct vs Dual Duct)

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	0.23	N/A	0.23	37
Alterations	0.52	N/A	0.52	85
Total	**0.75**	**N/A**	**0.75**	**122**

Table 41: First-Year Statewide GHG Emissions Impacts (Dual Grilles to Outdoors vs Exhaust Duct with Intake Grille to Outdoors)

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	0.02	N/A	0.02	3
Alterations	0.04	N/A	0.04	6
Total	**0.06**	**N/A**	**0.06**	**9**

Table 42: First-Year Statewide GHG Emissions Impacts Small Office (Dual Grilles to Indoor Communicating Space vs Exhaust Duct with Intake Grille to Communicating Space)

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	0.01	N/A	0.00	1
Alterations	0.01	N/A	0.00	2
Total	**0.02**	**N/A**	**0.00**	**3**

Table 43: First-Year Statewide GHG Emissions Impacts (Single Exhaust Duct vs Dual Ducts)

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	0.02	N/A	0.02	3
Alterations	0.04	N/A	0.04	6
Total	**0.06**	**N/A**	**0.06**	**9**

Table 44: First-Year Statewide GHG Emissions Impacts (Single Exhaust Duct vs Dual Ducts to Communicating Space)

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	0.12	N/A	0.12	19
Alterations	0.27	N/A	0.27	44
Total	**0.39**	**N/A**	**0.39**	**63**

Table 45: First-Year Statewide GHG Emissions Impacts (Sum)

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO_2e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO_2e)	Total Reduced GHG Emissions (Metric Ton CO_2e)	Total Monetary Value of Reduced GHG Emissions ($)
New Construction & Additions	0.40	N/A	0.40	63
Alterations	0.88	N/A	0.88	143
Total	**1.28**	**N/A**	**1.28**	**206**

6.3 Statewide Water Use Impacts

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

6.4 Statewide Material Impacts

The proposed code change will result in more HPWH ventilation ducts. Installing a HPWH ventilation duct involves several components and steps, including:

- **Wall Vent/Outdoor Grill:** Connects the duct in the room where the HPWH is located to another room or outdoors.
- **Boot:** Connects the duct to the wall vent/outdoor grille when there is no round connector to integrate into the wall vent/outdoor grille.
- **Coupler**: Connects to the intake or exhaust port on the HPWH.
- **Band Clamps or Tape:** Two band clamps secure the flexible duct to the coupler.
- **Flexible Ventilation Duct:** One duct facilitates airflow between the HPWH and connected space with R6 insulation.
- **Duct Hanger Straps:** Three straps attach the duct to the ceiling for stability.
- **Coupler:** One coupler connects to the HPWH's intake or exhaust port.
- **Silicone:** Silicone adhesive for sealing the exterior wall vent to the building.

Total material weights for each HPWH duct installation, which includes all the components above with an eight-inch diameter and twenty-five-foot-long duct has been tabulated; see Table 46. Material weights came from sources used to identify the incremental first costs for equipment. Equipment cost estimates were collected from an average of retailer and distributor product listings (including Menards, Supply House, Home Depot, and Grainger) for each component required for the HPWH ventilation duct components.

For more information on the Statewide CASE Team's methodology and assumptions used to calculate embodied GHG emissions, see the [2028 CASE Methodology Report.]

Table 46: First-Year Statewide Impacts on Material Use

Material	Impact (response options: Increase, Decrease, No Change)	Per-Unit Impacts (Pounds per HPWH Unit)	First-Year Statewide Impacts (Pounds)	Embodied GHG emissions saved (Metric Tons CO2e)
Mercury	No Change	0	0	0
Lead	No Change	0	0	0
Copper	No Change	0	0	0
Concrete	No Change	0	0	0
Steel	Increase	5.40	1,479	-0.81
Insulation	Increase	7.50	2,055	-2.28
Wood	No Change	0	0	0
Plastic	Increase	4.92	1,348	-1.13
Refrigerants	No Change	0	0	0
Glass	No Change	0	0	0
Silicone	Increase	0.32	87	-0.56
Aluminum	Increase	5.40	1,479	-9.65
Polyester	Increase	1.50	411	-2.63
TOTAL	**N/A**	**17.82**	**4,882**	**-4.23**

6.5 Environmental Impacts

In addition to understanding the energy impacts of this measure, the following environmental impacts are a result of this code change.

Eliminating the single intake duct ventilation configuration to the outside, where the HPWH exhaust is directed into the building, removes the risk of expelling airborne particulates, gases, and bacteria originating in the HPWH room and exiting into the outdoor environment. With the updated code language for two ducts, outdoor air enters the HPWH intake and exits the HPWH back into the environment, or indoor air enters the HPWH intake and exits the HPWH back into the indoor environment.

6.6 Other Non-Energy Impacts

In addition to understanding the environmental impacts of this measure, the following potential non-energy impacts are a result of this code change.

Appropriately sized and insulated ducting for HPWHs will reduce condensation potential on surfaces (Rheem Manufacturing Company 2024) and moisture damage risk inside the conditioned space and/or other small water heater locations, which is a health and safety improvement (Klein 2025). Also, potential air quality risks are removed by eliminating the single duct intake ventilation configuration where outdoor air enters the HPWH room. These air quality risks are caused by ingress of airborne particulates, gases, and bacteria originating outdoors that enter the room. Updating the ventilation language to require two ducts also eliminates the HPWH's induced pressure imbalance in the room where the HPWH is installed (Colon, Martin and Parker 2016). The pressure imbalance can cause cold/hot, dry/humid air to enter the room through the cracks in the siding, vapor barrier, wall insulation, and drywall, which could lead to additional building maintenance. Alternately, cold air from indoors could be forced back outdoors due to the pressure imbalance through the wall structure.

7. Proposed Language Code

7.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the Alternative Calculation Method (ACM) Reference Manuals are provided below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions). New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics.*

Markups are provided to the restructured 2025 Energy Code that the CEC developed in response to feedback that aligning the structure of Title 24, Part 6 with other parts of the California Building Standards Code (Title 24) would improve readability, usability, and navigation.[8] New section numbers are shown as bold followed square brackets that document the section in the 2025 Title 24, Part 6 section numbers prior to the restructuring. For example, "**Section 601.1** [Section 130.0(a)] **General"** contains the content that is in the current Section 130.0(a).

Posting the proposed code language in this format is useful as it helps describe how the Energy Code changes proposed for nonresidential occupancies are isolated from the requirements for residential occupancies which are prohibited from being changed until the 2031 code cycle by Assembly Bill 130.

7.2 Administrative Code (Title 24, Part 1)

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

7.3 Energy Code (Title 24, Part 6)

There are proposed changes to Title 24, Part 6, see below.

Title 24, Part 6: Section 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

UNVENTED SURFACE is all door, wall and ceiling surfaces that do not have a vent installed to allow airflow to a communicating space.

Title 24, Part 6: 500.3.3 [Section 110.3(c)] Installation.

500.3.3.7 *[Section 110.3(c)7]* Air-Source Heat Pump Water Heaters (HPWHs).

HPWH shall meet the following requirements:

500.3.3.7.1 *[Section 110.3(c)7A]* Backup heat.

Backup heat is required for systems when inlet air is unconditioned, unless the compressor cut-off temperature is below the Heating Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup heat may be internal or external to the *HPWH*.

500.3.3.7.2 *[Section 110.3(c)7B]* Ventilation – Residential and Nonresidential with Group R Occupancy, and Common or Public Use Areas serving that Occupancy.

Consumer integrated *HPWHs* serving single-family or multifamily dwelling units, or nonresidential buildings with Group R Occupancy, and Common or Public Use Areas serving that Occupancy, shall be installed using a method provided by the manufacturer to meet or exceed the level of performance provided by one of the ventilation requirements below.

Minimum volume and opening size requirements shall be the sum of all *HPWHs* installed within the same space. Compressor capacity shall be determined using *AHRI 540* Table 4 reference conditions for refrigeration with the "High" rating test point.

500.3.3.7.2.1- For *HPWH* installation without ducts, the installation space shall have a volume not less than the greater of 100 cubic feet per kBtu per hour of compressor capacity, or the minimum volume provided by the manufacturer for this method; or

500.3.3.7.2.2- For *HPWH* installation without ducts, the installation space shall be vented to a communicating space via permanent openings, according to the following requirements:

1. Communicating space shall meet the minimum volume of Section 500.3.3.7.2.1 *[Section 110.3(c)7B2]* above, minus the volume of the *HPWH* installation space; and
2. Permanent openings shall consist of a single layer of fixed flat slat louvers or grilles, with a total minimum *Net Free Area (NFA)* the larger of 125 square inches plus 25 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method.
3. The permanent openings shall be fully louvered *doors* or two openings of equal area, one in the upper half of the enclosure and one in the bottom half of the enclosure. The top of the upper opening must be 12 inches or less from the enclosure top and the bottom of the lower vent must be 12 inches or less from the enclosure bottom; or

500.3.3.7.2.3- For *HPWH* installations with ducts, the following requirements shall be met:

1. The space joined to the installation space via ducts shall meet the minimum volume of Section 500.3.3.7.2.1 *[Section 110.3(c)7B2]* above, minus the volume of the *HPWH* installation space; and
2. All duct connections and *building* penetrations shall be sealed; and
3. Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and
4. Where only the *HPWH* inlet or outlet is ducted, installation space shall include permanent openings which consist of a single layer of fixed flat slat louvers or grilles in the bottom half of the room, and/or a *door* undercut. With a ducted inlet, the minimum *NFA* shall be equal to the cross-sectional area of the duct. With a ducted exhaust, the minimum *NFA* shall be the larger of 20 square inches or the minimum *NFA* provided by the manufacturer for this method; and
5. Where the inlet and outlet ducts both terminate within the same *pressure boundary*, airflow from the termination points shall be diverted away from each other.

NOTE: Ducting only the inlet or the exhaust across the *pressure boundary* could interfere with *balanced ventilation systems*. This should be considered when specifying *HPWH* location and ventilation method.

500.3.3.7.3 *[Section 110.3(c)7C]* Ventilation – Nonresidential Excluding Group R Occupancy, and Common or Public Use Areas serving that Occupancy.

Consumer integrated HPWHs serving nonresidential occupancies shall be installed using one of the methods in either Section 500.3.3.7.3.1, 500.3.3.7.3.2, or 500.3.3.7.3.3.

500.3.3.7.3.1- Installations Per Manufacturer Provided Method

For *HPWH* installations following a manufacturer provided method, this method shall meet or exceed the level of performance provided by one of the ventilation requirements in either Section 500.3.3.7.3.2 or 500.3.3.7.3.3.

500.3.3.7.3.2- Installations Without Ducts

For *HPWH* installations without ducts connected to the *HPWH*, the following requirements shall be met:

1. The installation space shall have a volume larger than 100 cubic feet per kBtu per hour of the combined compressor capacity and larger than the minimum volume provided by the manufacturer. Compressor capacity

shall be determined using *AHRI 540* Table 4 reference conditions for refrigeration with the "High" rating test point.

2. Minimum room volume shall be at least the sum of all required volumes for all *HPWHs* installed within the same space.
3. The center of the *HPWH* outlet port of all unducted *HPWHs* shall be directed at an angle of 90 degrees or more away from all *unvented surfaces* and permanently installed equipment closer than the manufacturer specified minimum distance. If the manufacturer does not specify a minimum distance, then the minimum distance between *unvented surfaces* and the center of HPWH outlet port shall be 24 inches.
4. *HPWH* exhaust air shall be directed at a minimum angle of 90 degrees away from each other or be separated by a minimum of 24 inches.

Exception 1 to 500.3.3.7.3.2- A *HPWH* may be installed in a smaller volume space without ducts if the installation space contains permanently installed equipment which generates waste heat sufficient to meet the thermal energy needs of all *HPWHs* installed in the space. A calculation shall be done using an energy model that meets the requirements of the ACM to confirm that the method of providing a source of heat to the *HPWH* room meets or exceeds the level of performance provided by the ventilation requirements of Section 500.3.3.7.3.2.

Permanently installed equipment which generates waste heat may include, but is not limited to, one or more commercial refrigerators, ice makers and/or ovens.

500.3.3.7.3.3- Installations With Ducts

For *HPWH* installations with ducts connected to the *HPWH*, the following requirements shall be met for all installations with ducts in addition to one of the ventilation requirements in either Section 500.3.3.7.3.3.1 or 500.3.3.7.3.3.2:

1. Air for the inlet and outlet of the *HPWH* shall both terminate on the same side of a *pressure boundary*, either both to outside or both to inside the building; and
2. Minimum ventilation opening size shall be at least the sum of all required openings for all *HPWH*s installed within the same space; and
3. The space joined to the installation space via ducts shall meet the minimum volume of Section 500.3.3.7.3.2 [Section 110.3(c)7C2] above, minus the volume of the *HPWH* installation space; and
4. All duct joints, connections and building penetrations shall be sealed; and

5. Outlet ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and
6. Outlet ducts shall be installed such that internal condensation will drain back to the *HPWH*'s internal condensate pan; and
7. All duct vent caps (including exterior facing duct vent caps with a bug screen and rain/snow shield) shall have a minimum *NFA* equal to 110 percent of the cross-sectional area of the unducted HPWH outlet port; and
8. Outlet ducts shall terminate at a point within 4 inches of the top of the *HPWH* installation space.

500.3.3.7.3.3.1: Installations with both the inlet and outlet ducted.

For installations where both the inlet and outlet are ducted, airflow from the termination points shall be diverted away from each other and be separated by a minimum of 24 inches.

500.3.3.7.3.3.2: Installations with only the outlet ducted.

For installations where only the outlet ducted a permanent opening shall be used to provide makeup air. In addition, either requirement one or two below shall apply:

1. Where only the *HPWH* outlet is ducted to a communicating space, the *HPWH* installation space shall be within the conditioned space *pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a *door* undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.
2. Where only the HPWH outlet is ducted to outside, the *HPWH* installation space shall be in the unconditioned space outside of the building *pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a door undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.

7.4 Reference Appendices

There are no proposed changes to the Reference Appendices.

7.5 Compliance Manuals

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

7.6 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

7.7 Compliance Forms

As discussed in Section 2.4.5, there are proposed changes to NRCC-PLB-E Table F element 22 which lists HPWH ventilation options. This element should be updated with new ventilation options proposed for the 2028 code to reflect updates to section Subsection 500.3.3.7 [Section 110.3(c)7]. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

There are proposed changes to the NRCI-PLB-E compliance form see below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

A ventilation method meeting one of the following:

- The designated space for the future heat pump water heater shall have a minimum volume of 700 cubic feet; or
- The designated space for the future heat pump water heater shall vent to a communicating space in the same pressure boundary via an 8 inch diameter exhaust duct and a permanent opening~~s~~ with a minimum NFA of ~~250~~125 square inches~~.~~, so that the total combined volume connected via permanent openings is 700 cubic feet or larger. The permanent openings shall be:
    - A ~~Fully~~ louvered door~~s~~ with fixed louvers; or
    - A ~~Two permanent~~ fixed opening~~s~~ located within 12 inches from the enclosure ~~top and~~ bottom
- The designated space for the future heat pump water heater shall include two 8 inche~~s~~ diameter capped ducts, venting to the building exterior:
    - All ducts, connections, and building penetrations shall be sealed
    - Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to a minimum level of R-6.
    - Airflow from termination points shall be diverted away from each other

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Appendix A: Technical Summary of HPWH Ventilation Effects on Performance

This section summarizes of the Larson and Larson, Heat Pump Water Heaters in Small Spaces Lab Testing: "The Amazing Shrinking Room" study funded by the Northwest Energy Efficiency Alliance (NEEA) in 2022, with key findings related to the CASE Report highlighted here. Please refer to the full report for more details. This section was added to provide a summary of key content referenced within the body of the CASE Report, without having to provide the details in the body.

The goal of the “The Amazing Shrinking Room” lab evaluation was to quantify how HPWH efficiency changes in different sized rooms and how different ventilation configurations impact efficiency.

A photo of the basic room configuration is shown here:

Figure 5. Shrinking room HPWH location (left) and overall 960 cubic foot room within the lab space (right).

The test setup included a freestanding room with adjustable size through removable walls to evaluate HPWH performance when operating in room sizes of 83.5, 200, 453, 707, and 960 cubic feet. These different room sizes were chosen to represent common HPWH installation spaces, ranging from a small closet to basement or mechanical room. Fourteen different ventilation configurations (identified as “interventions” in the report) were implemented to determine HPWH performance in the 83.5 cubic foot room and one ventilation configuration in a 200 cubic foot room; see Figure 6. The freestanding room was located inside a lab space with an average temperature of 67.2°F , although there were small variations during the tests.

Ventilation configurations evaluated are as follows:

- Duct-SmMakeup-Full: Straight 8-inch diameter exhaust duct and a floor slot representative of a door undercut with an NFA of 18 square inches.
- Duct-LgMakeup-Full: Straight 8-inch diameter exhaust duct and wall grille in the upper part of the wall with an NFA of 130 square inches.
- Duct-LgMakeup-Half: Straight 8-inch diameter exhaust duct that is 50 percent blocked off and wall grille in the upper part of the wall with an NFA of 130 square inches.
- DirectedExhaust: HPWH exhaust rotated to face an upper louver panel on the door with an NFA of 129 square inches and a floor slot representative of a door undercut with an NFA of 18 square inches.
- Shelf: Upper door holes covered with a wire mesh with an NFA of 25 square inches, a shelf that separates the upper section of the room with the HPWH intake from the exhaust section of the HPWH where lower door holes covered with a wire mesh with an NFA of 25 square inches.
- Louvers-Full: A fully louvered door with an NFA of 218 square inches.
- Louvers-Half: Half of the width of the fully louvered door for an NFA of 109 square inches.
- Doorstop: 1-1/2 inch gap between the door and the door jamb for an NFA of 114 square inches.
- Grille-Upper: A single upper wall grille with an NFA of 130 square inches.
- Grille–Lower: A single lower wall grille with an NFA of 130 square inches.
- Grilles-Both: An upper wall grille with an NFA of 130 square inches and the same size lower wall grille.
- Grilles-Both(200): An upper wall grille with an NFA of 130 square inches and the same size lower wall grille in a 200 cubic foot room instead of the 83.5 cubic foot room used for the other tests.
- VentCaps-HighNFA: Upper door holes covered with wire mesh with an NFA of 25 square inches and the same size lower door holes with wire mesh.
- VentCaps-LowNFA: Upper door holes covered with plastic vent caps with an NFA of 11 square inches and the same size lower door holes of the same size covered with plastic vent caps.
- DownElbow: 90 degree elbow on the exhaust of the HPWH to direct cold air to the bottom of the small closet.

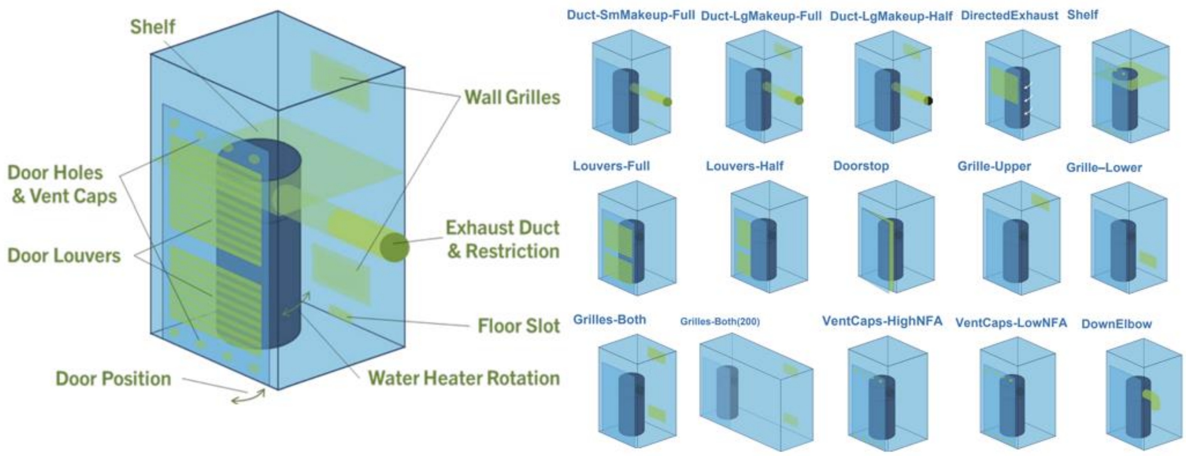

Figure 6: HPWH ventilation test configurations where green surfaces indicate ventilation locations.

Data collected during this lab testing included air temperatures, water temperature, and flow sensors, HPWH condenser coil airflow rate and electrical energy used by the HPWH.

The test configurations most relevant to this 2028 CASE Report include:

- Grilles–Both: This ventilation configuration is representative of a HPWH installed in a conditioned small room that uses airflow from a communicating space via a grille low on the wall and exhausts air through a grille high on the wall. This is the most efficient ventilation approach that uses grilles.
- Grille–Lower: This ventilation configuration is representative of a HPWH installed as a retrofit for a gas water heater in a small room that uses airflow from outside or a communicating space via a grille low on the wall.
- Duct-SmMakeup-Full: This ventilation configuration is representative of a HPWH installed in a small room that uses airflow from a communicating space via door undercut for the intake air and an 8-inch diameter duct connected to the same communicating space to keep cold exhaust air out of the small room. This is one of the compliance paths proposed in this 2028 code change proposal.
- Louvers-Full: This ventilation configuration is representative of a HPWH installed in a small room that uses a fully louvered door to exchange air with outside or a communicating space. This is one of the compliance paths in the 2025 energy code, but it is proposed to be removed in the 2028 HPWH ventilation clean-up proposal.
- Duct-LgMakeup-Half: This ventilation configuration is representative of a HPWH installed in a small room that uses airflow from a communicating space via door undercut for the intake air and an 8-inch diameter duct connected to the same

communicating space to keep cold exhaust air out of the small room. In this case the 50 percent blocked duct is meant to represent a long duct, a duct with many bends or a duct that is smaller than is designed for the HPWH which causes extra head pressure and reduced airflow.

The HPWH efficiency testing involved operating the HPWH with an 18 hour water demand profile under both high use (84 gallons total) and medium use (55 gallons total) draw schedule for each of the different sized rooms. All of the HPWH ventilation configuration tests used the medium demand water draw profile. The draw profiles are shown in Figure 7.

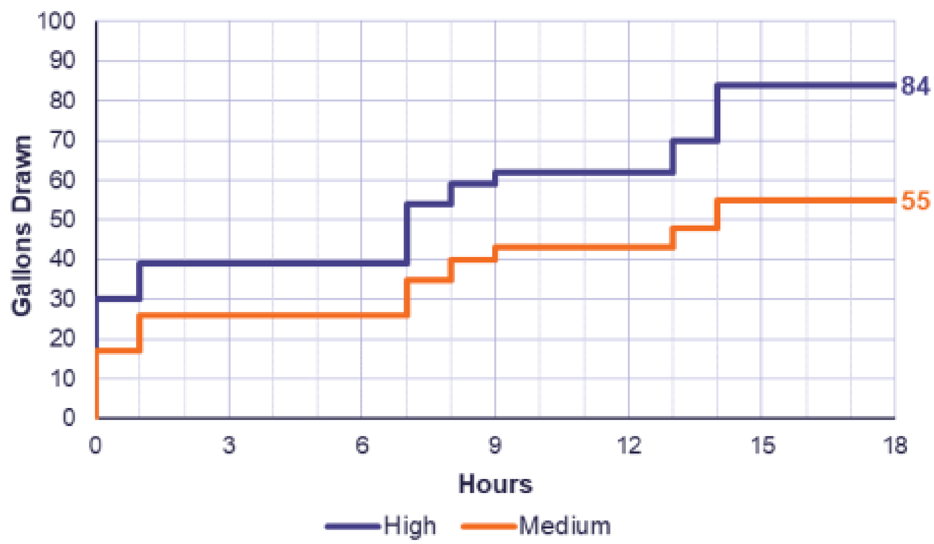

Figure 7: HPWH water draw profiles used during testing.

Key results related to HPWH room size and ventilation configuration include the following:

- HPWH exhaust air is typically ten degrees Fahrenheit cooler than the intake air.
- The size of the room must be larger than 450 to 700 cubic feet depending on the compressor size to prevent the room from being excessively cooled by the HPWH exhaust air. HWPH performance decreases by 6 to 54 percent in these small room cases without proper ventilation.[27] As the room size decreased, the minimum air temperature in the room was 14, 14, 18, 22 and 33°F lower than the average temperature of the lab space surrounding the room for the room sizes of 1000, 700, 450, 200 and 84 cubic feet respectively during the 18 hours of water draws.

[27] These results were based on a 55 gallon water draw per day. Larger water draw days will have a larger penalty for sub optimal ventilation approaches.

- A HPWH installed in a 200 cubic foot room with upper and lower grille (259 square inch NFA) has a one percent higher COP than a HPWH with a floor slot (18 square inch NFA) and an 8-inch-diameter exhaust duct.
- A HPWH installed in an 84 cubic foot room with upper and lower grilles (259 square inch NFA) has a three percent lower COP than a HPWH with a floor slot (18 square inch NFA) and an 8-inch-diameter exhaust duct.
- A HPWH installed in an 84 cubic foot room with a fully louvered door (286 square inch NFA) has a six percent lower COP than a HPWH with a floor slot (18 square inch NFA) and an 8-inch diameter exhaust duct.
- A HPWH installed in an 84 cubic foot room with a grille in the lower part of the wall/door (130 square inch NFA) has a 54 percent lower COP than a HPWH with a floor slot (18 square inch NFA) and an 8-inch diameter exhaust duct.
- A HPWH with an axial fan connected to an 8-inch diameter exhaust duct that is fifty percent blocked while an upper wall grille(130 square inches of NFA) is used for the intake has a 36 percent lower COP than an unrestricted 8-inch exhaust duct while an upper wall grille(130 square inches of NFA) is used for the intake. The 50 percent blocked case is intended to represent airflow restrictions caused by too many bends in the duct, small-diameter ducts, and long duct lengths.
- Table 9 of the report provides a range of $125 to $315 for labor and $235 to $575 for components to install HPWH ducts.

Appendix B: Assumptions for Cost-effectiveness Analysis

This section details the assumptions for the cost-effectiveness evaluation of the proposed HPWH ventilation clean-up measure for nonresidential buildings code measure in the following topics: Key Assumptions for Energy Savings Analysis and Energy Savings Methodology per Prototypical Building.

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.

The energy savings for the HPWH ventilation clean-up measure evaluate the benefits of implementing both intake and exhaust ducts that vent to the outdoors rather than only one duct (intake venting to the outdoors) and of implementing an exhaust duct paired with a makeup air grille instead of a dual grille in a small space. The Climate Zone 12 small office building was used for this analysis. Weather files for all sixteen climate zones were evaluated to identify if there were any climate zones that result in no savings. It is assumed that both new construction and alterations will have the same HPWH performance because the effect that the building envelope change will have on the HPWH will be insignificant.

HPWH storage capacities were selected by running CBECC simulations with the minimally compliant small office building in Climate Zone 12 for HPWHs rated with a 380-watt compressor, UEF of 3.62 and storage tank size of 40, 50, 65 or 80 gallons with first hour ratings of 58, 63, 77 and 87 gallons, respectively. These sizes and ratings were gathered from the consumer integrated HPWHs listed on the EnergyStar database and MAEDbS database.[28] The CBECC models were run with each HPWH size until a large enough HPWH tank size was chosen to provide enough hot water for the demand in that building. Then, the model with the HPWH operating with zone air temperature for the HPWH air intake and exhaust back into the zone was exported and edited in EnergyPlus to include outdoor air temperatures for the HPWH intake and an exhaust to outside.

Four standard designs were used, two have one HPWH ventilation duct and two have ventilation grilles.

For the two standard designs with one HPWH ventilation duct, the first has an intake ventilation duct to the outdoors and an exhaust duct, while the second standard design

[28] https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx

has one exhaust ventilation duct to the outdoors and an intake inside the building without a duct. The corresponding exhaust and intake ventilation without a duct connect to the installation space's air conditions. The proposed design was the same model without airflow crossing the pressure boundary by using either a dual-ducted HPWH with ducts connecting to the outdoors or a HPWH with dual ducts connecting to a communicating space within the building. A HPWH with both intake and exhaust ducts connected to the outdoors results in negligible room air temperature during operation, because no outdoor air directly enters the room; it only enters through the ventilation ducts.

For the two standard designs with ventilation grilles, the first has grilles that connect to the outdoors, while the second standard design has grilles that connect to a communicating space indoors. The proposed design was the same model, but with an exhaust duct connected to outdoors and a makeup air grille for intake air connected to outdoors or an exhaust duct connected to a communicating space within the building and a makeup air grille for intake air connected to a communicating space within the building. The HPWHs connected to outdoor air are located outside the conditioned space, so there is no conditioned load impact. The HPWHs connected to a communicating space indoors are located within the conditioned space, but it is assumed there is no impact on the conditioned load.

The standard design with a single intake duct connecting to the outdoors is based on the dual duct HPWH building model with the addition of a heat transfer calculation to quantify heating and cooling energy needed to account for the airflow into the building through the exhaust of the HPWH. A 10°F temperature drop across the HPWH condenser was assumed, so air entering the building is 10°F lower than the outdoor air temperature when the compressor is running and that same mass of air leaves the building at the zone air temperature. The HPWH compressor does not operate below the 37°F intake cutoff temperature. This airflow occurred only when the HPWH consumed a power value greater than zero (i.e., it followed the HPWH schedule) in the model, which equated to approximately 44 CFM on average per 24-hour day. The models were run with HPWH intake temperatures equal to the hourly value from the 2029 weather data files for each climate zone to determine HPWH energy consumption during one full year of operation to quantify the negative effect on space temperature which resulted in more heating load in the building in the standard design with a single duct connected to outside than the proposed design with dual ducts to outside.

Opposite the single intake duct standard design, the single exhaust duct standard design is based on the unducted HPWH building model with the addition of a heat transfer calculation to quantify heating and cooling energy needed to account for the airflow entering the building and leaving the building through the exhaust of the HPWH.

It was assumed that outdoor air is pulled into the building at the outdoor air temperature, and the same mass of air at the zone temperature is exhausted to the outdoors.

The standard design with grilles that connect the to the outdoors is based on the dual duct HPWH building model with additional energy consumption calculated by multiplying the electrical energy consumption by a factor between 0.98 and 1.13 depending on the climate zone to account for difference in COP efficiency lost when using two grilles when compared to an exhaust duct with a makeup air grille of the HPWH intake air for each climate zone for exterior closets. This assumption is based on a lab evaluation of three different HPWHs tested in an 84 cubic foot room two grilles that each have 130 square inches of NFA compared to an exhaust duct and an 18 square inch NFA makeup air grille for intake air (Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023). The factor between 0.98 and 1.13 scales the power consumption of the HPWH only when the compressor is running.

This airflow occurred only when the HPWH consumed a power value greater than zero (i.e., it followed the HPWH schedule) during one full year of operation to quantify the negative effect of intake and exhaust air mixing in a small closet with two grilles relative to the proposed design with a single exhaust duct and a grille for intake makeup air.

Opposite the HPWH analysis with grilles that connect to the outdoors, the standard design with grilles that connect to a communicating space indoors is based on the unducted HPWH building model with additional energy consumption calculated by multiplying the electrical energy consumption by a factor of 1.01 to account for efficiency lost when using two grilles. This assumption is based on a lab evaluation of three different HPWHs tested in an 84 cubic foot room and a 200 cubic foot room with two grilles that each have 130 square inches of NFA compared to an exhaust duct and an 18 square inch NFA makeup air grille for intake air (Larson, Larson and Gantley, Code Readiness: Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Conditioning 2023). The factor of 1.01[29] scales power consumption of the HPWH only when the compressor is running. This airflow occurred only when the HPWH consumed a power value greater than zero (i.e., it followed the HPWH schedule) during one full year of operation to quantify the negative effect of intake and exhaust air mixing in a small closet with two grilles relative to the proposed design with a single exhaust duct and a grille for intake makeup air.

[29] Based on the average difference in performance between the 84 cubic foot room with two grilles relative to the exhaust duct and an 18 square inch NFA makeup air grille, and the performance between the 200 cubic foot room with two grilles relative to the exhaust duct and an 18 square inch NFA makeup air grille.

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 47 presents the prototype buildings with a single duct connected to outdoors for the standard design used in the analysis. Table 47 presents the prototype buildings with a dual grille connected to outdoors or to indoors for the standard design used in the analysis.

Table 47: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis - Single Duct Standard Design Connected to Outdoors

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Standard Design – Small Office – Exhaust Duct	1	5,500	The small office prototype is the same as the proposed design with an intake and exhaust duct connected to a communicating space, except a heat transfer calculation was then used to quantify heating and cooling energy needed to account for the airflow into the building at the outdoor conditions that is mixed with the indoor air and later exits the building through the HPWH exhaust.
Standard Design – Quick Service Restaurant – Exhaust Duct	1	2,500	Energy savings are based on the small office building model listed above.
Standard Design – Small Office – Intake Duct	1	5,500	This protype is the same as the small office proposed design with an intake and exhaust duct connected to the outdoors, except a heat transfer calculation was then used to quantify heating and cooling energy needed to account for the airflow into the building at 10°F lower than the outdoor air temperature after it passes through the HPWH evaporative coil and air exiting the building at the zone air temperature.
Standard Design – Quick Service Restaurant – Intake Duct	1	2,500	Energy savings are based on the small office building model listed above.
Proposed Design – Small Office – Intake and Exhaust Duct	1	5,500	This protype is the same as the small office proposed design with an intake and exhaust duct to communicating space, but this model was exported and edited in EnergyPlus to include an intake node that matches the outside air conditions, and the exhaust is expelled outdoors also.
Proposed Design – Quick Service Restaurant – Intake and Exhaust Duct	1	2,500	Energy savings are based on the small office building model listed above.

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Proposed Design – Small Office – Intake and Exhaust Duct to Communicating Space	1	5,500	This protype is the same as the small office CBECC model with minimally compliant systems. The water heater was modified to include a 50 gallon integrated HPWH located inside the smallest building zone where the intake and the exhaust for the HPWH use the zone air conditions. It was assumed that duct heat transfer losses would be negligeable in this case.
Proposed Design – Quick Service Restaurant – Intake and Exhaust Duct to Communicating Space	1	2,500	Energy savings are based on the small office building model listed above.

Table 48: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis – Dual Grille Standard Design

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Standard Design – Small Office – Dual Grilles Connected to the Outdoors	1	5,500	The small office prototype is the same as the proposed design with an intake and exhaust duct connected to outdoors, except a scalar is used to increase the power consumption of the HPWH as a result of a lower average COP than an exhaust duct and a makeup air grille connected to outdoors.
Standard Design – Quick Service Restaurant – Dual Grilles Connected to the Outdoors	1	2,500	Energy savings are based on the small office building model listed above.
Standard Design – Small Office – Dual Grilles Connected to a Communicating Space Indoors	1	5,500	The small office prototype is the same as the proposed design with an intake and exhaust duct connected to a communication space, except a scalar is used to increase the power consumption of the HPWH as a result of a lower average COP than an exhaust duct and a makeup air grille connected to a communicating space.
Standard Design – Quick Service Restaurant – Dual Grilles Connected to a Communicating Space Indoors	1	2,500	Energy savings are based on the small office building model listed above.
Proposed Design – Small Office – Exhaust Duct to Outside and Grille for Makeup Air to Outside	1	5,500	This protype is the same as the small office proposed design with an intake and exhaust duct to outside.
Proposed Design – Quick Service Restaurant – Exhaust Duct to Outside and Grille for Makeup Air to Outside	1	2,500	Energy savings are based on the small office building model listed above.
Proposed Design – Small Office – Exhaust Duct to Communicating	1	5,500	This protype is the same as the small office proposed design with an intake and exhaust duct to a communicating space.

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Space and Grille for Makeup Air to Communicating Space			
Proposed Design – Quick Service Restaurant – Exhaust Duct to Communicating Space and Grille for Makeup Air to Communicating Space	1	2,500	Energy savings are based on the small office building model listed above.

There is an existing Title 24, Part 6 requirement that covers the HPWH vented with only one duct connected to the outdoors and applies to both new construction/additions and alterations, so the Standard Design is a minimally compliant building with the 2025 Title 24 requirements and a HPWH with an intake duct that connects to the outdoors, but an exhaust duct that delivers air into the room. The HPWH compressor power rating, tank size, and UEF rating were also specified.

The Proposed Design was identical to the Standard Design in all respects except for the revisions that reflect the proposed changes to the code. Table 49 presents the parameters modified and the values used in the Standard Design and Proposed Design. Specifically, the proposed conditions assume that there is no airflow entering the building from outside; it is contained within the ducting to the HPWH because this is a balanced ventilation system.

Table 49: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change - Single Duct Standard Design Connected to Outdoors

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Standard Design – Small Office – Intake Duct	All	Airflow into HPWH room	$M_{OutdoorAir}$	40 CFM	40 CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Standard Design – Quick Service Restaurant – Intake Duct	All	Airflow into HPWH room	$M_{OutdoorAir}$	40CFM	40CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Standard Design – Small Office – Exhaust Duct	All	Airflow into HPWH room	$M_{OutdoorAir}$	-40 CFM	-40 CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}
Standard Design – Quick Service Restaurant – Exhaust Duct	All	Airflow into HPWH room	$M_{OutdoorAir}$	-40 CFM	-40 CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}
Proposed Design – Small Office – Intake and Exhaust Ducts	All	Airflow into HPWH room	$M_{OutdoorAir}$	40CFM	0CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Proposed Design – Quick Service Restaurant – Intake and Exhaust Ducts	All	Airflow into HPWH room	$M_{OutdoorAir}$	40CFM	0CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Proposed Design – Small Office – Intake and Exhaust Duct to Communicating Space	All	Airflow into HPWH room	$M_{OutdoorAir}$	40CFM	0CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}
Proposed Design – Quick Service Restaurant – Intake and Exhaust Duct to Communicating Space	All	Airflow into HPWH room	$M_{OutdoorAir}$	40CFM	0CFM
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}

Table 50: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change – Dual Grille Standard Design

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Standard Design – Small Office – Dual Grilles Connected to the Outdoors Standard Design –	All	Energy Weight Factor	K_{COP}	0.98 to 1.13	0.98 to 1.13
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Standard Design – Small Office – Dual Grilles Connected to a Communicating Space Indoors	All	Energy Weight Factor	K_{COP}	1.01	1.01
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Proposed Design – Quick Service Restaurant – Exhaust Duct to Outside and Grille for Makeup Air to Outside	All	Energy Weight Factor	K_{COP}	0.98 to 1.13	0.98 to 1.13
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Proposed Design – Quick Service Restaurant – Exhaust Duct to Communicating Space	All	Energy Weight Factor	K_{COP}	1.01	1.01
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Outside Air Temp}	{Outside Air Temp}
Proposed Design – Small Office – Exhaust Duct to Outside and Grille for Makeup Air to Outside	All	Energy Weight Factor	K_{COP}	0.98 to 1.13	1
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}
Proposed Design – Small Office – Exhaust Duct to Communicating Space	All	Energy Weight Factor	K_{COP}	1.01	1
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}
Proposed Design – Quick Service Restaurant – Exhaust Duct to Outside and Grille for Makeup Air to Outside	All	Energy Weight Factor	K_{COP}	0.98 to 1.13	1
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
Proposed Design – Quick Service Restaurant – Exhaust Duct to Communicating Space	All	Energy Weight Factor	K_{COP}	1.01	1
	All	HPWH intake air Temp.	$T_{IntakeAir}$	{Zone Air Temp}	{Zone Air Temp}

The energy impacts of the proposed code change do vary by climate zone. The Statewide CASE Team simulated the energy impacts in Climate Zone 12 then ran this mode with weather files from all 16 climate zones and applied the climate-zone-specific LSC hourly factors when calculating energy and LSC impacts.

Appendix C: 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 Section 7 of this report for marked-up code language.

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

The purpose and necessity of changes to Title 24, Part 6 include the following:

Section: 110.3(c)7B

Purpose: The purpose of this change is to simplify the four existing compliance pathways implemented in the 2025 code to make unitary HPWH installation decision making simpler, as well as improving consumer-sized HPWH performance in nonresidential buildings.

Under the 2025 code, allowed methods of providing ventilation air included those approved by the manufacturer, installing the unit in a large unvented room of minimum size, installing in a closet with minimum ventilation area to adjacent spaces, and directly ducting the unit. The Statewide CASE Team recommends improvements to this code language for clarity and adjustments to requirements to reflect new research and better align with other codes in development. This proposal also recommends eliminating two ducting configurations from the 2025 code: inlet air ducted from outside with no exhaust duct and exhaust air ducted to outside with no inlet duct and remove the option to use wall/door louvers to connect to a communicating space.

Necessity: The necessity for this change is to remove the possibility for ingress of moisture, airborne particulates, gases, and bacteria among other health and safety concerns caused by intake ducts connected to outdoor vents and increased space conditioning load impacts when only one duct is used or condensation on nearby surfaces when a HPWH is in a small room and relying on a louvered wall/door to exchange exhaust air with a connecting space. In addition, the acceptance of HPWHs will increase because of proper HPWH ventilation.

Purpose and Necessity of Changes to the Reference Appendices

There are no proposed changes to reference appendices.

Appendix D: Assumptions for Statewide Savings Estimates

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 take the current market share rate into account. The Statewide CASE Team estimated that there is a negligible percent of current market share for the proposed code change for the new construction market and for the retrofit market. The current market share rate was estimated based on interviews with researchers and installers. Retrofit market adoption is expected to reach eighty percent of retrofit installations due to small business owners installing HPWHs themselves or installations taking place without knowledge of the updated code language based on Statewide CASE Team's professional judgment.

Table 51 presents the projected nonresidential new construction that the proposed code change will impact in 2028. Table 52 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2028. The Statewide CASE Team developed these estimates using the methods described in this section.

The Statewide CASE Team estimated the percentage of newly constructed floor space that the proposed code change would impact. Table 53 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 floor space 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 54, Table 55, Table 56, Table 57 and Table 58 represent the assumed percentage of affected floorspace defined in Table 53 by climate zone for each proposed ducting configuration.

Table 51: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2028, by Climate Zone and Building Type (Million Square Feet)

Climate Zone	Small Office	Restaurant	Total
1	0.05	0.01	0.06
2	0.15	0.08	0.23
3	0.3	0.31	0.61
4	0.05	0.16	0.21
5	0.11	0.03	0.14

Climate Zone	Small Office	Restaurant	Total
6	0.22	0.34	0.56
7	0.03	0.21	0.24
8	0.29	0.51	0.8
9	0.64	0.82	1.46
10	0.19	0.49	0.68
11	0.09	0.08	0.17
12	0.38	0.34	0.72
13	0.33	0.15	0.48
14	0.09	0.11	0.2
15	0.05	0.05	0.1
16	0.04	0.03	0.07
Total	**3.02**	**3.74**	**6.76**

Table 52: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2028 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Climate Zone	Small Office	Restaurant	Total
1	4.46	0.61	5.07
2	12.41	3.65	16.06
3	19.56	14.59	34.15
4	9.02	7.42	16.44
5	7.02	1.52	8.54
6	13.19	17	30.19
7	8.45	10.74	19.19
8	13.18	24.6	37.78
9	22.07	39.73	61.8
10	24.63	33.66	58.29
11	10.64	3.6	14.24
12	40.87	17.27	58.14
13	22.73	7.88	30.61
14	5.58	7.08	12.66
15	7.39	3.58	10.97
16	2.95	1.95	4.9
Total	**224.14**	**194.88**	**419.02**

Table 53: 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)
Small Office	5	<1
Restaurant	<1	<1

Table 54: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Single Intake Duct vs Dual Ducts

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

Table 55: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Dual Grilles to Outdoors vs. Exhaust Duct with Intake Grille to Outdoors

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

Table 56: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Dual Grilles to Indoor Communicating Space vs. Exhaust Duct with Intake Grille to Communicating Space

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	44	44
2	44	44
3	44	44
4	44	44
5	44	44
6	44	44
7	44	44
8	44	44
9	44	44
10	44	44
11	44	44
12	44	44
13	44	44
14	44	44
15	44	44
16	44	44

Table 57: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Single Exhaust Ducts to Outside vs. Dual Ducts

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

Table 58: Percentage of Nonresidential Floorspace Impacted by Proposed Measure, by Climate Zone – Single Exhaust Ducts to Outside vs. Dual Ducts to Communicating Space

Climate Zone	New Construction Impacted (Percent Square Footage)	Existing Building Stock (Alterations) Impacted (Percent Square Footage)
1	22	22
2	22	22
3	22	22
4	22	22
5	22	22
6	22	22
7	22	22
8	22	22
9	22	22
10	22	22
11	22	22
12	22	22
13	22	22
14	22	22
15	22	22
16	22	22

Appendix E: Environmental Analysis

This section discusses the California Environmental Quality Act (CEQA)'s requirements for a proposal's potential environmental impacts for the proposed measure with the following topics:

- Potential Significant Environmental Effect of Proposal
- Direct Environmental Impacts (Benefits and Adverse Impacts)
- Indirect Environmental Impacts (Benefits and Adverse Impacts)
- Mitigation Measures
- Reasonable Alternatives to Proposal
- Water Use and Water Quality Impacts Methodology

Each topic is detailed below.

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

The proposed measure has direct environmental benefits and minor adverse environmental impacts.

Direct Environmental Benefits

Direct benefits associated with this measure include energy savings, and GHG emission reductions as a result of requiring both intake and exhaust ventilation ducts to terminate outdoors rather than one intake duct terminating outdoors or using an exhaust duct instead of a second ventilation grille for HPWH exhaust air because this increases HPWH efficiency and decreases heating and cooling energy by limiting pressure imbalance (outdoor air ingress into the building) in the building.

Direct Adverse Environmental Impacts

Direct adverse environmental impacts associated with this measure are GHG emission increases due to the manufacturing of additional components necessary to implement a second ventilation duct for the HPWH. The additional components necessary for this installation include a second ventilation duct, boot, hanger straps, exterior vent, adhesive to provide an air/water seal between the exterior vent and the exterior wall, coupler to connect the vent to the HPWH intake/exhaust port and band clamps or tap to secure the ventilation ducts to each component while limiting air leakage. Potential mitigation measures are provided below in the section titled “Mitigation Measures.”

Indirect Environmental Impacts

The proposed measure has indirect environmental benefits, but no minor indirect adverse environmental impacts.

Indirect Environmental Benefits

Indirect environmental benefits associated with this measure include reduced manufacturing of drywall and paint products resulting from mitigating HPWH room moisture damage through proper HPWH ventilation to the outdoors. This would impact the need for drywall replacement and repainting.

Indirect Adverse Environmental Impacts

Indirect adverse environmental impacts associated with this measure include reduced manufacturing of HPWH ventilation ducts, insulation, ventilation duct hanger straps, wall caps, ventilation tape, and other connecting components such as zip ties and band clamps needed to implement a HPWH ventilation duct.

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

Alternatives to the proposed code change to require both intake and exhaust ducts when ventilating HPWH to the outdoors instead of allowing one duct (intake) to the outdoors or using an exhaust duct paired with a wall/door ventilation grille instead of two wall/door ventilation grilles include: (1) disallowing an intake ventilation duct that connects the HPWH to the outdoors and (2) disallowing dual duct HPWH ventilation configurations altogether. The benefits and adverse impacts of these alternatives to the proposal are detailed below.

Alternate option 1: Disallowing HPWH intake ducts to the outdoors would have the benefit of reducing the manufacture of ducting components because installers would instead use a grille to a communicating indoor space if the HPWH was installed in a conditioned space or use a grille for to the outdoors if the HPWH was installed in an unconditioned space. One adverse effect of this alternative is that HPWHs operating with indoor air instead of outdoor air in hot climates year-round will use more energy.

Alternate option 2: Disallowing dual duct installations would have the benefits and adverse impacts of alternate option 1; however not all wall/door louver ventilation systems for HPWHs are cost-effective for small rooms due to custom sizes or construction types. A second duct may be more cost-effective.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

Appendix F: 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 Final CASE Report that reflects broad support. Public stakeholders provide valuable feedback on 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 section summarizes the stakeholder engagement conducted by the Statewide CASE Team during the development and refinement of the report's recommendations.

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 results of analysis
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted one stakeholder meeting for the Nonresidential HPWH ventilation clean-up via webinar, as described in Table 59. 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 59: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of Stakeholder Meeting 4: Covered Processes, NR Envelope, NR Water Heating Utility-Sponsored Stakeholder Meeting	Thursday, October 23, 2025	• **Purpose**: Update mandatory HPWH ventilation code language for nonresidential buildings to reflect new research and better align with other codes in development. This measure also recommends eliminating two ducting configurations from the 2025 code: inlet air ducted from outside with no exhaust duct and exhaust ducted to outside with no inlet duct. • **Proposed code change** • **Benefits**: Simplify the HPWH ventilation decision-making process, reduce building energy consumption, prevent IAQ issues, reduce moisture damage risk potential, and alleviate health and safety concerns. • **Applicable code section** • **Current market conditions** • **Market barriers and solutions** • **Feedback requested**: What percentage of new construction small office buildings and quick service restaurants are implementing HPWHs with ventilation ducts? What percentage of retrofit small office buildings and quick service restaurants are implementing HPWHs with ventilation ducts? Are HPWHs with either an intake or an exhaust duct installed more frequently in one of the buildings? • **Technical considerations** • **Modeling assumptions** - standard design and proposed design • **Compliance verification** • **Compliance barriers and solutions**

The first round of utility-sponsored stakeholder meetings began in October 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.

During the Nonresidential Water Heating, HVAC, Utility-Sponsored Stakeholder Meeting on October 23rd, 2025, three survey questions were asked to quantify the prevalence of HPWHs with either an intake duct or an exhaust duct in small office and quick service restaurant buildings for new construction and alterations and separately for retrofits. The third question asked whether these installations were more common in small office buildings or quick service restaurants. Notes and survey responses from this stakeholder meeting are available in the meeting notes for [Nonresidential Water Heating, HVAC, Utility-Sponsored Stakeholder Meeting] on the California Energy Codes and Standards webpage (Statewide CASE Team 2025).

These three questions aimed to quantify the market share of HPWHs with single ducts that would be required to implement dual ducts if their project occurred in 2028. Three responses were collected for the question about new construction and alterations. The average percent implementation was 8 percent, with a range of 0.1 percent to 25 percent of buildings estimated to have implemented HPWHs with a single duct annually. The retrofit install base provided a lower average from four responses. The average percentage of retrofits was 2.4 percent, with a range of 0.1 to 5 percent. Lastly, five stakeholders answered the question about what building type has more HPWH installations with single ducts. The average was two times more installations in quick service restaurants than small offices, with a range of ten times more in small offices than quick service restaurants and ten times more in quick service restaurants than small offices.

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 a 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 beyond 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 60.

Table 60: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
CEC	Codes and Standards	1.3
NORESCO	Code Compliance	1.2, 3.1, 3.3, 3.4, 5.1
Gary Klein, Gary Klein & Associates	HPWH Subject Matter Expert	2.2, 4.2.2, 6.6
SDG&E	Utility	Summarized in 1.3
PG&E	Utility	Aided in gathering survey responses
Kyle Neuhaus-Bergeron, A.O. Smith	Manufacturer	Feedback on proposed code language
Michael Corbet, Bradford White	Manufacturer	Feedback on proposed code language
Rheem	Manufacturer	Product information
Rinnai	Manufacturer	Product information
Gary Klein, Gary Klein & Associates	HPWH Subject Matter Expert	2.2, 4.2.2, 6.6
Ben Larson, Larson Energy Research	HPWH Subject Matter Expert	Provided guidance on guidance on code language in section 7.3
Maya Gantley, 2050 Partners	HPWH Subject Matter Expert	Provided guidance on section 6.1
Harry Clark Plumbing, Heating & Air	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1.
All State Plumbing Company	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
Alpha & Omega Plumbing & Drain Cleaning	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
Shoreway Plumbing	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
Rick's Plumbing	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
NorCal Water Heaters	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
AccuFlow Plumbing	Plumber/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1
Sierra Valley Mechanical	HVAC Designer/Installer	Summarized in 1.3 and assumptions in 5.1, 5.2 and 6.1

Engagement with ESJ communities

The Statewide CASE Team conducted phone outreach to plumbing contractors working in or near ESJ communities. The purpose was to gather installer feedback on whether the added first cost of the proposed HPWH ventilation clean-up measure could be a barrier to adoption in these markets. In the limited subset of cases where a second duct would be required, that added first cost is estimated at approximately $600.

Contractors were identified from publicly listed plumbing firms serving areas that overlap with CalEnviroScreen 4.0 high-score census tracts and Senate Bill 535 Disadvantaged Communities. Outreach targeted installers rather than building owners or residents because installers frame the upfront cost conversation with customers and can speak directly to whether cost changes affect adoption decisions.

The outreach did not include direct engagement with building owners, tenants, or community-based organizations in disadvantaged communities. Input from these groups is welcomed during public review.

The Statewide CASE Team made ten phone calls to HPWH installers in these communities. Three installers completed interviews. The remaining seven either did not respond to outreach or declined to participate. Interviews covered installation frequency, common reasons customers decline HPWHs, how often installations include any venting, direct experience with moisture issues, and reaction to a hypothetical $600 increase in first cost for adding a second duct. Respondents were also given the Statewide CASE Team’s modeled context of approximately $1,200 in avoided energy impacts over ten years from preventing improper single-duct installations.

All three respondents indicated that ducted HPWH installations are uncommon in their own work. One respondent primarily installs HPWHs in closets with existing louvers or sufficient room volume and has not done a ducted installation. Another respondent rarely installs HPWHs but said the work is mostly commercial when they do, with ducts rarely included. None of the respondents reported direct experience with moisture damage tied to HPWH ventilation.

Two of the three respondents said the added $600 cost would likely cause some customers to reconsider or decline HPWH installation. One of these respondents noted that customers in their service area are highly price-sensitive and typically want near-term savings or rebates to justify higher upfront costs. The other described customer resistance as scaling with out-of-pocket cost. When rebates covered most of the cost, HPWH projects moved quickly. As out-of-pocket costs grow, customers with working gas water heaters start declining the work, and as out-of-pocket costs approach or exceed the cost of a gas replacement, concerns about HPWH performance and electricity costs become more prominent in the customer’s decision. The third respondent said the added cost would not materially change adoption and that the installer would explain the cost and its code basis to the customer as part of the standard scope discussion.

The ten-year payback context did not shift any respondent's position. One respondent explained that long-term payback alone is not sufficient to persuade cost-sensitive customers and that immediate rebates or incentives would have more influence. Another respondent noted that improper ducting was not an issue they had previously encountered and said ducting a water heater is straightforward from a design standpoint. The third respondent maintained their earlier position that the added cost would not materially change customer decisions. All three respondents gave permission for their input to be cited as installer feedback.

Three interviews is a small sample, and the outreach only reached installers. Customers in disadvantaged communities were not contacted directly. The findings reflect the installers' perspective on how customers in these areas respond to cost, not a direct measure of customer response.

Online Survey of Program Directors and Plumbers

The Statewide CASE Team developed a survey to help inform the proposed measures. A summary of key survey results is provided below:

- Three individuals respondent anonymously including two program directors and one plumber.
- These respondents indicated that HPWHs water heaters are typically being installed indoors. Zero to ten percent of HPWHs are being installed in outdoor enclosures or outdoor closets and less than five percent are being installed on roofs and unconditioned interior spaces.
- HPWHs are typically installed without ducts.
- Installing HPWHs with ducts in new construction is almost always feasible, but retrofits are only sometimes feasible.
- The percentage of HPWHs currently being installed in rooms less than 700 square feet varies significantly from installer to installer. Some installers report that five to ten percent of HPWHs are being installed in small rooms while others indicated that more than 75 percent of HPWHs are being installed in small rooms.

Phone Survey of Installers for HPWH Ventilation Duct Installation Time

The Statewide CASE Team made 35 phone calls to survey plumbers that install HPWHs. Contacts were gathered based on HPWH manufacturer registered installers and the TECH program. Plumbers were asked to quantify the amount of time it takes them to install a HPWH duct including all of the steps outlined in Section 5.3. A summary of the responses is provided in Table 61

Table 61: Number of Hours Required to Install a HPWH Ventilation Duct

Respondent	Market Role	Average Time to Install the First HPWH Duct (hrs)	Average Time to Install the Second HPWH Duct (hrs)
1	Installer	3	3
2	Installer	2	2
3	Installer	2	2
4	Installer	2	1
5	Installer	1	1
6	Installer	2	1
7	Installer	1.5	1.5
8	Installer	1.5	1.5
Average	**---**	**1.9**	**1.6**

The total estimated cost of installing a single HPWH duct is $233 and $202 for a second duct based on an hour rate of $124 per hour for a plumber.

Online Survey of Interested Professionals for HPWH Ventilation Clean-Up Measure

The Statewide CASE Team surveyed industry experts. Respondents addressed several HPWH ventilation measure specific questions including the following:

1. Of the projects you have worked on over the past 12 months, approximately how many have included a water heater installation in a nonresidential building?

- ☐ None
- ☐ 1 – 10 projects
- ☐ 11 – 20 projects
- ☐ 21 – 50 projects
- ☐ More than 50 projects

2. Of your nonresidential projects with water heater installations in the past 12 months, what portion installed a consumer integrated heat pump water heater (HPWH) where the water storage tank, heat pump, compressor, and fan are all part of one unit?

- ☐ 0% (None)
- ☐ Other percentage (please enter a number between 1 and 100): ________
- ☐ Don’t know

3. Of the nonresidential HPWH projects you have worked on in the past 12 months, what percentage of HPWHs were installed in small spaces **(less than 700 cubic feet – e.g., 9’x9’x8’)**?

- ☐ 0% (None)
- ☐ Other percentage (please enter a number between 1 and 100): ______
- ☐ Don’t know

Consumer Heat Pump Water Heaters (HPWHs) can be installed with several different ventilation configurations including:

- **No ducts**: The HPWH is installed as-is, without any modifications from the manufacturers box.
- **Intake duct**: A flexible ventilation duct is attached to the intake side of the HPWH compressor to pull air from another location inside or outside the building.
- **Exhaust duct**: A flexible ventilation duct is attached to the exhaust side of the HPWH to push air to another location inside or outside the building.
- **Fully ducted**: Both intake and exhaust ducts are used for ventilation.

4. In the past 12 months, what percentage of your nonresidential HPWH projects located in small spaces **(less than 700 cubic feet)** had the following intake and exhaust configurations? *Please provide a percentage that best applies to each configuration.*

COLUMNS: 0%, Other percentage (please enter a number between 1 and 100, Don’t know)

ROWS:

1. HPWH with **no ducts**
2. HPWH with **either** an intake duct **or** an exhaust duct:
3. HPWH with **both** an intake duct **and** exhaust duct:

Installing a ventilation duct for a Heat Pump Water Heater (HPWH) involves several components and steps, including:

- **Wall Vent:** Connects the room where the HPWH is located to another room or outdoors.
- **Band Clamps or Tape:** Secures the flexible duct to the coupler.

- **Flexible Ventilation Duct:** Facilitates airflow between the HPWH and connected space.
- **Duct Hanger Straps:** Attaches the duct to the ceiling for stability.
- **Coupler:** Connects to the intake or exhaust port on the HPWH.

The installer must cut a hole in the wall of the HPWH room to connect to the outdoors, and both sides of the wall vent must be sealed to prevent air and water leakage. Once sealed, the duct, hanger straps, and coupler are installed to complete the ventilation setup.

5. Imagine you had to install one HPWH duct with an OUTDOOR vent using the configuration and steps described above. What would you estimate is the **incremental labor cost** for installing **<u>this single duct</u>** (including all components listed above) that **connects to the OUTSIDE**? *Please select the cost range that best applies to nonresidential buildings.*

☐ $0

☐ $1-100

☐ $101-200

☐ $201-300

☐ $301-400

☐ $401-500

☐ $501-600

☐ $601-700

☐ $701-800

☐ $801-$900

☐ $901-1000

☐ More than $1000

☐ Don’t know

6. Imagine you had installed one HPWH duct with an OUTDOOR vent using the configuration and steps described above. What would you estimate is the **incremental labor cost** for installing **<u>one ADDITIONAL duct</u>** (including all components listed above) that **connects to the OUTSIDE**? *Please select the cost range that best applies to nonresidential buildings.*

- ☐ $0
- ☐ $1-100
- ☐ $101-200
- ☐ $201-300
- ☐ $301-400
- ☐ $401-500
- ☐ $501-600
- ☐ $601-700
- ☐ $701-800
- ☐ $801-$900
- ☐ $901-1000
- ☐ More than $1000
- ☐ Don’t know

7. Based on your experience with HPWHs, please rate the feasibility of installing both intake and exhaust ducting in nonresidential buildings?

COLUMN: Never feasible, Rarely feasible, Sometimes feasible, Very often feasible, Always feasible, Don't know

ROW:

1. Nonresidential - New Construction

97. Nonresidential - Existing Buildings

8. Please describe the barriers in detail for cases when installing both intake and exhaust ducting in nonresidential buildings is never or rarely feasible.

[OPEN END]

9. Based on your experience, what percentage of buildings experience moisture damage caused by HPWHs with poor ducting? *(Note that this would not include moisture damage due to water leaks.)*

- ☐ 0% (None)
- ☐ Other percentage (please provide a number between 1 and 100): _____
- ☐ Don’t know

10. Based on your experience with nonresidential HPWH system configurations in small spaces (<700 cubic feet), which of the following would reduce **indoor air quality (due to ingress of airborne particulates, gases, and bacteria) in the room and cause a room pressure imbalance**? Select all that apply.

- ☐ HPWH with no ducts
- ☐ HPWH with one duct (intake OR exhaust) connected to an outdoor vent
- ☐ HPWH with two ducts (intake AND exhaust) connected to an outdoor vent
- ☐ No change in indoor air quality and room pressure balance with the number of HPWH system ducts
- ☐ Don't know

Responses to survey questions are summarized below.

A summary of the responses to questions 1 through 4 are provided in Table 62.

Table 62: Market Role of Respondents that Indicated HPWH Ventilation Ducts are Used in Nonresidential HPWH Projects.

Respondent	Market Role
Person 1	Compliance Consultant, Commissioning (Cx) Agent, Design Professional & Energy or Environmental Consultant
Person 2	Building Management or Ownership, Compliance Consultant, Commissioning (Cx) Agent, ECC-Raters & Operations or Maintenance
Person 3	Design Professional
Person 4	Compliance Consultant, Design Professional, Efficiency Advocate, Energy or Environmental Consultant & Operations or Maintenance
Person 5	Manufacturer, Distributor, or Vendor
Person 6	Design Professional & Manufacturer, Distributor, or Vendor
Person 7	Efficiency Advocate
Person 8	Design Professional

Table 63: Estimated Labor Cost to Install a HPWH Ventilation Duct.

Respondent	Water Heater Installs	Percent of Installs being HPWHs	Percent of HPWH Installs in 700 cu. ft. or Smaller	Percent Used No Ducts	Percent Used Either Intake or Exhaust Ducts	Percent Used Intake & Exhaust Ducts
Person 1	50	50	10	75	0	25
Person 2	16	80	100	100	0	0
Person 3	36	25	75	40	40	20
Person 4	50	60	80	35	30	35
Person 5	50	40	50	90	5	5
Person 6	50	20	50	75	0	25
Person 7	5	80	50	N/A	N/A	N/A
Person 8	16	15	50	100	0	0
Average	**34**	**46%**	**58%**	**74%**	**11%**	**16%**
Weighted Average of Total Installs for 8 Respondents	**34**	**41%**	**24%**	**14%**	**4%**	**4%**
Weighted Average of Total Installs for All 27 Respondents	**29**	**14%**	**8%**	**5%**	**1%**	**2%**

The table above summarizes information from eight respondents who use HPWHs. The other 27 respondents are not using HPWHs. Across all 35 respondents, about 770 water heaters were installed in the past 12 months in nonresidential buildings. Applying the ratio of the 273 projects shown in the table above where HPWHs were installed, only about 15 percent of water heater installations in nonresidential buildings are HPWHs. About 2 percent of all water heaters installed are a HPWH with some kind of ducting, and 1 percent of all water heater installations are HPWHs where only one duct is being installed. This is considered a negligible number of existing projects where HPWHs are being installed with one duct.

A summary of the responses to questions 5 and 6 is provided in

Table 64.

Table 64: Estimated Labor Cost to Install a HPWH Ventilation Duct.

Respondent	Market Role	Average Cost to Install the First HPWH Duct ($)	Average Cost to Install the Second HPWH Duct ($)
Person 1	Compliance Consultant, Commissioning (Cx) Agent, Design Professional & Energy or Environmental Consultant	750	450
Person 2	Compliance Consultant , Design Professional, Efficiency Advocate Energy or Environmental Consultant & Operations or Maintenance	950	650
Person 3	Manufacturer, Distributor, or Vendor	>1000	>1000
Person 4	Design Professional, Manufacturer, Distributor, or Vendor	>1000	>1000
Person 5	Efficiency Advocate	450	550
Person 6	Design Professional	850	>1000
Average	**---**	**830**	**780**

It is important to note the large difference in expected costs for HPWH duct installation from designers' responses above, averaging $830 for a single HPWH ventilation duct and $780 for a second HPWH ventilation duct. This is approximately four times higher than what the installers estimated as the installation labor cost.

A summary of the responses to question 7 are provided in Table 65.

Table 65: Feasibility of Installing HPWH Ventilation Ducts in Existing Buildings and New Construction.

Respondent	Existing Buildings	New Construction
Never feasible	0	0
Rarely Feasible	2	4
Sometimes feasible	5	7
Very often feasible	4	1
Always feasible	2	1
Don't Know	0	0

Responses to question seven indicate that installing HPWH ventilation ducts in existing buildings is more often feasible than in new construction.

A summary of the responses to question 8 related to barriers identified when using both an intake and an exhaust duct for HPWHs which make installation never or rarely feasible are listed below:

- ◻ Access to adequate locations for ducting is at a premium
- ◻ Space constraints, cold air is bothersome. Focus needs to be on makeup Btus as a heat source, not ducting
- ◻ Space and access
- ◻ Size of ventilation system relative to HPWH capacity

A common theme in responses to question 8 was that the size of the HPWH room/closet is a limiting factor. It seems that fitting the ducts in the space is a challenge. One respondent indicates that the available heat in the air, provided by either makeup air entering the room or heat sources in the room, is more important than ducting. There are situations in which heat from other appliances can increase the available Btus in the HPWH room, enough to balance the cold air output of the HPWH. An example would be a café which commonly has an icemaker in the mechanical room where the HPWH would be located.

Responses to question 9 indicate that only one respondent reports moisture damage as a result of poor HPWH ducting. This respondent indicated that 25 percent of buildings have moisture damage due to poor HPWH ducting. Accounting for 15 other people who responded to this question indicating no moisture issues or not knowing of any moisture issues, it is assumed that about one percent of ducted HPWH installations result in moisture damage due to poor HPWH ducting.

A summary of the responses to question 10 are provided in Table 66.

Table 66: Ventilation Configurations in Small Spaces Expected to Cause a Room Pressure Imbalance and Cause Air Quality Concerns.

Respondent	Percent of Reponses
HPWH with no ducts	13
HPWH with one duct (intake OR exhaust) connected to an outdoor vent	38
HPWH with two ducts (intake AND exhaust) connected to an outdoor vent	6
No change in indoor air quality and room pressure balance with the number of HPWH system ducts	6
Don’t know	38

Of the 14 respondents, only 38 percent indicated that using one duct would result in a building pressure imbalance. This indicates that the topic of building pressure imbalances is an important education topic for designers and installers so that they understand the impacts and potential benefits of ducting.

Appendix G: Markup of Non-Restructured 2025 Title 24, Part 6

This section details the proposed language for the HPWH ventilation clean-up measure for nonresidential buildings code measure. This measure would simplify the four existing 2025 compliance pathways to make unitary HPWH installation planning simpler, as well as improving consumer-sized HPWH performance in nonresidential buildings.

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).

Administrative Code (Title 24, Part 1)

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

Energy Code (Title 24, Part 6)

There are proposed changes to the non-restructured version of Title 24, Part 6, see below.

Title 24, Part 6: 110.3(c)7

Air-Source Heat Pump Water Heaters (HPWHs). HPWH shall meet the following requirements:

A. **Backup Heat.** Backup heat is required for systems when inlet air is unconditioned, unless the compressor cut-off temperature is below the Heating Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup heat may be internal or external to the HPWH.

B. Ventilation **– Residential and Nonresidential with Group R Occupancy, and Common or Public Use Areas serving that Occupancy**. Consumer integrated HPWHs serving single-family or multifamily dwelling units, or nonresidential buildings with Group R Occupancy, and Common or Public Use Areas serving that Occupancy shall meet one of the ventilation requirements below. Minimum volume and opening size requirements shall be the sum of all HPWHs installed within the same space. Compressor capacity shall be determined using AHRI 540 Table 4 reference conditions for refrigeration with the "High" rating test point:

1. Installed using a method provided by the manufacturer to meet or exceed the level of performance provided by the ventilation requirements of Section 110.3(c)7B2 through Section 110.3(c)7B4.
2. For HPWH installation without ducts, the installation space shall have a volume not less than the greater of 100 cubic feet per kBtu per hour of compressor capacity, or the minimum volume provided by the manufacturer for this method; or
3. For HPWH installation without ducts, the installation space shall be vented to a communicating space via permanent openings, according to the following requirements:
    i. Communicating space shall meet the minimum volume of Section 110.3(c)7B2 above, minus the volume of the HPWH installation space; and
    ii. Permanent openings shall consist of a single layer of fixed flat slat louvers or grilles, with a total minimum Net Free Area (NFA) the larger of 125 square inches plus 25 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method. The permanent openings shall be fully louvered doors or two openings of equal area, one in the upper half of the enclosure and one in the bottom half of the enclosure. The top of the upper opening must be 12 inches or less from the enclosure top and the bottom of the lower vent must be 12 inches or less from the enclosure bottom; or
4. For HPWH installations with ducts, the following requirements shall be met:
    i. The space joined to the installation space via ducts shall meet the minimum volume of Section 110.3(c)7B2 above, minus the volume of the HPWH installation space; and
    ii. All duct connections and building penetrations shall be sealed; and
    iii. Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and
    iv. Where only the HPWH inlet or outlet is ducted, installation space shall include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom half of the room, and/or a door undercut. With a ducted inlet, the minimum NFA shall be equal to

the cross-sectional area of the duct. With a ducted exhaust, the minimum NFA shall be the larger of 20 square inches or the minimum NFA provided by the manufacturer for this method; and

v. Where the inlet and outlet ducts shall both terminate within the same pressure boundary, airflow from the termination points shall be diverted away from each other; or.

Note: Ducting only the inlet or the exhaust across the pressure boundary could interfere with balanced ventilation systems. This should be considered when specifying HPWH location and ventilation method.

C. **Ventilation – Nonresidential Excluding Group R Occupancy, and Common or Public Use Areas serving that Occupancy**. Consumer i*ntegrated HPWHs* serving nonresidential occupancies shall be installed using one of the methods in either Section 500.3.3.7.3.1, 500.3.3.7.3.2, or 500.3.3.7.3.3.

1. **Installations Per Manufacturer Provided Method**. For *HPWH* installations following a manufacturer provided method, this method shall meet or exceed the level of performance provided by one of the ventilation requirements in either Section *110.3(c)7C2 or 110.3(c)7C3*.

2. **Installations Without Ducts**. For *HPWH* installations without ducts connected to the HPWH, the following requirements shall be met:

   a. The installation space shall have a volume larger than 100 cubic feet per kBtu per hour of the combined compressor capacity and larger than the minimum volume provided by the manufacturer. Compressor capacity shall be determined using *AHRI 540* Table 4 reference conditions for refrigeration with the “High” rating test point.

   b. Minimum room volume shall be at least the sum of all required volumes for all *HPWHs* installed within the same space.

   c. The center of the HPWH outlet port of all unducted *HPWHs* shall be directed at an angle of 90 degrees or more away from all *unvented surfaces* and permanently installed equipment closer than the manufacturer specified minimum distance. If the manufacturer does not specify a minimum distance, then the minimum distance between unvented surfaces and the center of HPWH outlet port shall be 24 inches.

d. HPWH exhaust air shall be directed at a minimum angle of 90 degrees away from each other or be separated by a minimum of 24 inches.

Exception 1 to *110.3(c)7C2*- A *HPWH* may be installed in a smaller volume space without ducts if the installation space contains permanently installed equipment which generates waste heat sufficient to meet the thermal energy needs of all *HPWHs* installed in the space. A calculation shall be done using an energy model that meets the requirements of the ACM to confirm that the method of providing a source of heat to the *HPWH* room meets or exceeds the level of performance provided by the ventilation requirements of Section 500.3.3.7.3.2.

Permanently installed equipment which generates waste heat may include, but is not limited to, one or more commercial refrigerators, ice makers and/or ovens.

3. **Installations With Ducts**. For *HPWH* installations with ducts connected to the *HPWH*, the following requirements shall be met for all installations with ducts in addition to one of the ventilation requirements in either Section *110.3(c)7C3i or 110.3(c)7C3j*:

   a. Air for the inlet and outlet of the *HPWH* shall both terminate on the same side of a *pressure boundary*, either both to outside or both to inside the building; and

   b. Minimum ventilation opening size shall be at least the sum of all required openings for all *HPWHs* installed within the same space; and

   c. The space joined to the installation space via ducts shall meet the minimum volume of Section 110.3(c)7C2 above, minus the volume of the *HPWH* installation space; and

   d. All duct joints, connections and building penetrations shall be sealed; and

   e. Outlet ducts and all ducts which cross *pressure boundaries* shall be insulated to minimum of R-6; and

   f. Outlet ducts shall be installed such that internal condensation will drain back to the *HPWH's* condensate pan; and

g. All duct vent caps (including exterior facing duct vent caps with a bug screen and rain/snow shield) shall have a minimum *NFA* equal to 110 percent of the cross-sectional area of the unducted HPWH outlet port; and

h. Outlet ducts shall terminate at a point within 4 inches of the top of the *HPWH* installation space.

110.3(c)7C3i- Installations with both the inlet and outlet ducted. For installations where both the inlet and outlet are ducted, airflow from the termination points shall be diverted away from each other and be separated by a minimum of 24 inches.

110.3(c)7C3j- Installations with only the outlet ducted. For installations where only the outlet ducted a permanent opening shall be used to provide makeup air. In addition, either requirement i or ii below shall apply:

i. Where only the *HPWH* outlet is ducted to a communicating space, the *HPWH* installation space shall be within the conditioned space *pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a door undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.

ii. Where only the *HPWH* outlet is ducted to outside, the *HPWH* installation space shall be in the unconditioned space outside of the building *pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a door undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.

Reference Appendices

There are no proposed changes to the Reference Appendices.

Compliance Manuals

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

ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

Compliance Forms

As discussed in Section 2.4.5, there are proposed changes to NRCC-PLB-E Table F element 22 which lists HPWH ventilation options. This element should be updated with new ventilation options proposed for the 2028 code to reflect updates to section Subsection Section 110.3(c)7. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

There are proposed changes to the NRCI-PLB-E compliance form see below. Changes to the 2025 documents should be marked with dark blue underlining (new language) and ~~strikethroughs~~ (deletions).

A ventilation method meeting one of the following:

- The designated space for the future heat pump water heater shall have a minimum volume of 700 cubic feet; or
- The designated space for the future heat pump water heater shall vent to a communicating space in the same pressure boundary via an 8 inch diameter exhaust duct and a permanent opening~~s~~ with a minimum NFA of ~~250~~125 square inches~~.~~, so that the total combined volume connected via permanent openings is 700 cubic feet or larger. The permanent openings shall be:
    - A ~~Fully~~ louvered door~~s~~ with fixed louvers; or
    - A ~~Two permanent~~ fixed opening~~s~~ located within 12 inches from the enclosure ~~top and~~ bottom
- The designated space for the future heat pump water heater shall include two 8 inche~~s~~ diameter capped ducts, venting to the building exterior:
    - All ducts, connections, and building penetrations shall be sealed
    - Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to a minimum level of R-6.
    - Airflow from termination points shall be diverted away from each other.

Appendix H: Summary of HPWH Ventilation Lab Findings

This section summarizes the "Comparison of HPWHs Ducted to the Outdoors and Unducted in a Small Space" study funded by the California Energy Codes and Standards Utility Program in 2025 and 2026, and presents key findings related to ducted HPWH ventilation. This is an ongoing experiment at the Frontier Energy Building Science Research Lab in Davis, California. Heating season results were presented at the ACEEE Hot Water and Hot Air Forum in March of 2026.

The goal of this lab evaluation was to quantify the energy use, air quality, and moisture impacts of different HPWH ventilation approaches including the following:

- Intake & Exhaust: One duct is connected to the inlet port of the HPWH to use outside air for the intake of the HPWH and one duct is connected to the outlet port of the HPWH to push HPHW exhaust air back to outside the building.
- Intake: One duct is connected to the inlet port of the HPWH to use outside air for the intake of the HPWH and the outlet port directs HPWH exhaust air inside the building.
- Exhaust: The inlet port is not ducted. Intake air for the HPWH comes from inside the building and one duct is connected to the outlet port of the HPWH to push HPHW exhaust air back to outside the building.
- No Ducts: The inlet port and outlet port are not ducted. Intake air for the HPWH comes from inside the building and the outlet port directs HPWH exhaust air inside the building.

Figure 8 provides a graphic to show the airflow of the HPWH ventilation air through the ducts and into or out of the building.

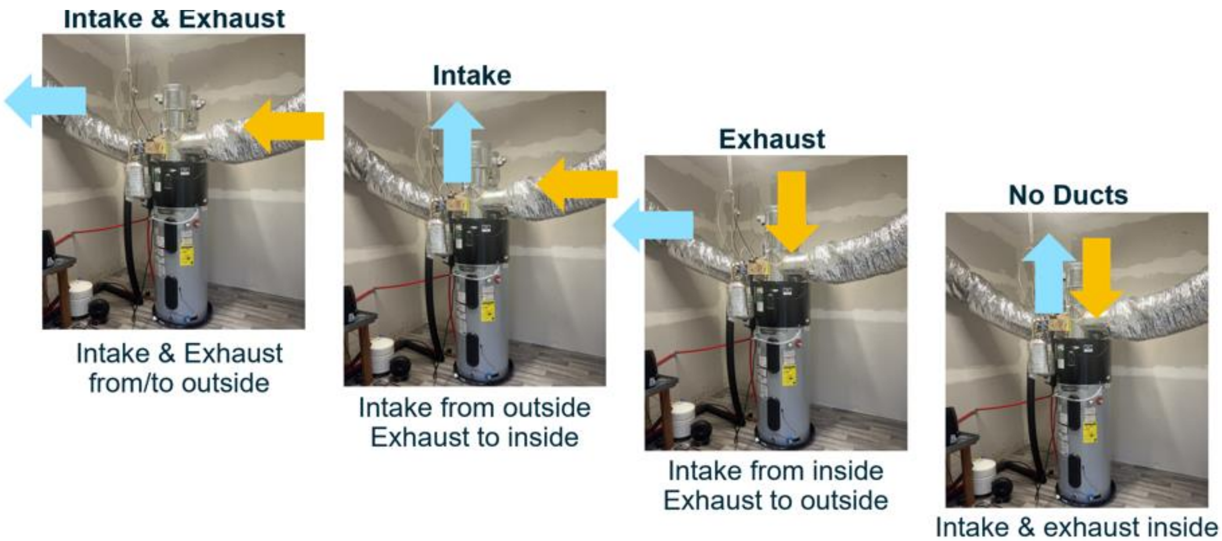

Figure 8: HPWH ventilation test configurations.

This presentation highlights the impact of cold HPWH exhaust air on the conditioning load of a 10-foot by 10-foot by 10-foot insulated building during heating season. The building includes several components such as the HPWH test, a mini split HVAC system, heater, condensate pump, and data acquisition equipment. The mini split HVAC heating system setpoint was 70°F during the test period from January through March of 2026. The heater was used to represent building occupancy with a daily sensible gain of about 2.5 kilowatt-hours.

Results indicate that the No Ducts and Exhaust Duct configurations resulted in the least HPWH energy use during days where the HVAC was set to heating mode for days ranging from a mean outdoor temperature while the HPWH was running of 55°F to 72°F (see Figure 9). Even with the HPWH efficiency benefits, the No Ducts ventilation configuration resulted in 0.2 to 0.4 kilowatt-hour more energy use per day than the exhaust duct configuration and the Intake and Exhaust duct configuration because the mini split HVAC system had to reheat the building after the HPWH exhaust cold air into it, see Figure 10. Building energy use includes both the mini split HVAC energy to maintain the heating setpoint and the HPWH energy use to heat the water.

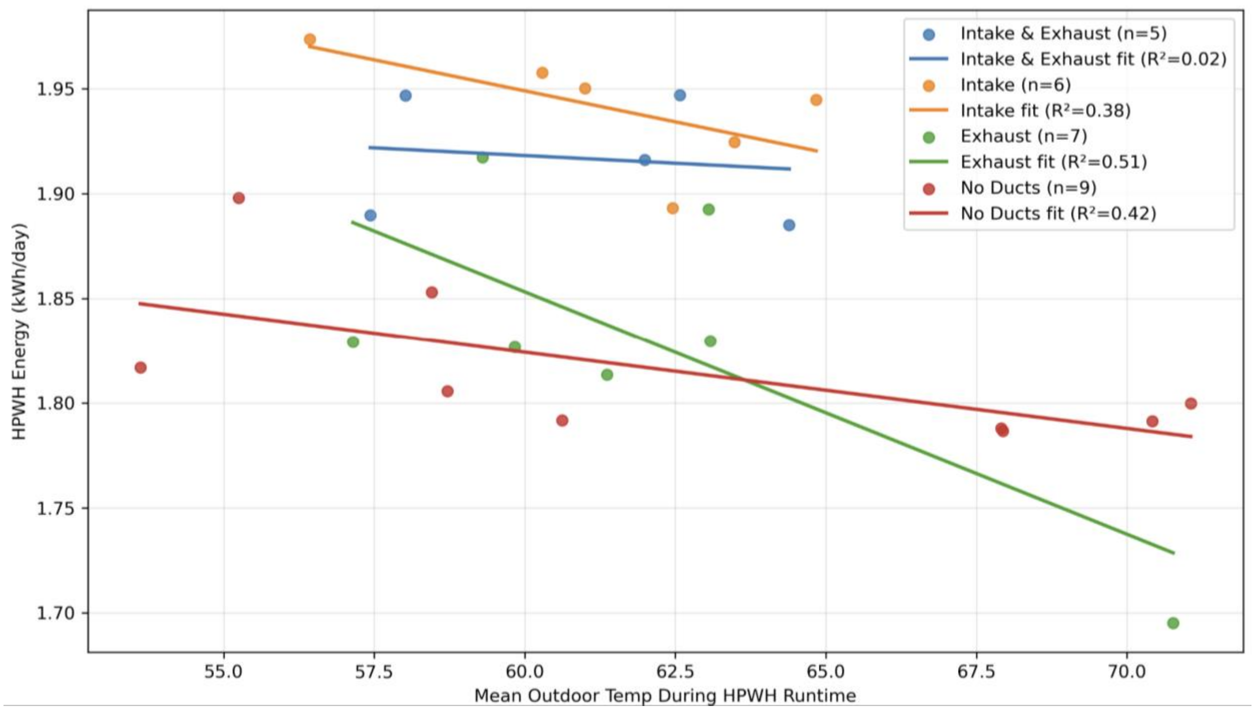

Figure 9: Daily average HPWH energy use vs. average outdoor temperature while the HPWH fan was running.

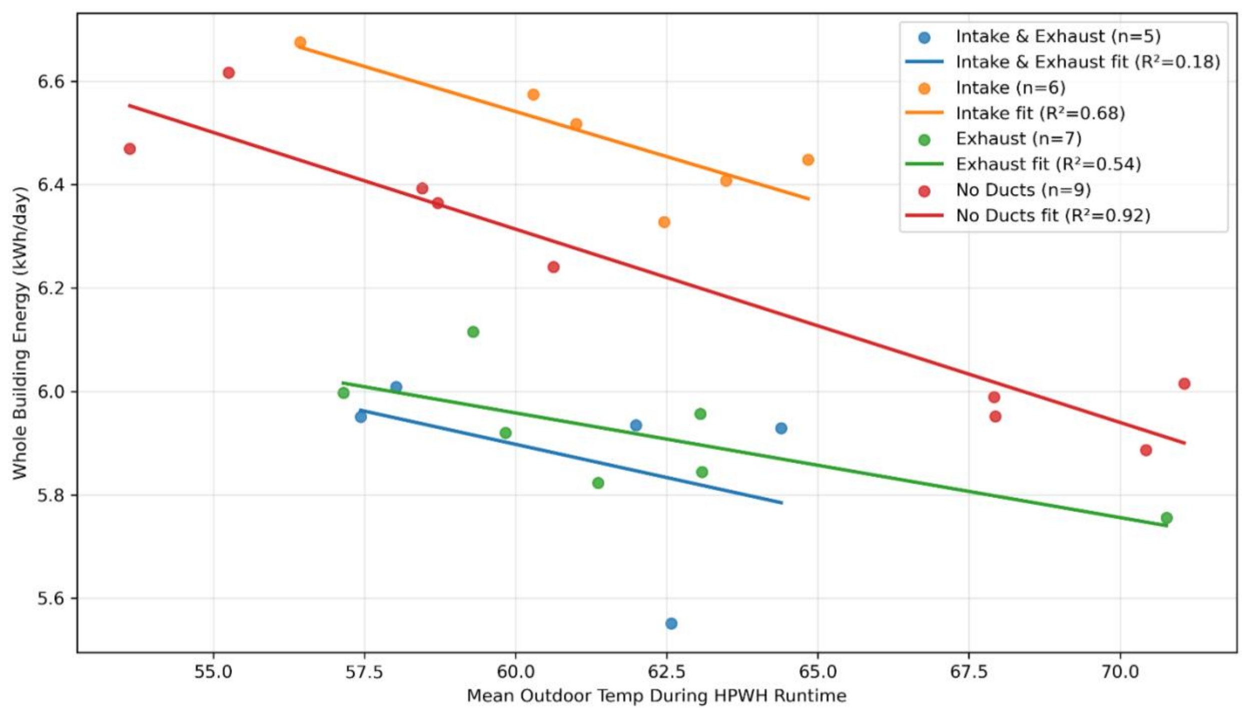

Figure 10: Daily average combined HPWH and HVAC energy use vs. average outdoor temperature while the HPWH fan was running.

These tests were run using a 56-gallon water draw profile similar to the DOE 24-hour test. Air quality data was collected inside the HPWH room and compared to the outdoor air quality, see Figure 11.

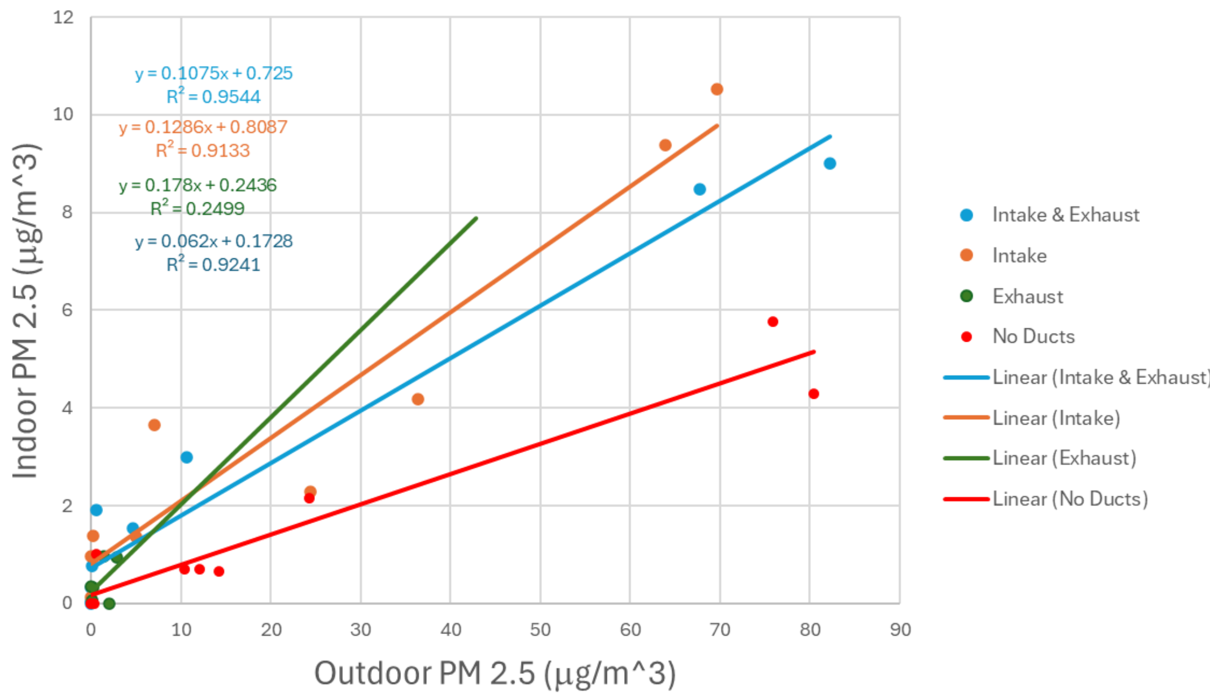

Figure 11: Daily average indoor PM 2.5 vs. outdoor PM 2.5.

Test results show that the indoor air quality is worst with the single duct ventilation approaches.

In addition to PM 2.5 measurement, the ambient conditions and intake and exhaust conditions were measured during testing. Results indicated that the HPWH exhaust dropped below dew point for Intake & Exhaust and Exhaust ducting configurations which indicates a need for insulating the exhaust ducts to prevent condensation from forming on the outside of the duct while condensation forms inside the duct.