

Nonresidential Water Heating



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Catherine Chappell, David Douglass-Jamies (TRC) Draft CASE Report



The California Statewide Codes and Standards Enhancement (CASE) Program is funded in part by California utility customers under the auspices of the California Public Utilities Commission.

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Document Information

Category:	Codes and Standards
Keywords:	Statewide Codes and Standards Enhancement (CASE) Initiative; California Statewide Utility Codes and Standards Team; Codes and Standards Enhancements; 2028 California Energy Code; 2028 Title 24, Part 6; California Energy Commission; energy efficiency
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Acronyms

Table 1 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a [glossary of terms](#).

Table 1: List of Acronyms

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

FSOR	Final Statement of Reasons
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation, and Air Conditioning
IDF	Input Data File
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISOR	Initial Statement of Reasons
Kg/s	Kilograms per Second
kWh	Kilowatt-Hour
kWh/year	Kilowatt-Hour Per Year
LED	Light Emitting Diode
LPD	Lighting Power Density
LSC	Long-term System Cost
MeasureSET	CASE Measure Savings Estimation Template
MG	Million Gallons of Water
NAICS	North American Industry Classification System
NPDI	Net Private Domestic Investment
PEP	Public Engagement Plan
PV	Present Value
SDD	Standards Data Dictionary
SOC	Standard Occupational Classification
SPMS	Saturation Pressure Measurement Sensors
SRIA	Standardized Regulatory Impact Assessment
TMHS	Temperature Maintenance Heater in Series
UL	Underwriters Laboratories
W	Watt

1. Introduction

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

Email comments and suggestions to info@title24stakeholders.com and jmgarcia@trcccompanies.com. Comments will either not be released for public review or will be anonymized if shared.

1.1 Report Context

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

1.2 Proposal Sponsors

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

1.2.1 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders. The proposal incorporates feedback received during a public stakeholder workshops that the Statewide CASE Team held on October 23, 2025 and March 10, 2026.

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

2. Circulator Pump Controls

2.1 Circulator Pump Controls - Measure Description

2.1.1 Proposed Code Change

The proposed code change would add a prescriptive requirement for digital controls for circulator pumps in service hot water systems in nonresidential buildings. It would stipulate acceptable control types based on the hot water loop system and whether the system has risers or not. Applicable controls would include internal or external controls that reduce energy use at the pump and/or water heater. Proposed continuous and non-continuous pump control methods include pressure-based variable speed control with thermal balancing valve(s), constant return temperature control, demand flow-based control, aquastat, and digital timeclock.

The proposed measure would apply to new construction, alterations, and additions. Confirmation of correct equipment selection and installation would be via self-attestation on the design Nonresidential Certificate of Compliance (NRCC) and Nonresidential Certificate of Installation (NRCI) forms.

Table 2 summarizes the scope of the proposed code change.

Table 2: Scope of Proposed Code Change

A indicates the proposed code change is relevant.

Building Type(s)		Construction Type(s)		Type of Change	
<input type="checkbox"/> Single Family		<input checked="" type="checkbox"/> New Construction		<input type="checkbox"/> Mandatory	
<input type="checkbox"/> Multifamily		<input checked="" type="checkbox"/> Additions		<input checked="" type="checkbox"/> Prescriptive	
<input checked="" type="checkbox"/> Nonresidential (not Group R uses)		<input checked="" type="checkbox"/> Alterations		<input type="checkbox"/> Performance	
Application Climate Zones (CZs)	Energy Code Sections	Compliance Forms		Sections of ACM Reference Manuals	
CZs 1-16	<ul style="list-style-type: none"> Part 6, Section 110.3(a)2 JA14: Qualification Requirements for Hot Water Systems 	NRCC, NRCI, LMCC, & LMCI		Section 5.9.3 Recirculation Systems	
Third Party Verification)			Updates to Compliance Software		
No changes to third party verification			<input type="checkbox"/> No updates		
<input type="checkbox"/> Update existing verification requirements			Update existing feature		
<input type="checkbox"/> Add new verification requirements			<input checked="" type="checkbox"/> Add new feature		

2.1.2 Benefits of Proposed Change

The proposed code change would result in the reduction of energy use from the water heater and the circulator pump. The water heater energy savings are due to the reduction in recirculation system pipe heat losses and reduced tank destratification. The tank destratification would increase the viability and efficiency of heat pump water heaters. The proposed code change would require advanced controls that are typically easier to set up and more persistent than basic controls.

Several studies have evaluated the benefits of advanced controls for circulator pumps, although some of these studies evaluated a combined measure that included advanced pump controls and electronically commutated motors (ECM). Based on a Northwest Energy Efficiency Alliance (NEEA) study which implemented ECM first, then advanced pump controls, the Statewide CASE Team determined that advanced pump controls alone reduced runtime by approximately 55-85 percent, and increased water heater energy savings by approximately 1-14 percent in nonresidential applications. A National Renewable Energy Laboratory (NREL) study that implemented ECM and advanced pump controls simultaneously suggests that ECM pumps with advanced controls can provide greater than 50 percent electricity savings at the circulator pump (Dean, Honnekeri and Barker 2018). However, this study does not separate out savings associated with controls from those savings associated with the switch from an induction motor to ECM. Another study conducted on four (Conservation Applied Research and Development (CARD) 2018). The digital pump controls used in this study were demand controls via flow sensors and return water temperature sensors. A Code Readiness study looked at constant return temperature controls and proportional, differential, pressure control. The study showed constant return temperature controls resulted in 41 percent daily pump energy savings and roughly 20 percent savings from the reduction in distribution losses. The study also showed that proportional pressure controls had pump energy savings between 19 – 91 percent and 17 – 34 percent savings from the reduction in distribution losses.

2.1.3 Background Information

The current Title 24, Part 6 includes a mandatory requirement that circulating pumps are capable of automatically turning off. There are no prescriptive requirements for advanced pump controls for nonresidential buildings with central water heating systems. There is an existing mandatory code requirement that requires the circulator pump to be capable of turning off automatically. Based on stakeholder feedback and plans review, the Statewide CASE Team determined an analog timeclock often meets this requirement. Some practitioners also specify or install an aquastat. The experience of the Statewide CASE Team is that these controls have persistence issues; timeclocks can experience clock drift, and aquastats, where installed, are often set higher than the tank set point. During a live, informal poll held at the first stakeholder presentation,

participants reported deactivation of controls. Half of the respondents indicated that projects bypass controls, one quarter reported operation in a disabled or single-speed operation, and one quarter indicated persistent control use.

The proposed code change would require advanced controls. Basic and digital controls are defined in the following sections.

2.1.3.1 Basic Controls

Basic pump controls are the base case method to control circulator pump operation and include repeat cycle pump timers, timeclocks, aquastats, and other devices that do not meet the requirements of the proposed code change. Basic controls lack lockout options, the ability to retain control settings during power outages, remote monitoring, alerts capability with timer-based controls, and the capability to auto-adjust time due to clock drift or daylight savings time changes, all of which can result in sub-optimal performance and excess energy usage.

2.1.3.2 Advanced Controls

Advanced pump controls control circulator pump operation more reliably with persistence and include electronic options such as integrated variable speed pump controls designed in circulator pumps for SWH systems such as constant return temperature for one loop distribution systems, constant pressure control with thermal balancing valves for riser distribution systems. Advanced external pump controllers offer features that result in energy savings, including demand control systems that employ hot water demand and return temperature-based sensors or repeat cycle timers. Advanced pump controls offer features including lockout option, ability to retain control setting during power outages and remote monitoring and alerts capability via WiFi.

2.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 2.6: Circulator Pump Controls - Proposed Language of this report for detailed revisions to code language.

2.1.4.1 Energy Code Change Summary

SECTION 140.5 – PRESCRIPTIVE REQUIREMENTS FOR SERVICE HOT WATER SYSTEMS

Subsection 140.5(d): The proposed measure would add a requirement for service hot water systems in nonresidential new construction, additions, and alterations to include a pump with one of the approved advanced pump controls.

Section 141.0: ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS, TO EXISTING OUTDOOR LIGHTING, AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

Section 141.0(a)1: The code language for additions in section 141.0(a)1. already requires compliance with section 140.5(a), so no edits are needed to cover additions.

Section 141.0(b)2.N.:The code language for alterations in section 141.0(b)2.N. need to be edited to add a reference to the proposed code language in 140.5(d).

2.1.4.2 Reference Appendices Change Summary

No changes proposed

2.1.4.3 Compliance Manuals Change Summary

The proposed measure would update section 4.8.3 of the Nonresidential Compliance Manual, which outlines prescriptive requirements for service hot water systems. The manual would need new guidance on how to install and set up digital controls for both integrated and external controls.

2.1.4.4 Alternative Calculation Method Reference Manual Change Summary

This proposed measure would add a Section 5.9.3 Recirculation Systems. This would include a requirement for calculating the savings associated with the control selected from the approved list. This calculation would include a derate factor, based on industry research, for demand controls.

2.1.4.5 Compliance Forms Change Summary

This proposed measure would alter four compliance documents.

Form NRCC-PLB would add a statement and a single check box to Table H.

Form NRCI-PLB would add a single line item to Table F.

Form LMCC-PLB-E would add a statement and a single checkbox to Table H, Form LMCI-PLB-01-E would add a line item to each of Tables B and C.

The updated reference appendix, as described above, would provide guidance based on the application and control strategy.

2.1.5 Measure Context

2.1.5.1 Comparable Model Codes or Standards

The Statewide CASE Team is not aware of comparable model codes or standards.

2.1.5.2 Interactions with Other Regulations

This proposal does not conflict with federal requirements for ECM pumps since the digital controls in the proposed measure can be external to the pump. Based on the federal requirement, the Statewide CASE Team assumed the baseline case for modeling and savings calculations to be a circulator pump with a single speed ECM motor.

2.2 Circulator Pump Controls - Compliance and Enforcement

2.2.1 Compliance Considerations

The proposed measure updates the existing compliance process by updating the forms referenced in Section 2.1.4.5.

These updates build on the existing compliance workflow and do not introduce a new form, compliance pathway, or documentation system. The building department already reviews both forms as part of the plan check and inspection process. Since this proposal only modifies the existing form language, the feasibility of compliance remains high. Building departments would review the updated fields at the same time they review the rest of the form. The building departments would not need any new enforcement workflow, software, or procedural change to implement this update. As with all code updates, stakeholders would require training to understand the proposed measure and for amended compliance forms.

The proposal does not introduce any diagnostic testing, field verification, or performance testing requirements. Designers and contractors would continue to certify compliance through the existing declaration process via the NRCC, NRCI, LMCC and LMCI forms.¹ Updates to the compliance forms, which are filled out by the designer and contractor, will streamline the building department inspection process.

The proposal introduces a minor increase in documentation responsibility for designers and contractors because each must confirm a new compliance element on the existing forms. However, the measure does not add any additional steps to either the compliance workflow or extend the review timeline. For designers, the added burden is understanding the new design requirements and documenting those on the updated NRCC. For contractors, the added burden is confirming the installed system meets the updated requirement on the NRCI form. For building departments, the measure introduces only a minor change to current practice by adding review of the updated form

¹ Non-Residential (NR) and Low-Rise Multi Family Residential (LM) Certificate of Compliance (CC) and Certificate of Installation (CI) forms

entries during plan checking. The review process, structure, and format remain the same, resulting in a minimal increase in effort.

This measure integrates into the existing compliance framework instead of adding separate forms or procedures. By limiting the change to four existing form fields the proposal avoids introducing additional compliance paths, preserves familiarity with forms, and maintains current workflows for review. This approach allows all parties to implement the measure with minimal disruption while still achieving the savings goals.

2.2.2 Impact on Market Actors

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

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

Market Actor	Impact(s)	Suggested Outreach and Education
Builders ^a	None	None
Design Professionals ^b	Required to specify pumps with required controls.	Training and best practices for designers.
Construction Team ^c	Installing pumps and external controls that they may not have worked with before.	Awareness and training on circulation pumps with controls.
Building Departments ^d	Reviewing plans and compliance forms.	Education on specifics to look for in design plans.
Verification Testers ^e	N/A	N/A
Building Owners, Managers, and Occupants	Reduced energy bills and increased maintenance.	Awareness of savings and education on necessary maintenance. Signage near pumps denoting control types and maintenance best practices.
Manufacturers and Distributors	Increased demand for pumps focused on applications in service hot water systems.	Educate manufacturers on importance of designing pump controls focused on applications in service hot water systems.

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

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

Builders. The proposed change would likely affect commercial builders; however, in the majority of cases it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industries equally; instead, it would primarily affect specific subsectors within the industry. Table 4 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 4: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
Nonresidential Electrical Contractors	3,245	72,794	7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	5.8

Source: (State of California n.d.)

*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. US Bureau of Labor Statistics, Handbook of Methods. <https://www.bls.gov/opub/hom/cew/concepts.htm>

2.2.3 Compliance Software Updates

The proposed measure would require three updates to California’s Building Energy Code Compliance (CBECC) software. First, the software would need to add a user input for the pump control. Second, the proposed measure would require an update to the software to include a multiplier based on the selected control (basic or advanced). Third, the measure may require updates to the software to support compliance reporting via the NRCC-PRF-E form.

2.2.4 Cost of Enforcement

The Statewide CASE Team acknowledges that changes to the code will impact enforcement costs. This report is an evaluation of specific measures, and the collective

impact of all proposed changes for the 2028 Title 24, Part 6 may represent an increase in training and/or workload for enforcement personnel.

There will be additional costs for more time to ensure compliance with the proposed measure, including training on the new measure and additional labor for enforcement and verification for all projects implementing the measure.

2.3 Circulator Pump Controls - Market and Economic Analysis

2.3.1 Market Structure and Availability

2.3.1.1 Current Market Structure and Availability

Manufacturers, distributors, design professionals, and installing contractors all play direct roles in supplying and implementing circulator pumps with advanced controls for service hot water (SHW) systems. Mechanical and plumbing wholesale distributors primarily supply California's SHW circulator pump market. Mechanical engineers and design-build contractors specify equipment during design, and installers procure the pumps through regional distribution. This process results in equipment availability of specified products. The SHW pump market includes two dominant product types; pumps with fixed discrete speeds and digitally controlled variable speed pumps using pressure, temperature, or time-based control logic. The recent DOE ruling requires contractors to install ECM pumps starting in 2028. Without the proposed code change, the Statewide CASE Team expects that the default configuration of most ECM pumps would be in a constant speed mode and continue to run even under low or no-load conditions based on current practice.

Most manufacturers that design digitally controlled circulator pumps do so for hydronic heating systems that require dynamic flow control. Manufacturers design these platforms to operate across multiple system types. Designers and contractors adopted these products rapidly in space heating systems but have applied them less in SHW systems.

This measure would not introduce a new technology category, instead it would standardize an existing product class that contractors already install in adjacent system types. Manufacturers already support the required control strategies, and distributors already supply the hardware. Thus, the market has sufficient capacity to meet demand of the proposed measure.

2.3.1.2 Market Challenges and Solutions

The market for circulator pumps with advanced controls is generally mature in related applications such as hydronic heating. Multiple manufacturers, including Bell & Gosset and Grundfos, currently supply commercially available digital pump platforms that are

available for SHW systems. Installers can configure these products based on the proposal's required control strategies.

Since this measure represents a shift from fixed-speed to variable-speed operation, it may require minor changes in standard design and installation practices. Section 2.3.2.3 addresses this challenge.

2.3.2 Design and Construction Practices

2.3.2.1 Current Design and Construction Practices

Current nonresidential SHW systems typically use one of two design approaches: continuous recirculation or time-based circulation using simple timers. A small portion of projects include the advanced pump controls proposed by this measure, for instance the Statewide CASE Team interviewed a contractor who uses constant return pressure control with thermal balancing valves for small projects. Designers generally size recirculation pumps to meet peak flow and head conditions and then operate them at constant speed regardless of system load. Designers commonly control pumps using 24-hour operation for critical facilities, time clocks, or manual switches. Temperature controls occur primarily at the water heater or mixing valve level as opposed to through the pump logic. Few designs actively modulate pump speed based on return temperature, pressure, or flow conditions.

Under the proposed measure, designers would specify circulator pumps with digital control capability and contractors would configure the control method during setup. This design results in pumps modulating output based on the controls rather than running continuously at a single speed. This design represents a change in control strategy and not in the core system technology.

The proposal would not require larger equipment rooms, additional piping, or alternate system layouts. The proposal would not increase electrical service requirements because digital circulators operate on the same branch circuitry as existing ECM pumps.

The primary design change lies in specifying pump models that include configurable control logic and documenting the selected control strategy in compliance documents.

2.3.2.2 Health and Safety Considerations

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

2.3.2.3 Design and Construction Challenges and Solutions

The Statewide Case Team identified the design and construction challenges and solutions to them. These challenges include design familiarity, control configuration uncertainty, distribution practices, and concern over temperature stability. The concern for designers is that they primarily associate variable-speed pumps with hydronic heating controls rather than for SHW. The second concern is that installers may lack familiarity with selecting and configuring control modes during the system set up. The distribution practices concerns are due to some wholesalers stocking digital circulators primarily for space heating applications and not initially labelling them for SHW systems. Some designers express reservations that modulating pump speed could affect hot water availability at fixtures.

Other challenges include variability of performance and startup complexity from one manufacturer to another with the same advanced control option. One manufacturer may have control features that are ready to use out of the box that any contractor can set up with minimal complexity and startup time, while another manufacturer may offer the same advanced control option that requires the contractor to upload the control option via laptop, and have knowledge of complex proportional integral derivative (PID) controller settings that are not user friendly. As the market matures and programs and codes push for reliable and user-friendly advanced controls, more manufacturers should offer user-friendly integrated advanced control options suitable for SHW recirculation.

The solutions to these challenges include training and education, design guidance, clear compliance pathways, and product familiarity. Guidance documentation, training programs, and continuing education courses would relieve the challenges associated with familiarity and a lack of information. Manufacturers and other organizations could supply this educational material. Based on the Statewide CASE team's discussions with a contractor, the proposed measure is already being specified and installed, including in small buildings, indicating that an effort to provide the necessary support to the engineering community is already underway.

2.3.3 Energy Equity and Environmental Justice

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

² The California Public Utilities Commission (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

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice.

This section is still in progress. The Statewide CASE Team is continuing to engage with stakeholders to determine potential impacts on ESJ communities and will update this section with any additional findings.

2.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team will complete this section for the Final CASE Report.

2.3.5 Economic and Fiscal Impacts

The Statewide CASE Team will complete this section for the Final CASE Report.

2.4 Circulator Pump Controls - Cost Effectiveness

2.4.1 Cost Effectiveness Methodology

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

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

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

Costs include first costs and ongoing maintenance costs assessed over the 30-year period. Benefits and costs are evaluated incrementally, relative to the most recently

Communities, which comprises “(1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0 (1,984 tracts); (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores (19 tracts); (3) Census tracts identified in the 2017 Disadvantaged Community (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).

adopted Energy Code. The analysis excludes design costs and incremental code compliance verification costs.

2.4.2 Energy and Energy Cost Savings Results

Appendix A presents the methodology and assumptions of the energy and energy cost savings analysis.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per unit are presented in Table 5 through Table 7. Energy changes from the measure occur in three areas: 1) thermal energy savings from reduced heat losses from the pipes; 2) a reduction in pump power from efficient ECM motors and utilization of variable speed operation versus the fixed speed base case, and c) potential increases in central plant fuel / electricity use to make up for reduced mechanical heat from the pump being transmitted to the circulation water, in the measure case. The first year savings per square foot for this measure range from 0.00 – 2.92 kWh per year depending on climate zone and the gas savings range from 0.00 – 3.50 kBtu per year depending on the climate zone. The peak demand reduction ranges from 0.00 – 5.69 kW per climate zone.

Table 8 presents total per-unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV\$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Table 5: First Year Electricity Savings (kWh) Per Square Foot – Circulator Pump Controls

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
Assembly	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
Grocery	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Large Office	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
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Medium Office	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
Medium Retail	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
Mixed-use Retail	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Non-refrigerated Warehouse	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
Restaurant	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92
Small Office	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Small School	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Strip Mall	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Table 6: First Year Peak Demand Reduction (kW) Per Square Foot – Circulator Pump Controls

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
Assembly	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
Grocery	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Large Office	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
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Medium Office	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Medium Retail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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
Mixed-use Retail	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Non-refrigerated Warehouse	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
Restaurant	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69
Small Office	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Small School	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Strip Mall	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

Table 7: First Year Natural Gas Savings (kBtu) Per Square Foot – Circulator Pump Controls

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
Assembly	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
Grocery	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Large Office	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
Large Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Medium Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Medium Retail	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Mixed-use Retail	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Non-refrigerated Warehouse	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
Restaurant	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Small Office	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Small School	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Strip Mall	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Table 8: Total 30-Year LSC Savings (2029 PV\$) Per Square Foot – Circulator Pump Controls

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
Assembly	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Grocery	1.40	1.40	1.40	1.40	1.40	1.41	1.40	1.41	1.40	1.40	1.40	1.40	1.40	1.41	1.40	1.40
Large Office	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Large Retail	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
Large School	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Medium Office	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Medium Retail	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Mixed-use Retail	0.57	0.57	0.57	0.57	0.57	0.56	0.56	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
Non-refrigerated Warehouse	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Restaurant	27.97	27.99	28.00	27.97	27.89	28.11	27.97	28.10	28.06	28.05	27.98	27.95	27.97	28.14	28.07	28.06
Small Office	0.97	0.97	0.96	0.96	0.97	0.95	0.96	0.98	0.98	0.98	0.96	0.97	0.97	0.97	0.96	0.98
Small School	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.40	1.40	1.40	1.38	1.38	1.38	1.39	1.38	1.40

2.4.3 Incremental First Cost

The incremental first cost will increase slightly. This is because all modern systems installed follow Section 110.3 and have at least basic controls. The increase in first costs is a result of the increased product cost. The Statewide CASE Team also assumed the increase in installation and maintenance cost of the proposal are zero. This is based on stakeholder feedback received.

To estimate the incremental first cost the Statewide CASE Team used the Grundfos line of pumps without digital controls (MAGNA1) and compared it to the line with variable speed reaction to digital controls (MAGNA3). The two pump sizes the Statewide CASE Team used in the analysis were 1/8 and 1/6 horsepower. These incremental cost increases resulted in an increase of \$156.25 for the 1/12, 1/6, and 1/3 horsepower pumps and \$1,450 for the 1/6 horsepower pump.

2.4.4 Incremental Maintenance and Replacement Costs

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

The proposed measure does not introduce additional maintenance requirements beyond those of existing ECM circulator pumps used in nonresidential SHW systems. Maintenance procedures remain consistent with current practices, including periodic inspections, verification of pump operation, and lubrication if applicable. This measure does not require specialized tools, additional labor, or changes to standard maintenance schedules.

The Statewide CASE Team assumed the incremental replacement cost associated with the measure is equivalent to the first-purchase price difference between the proposed and baseline. The expected useful life of the digitally controlled circulator pumps aligns with the typical ECM pump currently in service, estimated at 15-20 years, depending on operating hours and water conditions. Energy savings will persist over the pump's lifetime assuming proper maintenance practices. The measure does not introduce any features that would increase risk of premature failure relative to baseline ECM pumps.

2.4.5 Cost Effectiveness

The incremental cost of the proposed measure consists solely of the first cost difference and replacement cost difference for digitally controlled variable-speed circulator pumps relative to the baseline ECM pump. The Statewide Case Team assumed no additional maintenance costs associated with this measure, because estimates of installation, set up via the onboard pump controls menu, and maintenance are already part of normal project scopes and in the context of an alteration project.

The Statewide CASE Team is researching and documenting the projected additional costs associated with education and training, design, specifying and implementation of the proposed measure, to estimate impacts on overall cost effectiveness.

Results of the per-unit cost-effectiveness analyses are presented in Table 9 and Table 10 for new construction/additions and alterations, respectively.

In the tables below, all values are 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 proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including 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-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.

BCR analysis was conducted across 16 building prototypes for the proposed hot water distribution controls measure. Most of the prototypes demonstrate cost effectiveness, with BCRs exceeding 1.0. However, a subset of prototypes yielded BCRs below 1.0, indicating that the energy savings achievable in these configurations do not offset the incremental installed cost of the required controls. To ensure the measure applies only where it is demonstrated to be cost-effective, this measure would apply for systems with a total hot water distribution piping length below 160 linear feet. Systems below this threshold are excluded from the proposed requirement on the basis that compliance would impose costs disproportionate to the achievable energy savings. The Statewide CASE team established this threshold by identifying the piping length at which the BCR transitions from below 1.0 to above 1.0 across the analyzed prototypes.

Table 9: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	1.98	0.62	3.22
2	0.90	0.46	1.95
3	0.61	0.23	2.67
4	0.64	0.24	2.68
5	1.48	0.48	3.06

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
6	0.90	0.33	2.71
7	1.45	0.48	3.01
8	0.89	0.33	2.67
9	0.88	0.32	2.76
10	1.03	0.44	2.35
11	1.40	0.45	3.09
12	0.62	0.28	2.19
13	1.49	0.49	3.02
14	1.50	0.51	2.95
15	0.87	0.39	2.26
16	0.92	0.38	2.46

Table 10: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to- Cost Ratio
1	0.96	0.40	2.37
2	0.50	0.35	1.41
3	0.33	0.16	2.03
4	0.35	0.17	2.05
5	0.73	0.34	2.16
6	0.43	0.22	1.97
7	0.71	0.32	2.23
8	0.42	0.22	1.93
9	0.41	0.20	2.02
10	0.50	0.30	1.66
11	0.69	0.32	2.16
12	0.34	0.22	1.59
13	0.73	0.33	2.22
14	0.72	0.33	2.18
15	0.43	0.28	1.56
16	0.46	0.27	1.75

2.5 Circulator Pump Controls - Statewide Impacts

2.5.1 Statewide Energy and Energy Cost Savings

The Statewide CASE Team used the methodology described in 2.4.2 Energy and Energy Cost Savings Results. The Statewide CASE Team sourced the percentage of buildings impacted by the measure from the California Commercial End-Use Survey end use data (Commission 2022). The Statewide CASE Team then used the percentage of buildings impacted with the prototype energy and energy cost savings results to obtain statewide energy and energy cost savings.

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

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

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 11) and alterations (Table 12) by CZ. Table 13 presents first-year statewide savings from new construction, additions, and alterations.

Table 11: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2026 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	143,893.54	0.003	0.006	0.000	1.75	0.04
2	2,862,392.21	0.050	0.098	0.001	11.50	0.54
3	15,829,125.26	0.191	0.371	0.006	47.75	2.09
4	8,218,503.80	0.106	0.207	0.003	24.46	1.14
5	599,889.48	0.010	0.019	0.001	4.56	0.13
6	9,284,711.71	0.155	0.301	0.005	43.32	1.75
7	3,359,259.12	0.052	0.100	0.003	26.80	0.70
8	15,652,257.19	0.282	0.548	0.007	63.18	3.03
9	25,543,840.64	0.447	0.869	0.012	104.66	4.85
10	9,807,471.50	0.188	0.366	0.006	52.96	2.13
11	1,303,297.09	0.017	0.034	0.001	9.72	0.24
12	8,210,756.91	0.064	0.125	0.005	42.81	0.96
13	2,153,235.96	0.030	0.059	0.002	18.84	0.44
14	1,224,841.98	0.017	0.033	0.002	12.86	0.27
15	1,687,946.19	0.028	0.055	0.001	6.12	0.30
16	538,765.79	0.007	0.013	0.000	3.83	0.10
Total	106,420,188.37	1.647	3.204	0.055	475.12	18.70

Table 12: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide Additions Impacted by Proposed Change in 2026 (Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	592,482.26	0.005	0.011	0.000	2.20	0.07
2	10,452,325.91	0.110	0.214	0.002	14.14	1.06
3	49,002,451.07	0.325	0.633	0.007	63.60	3.38
4	26,977,274.53	0.194	0.377	0.004	34.56	1.98
5	1,938,956.73	0.016	0.030	0.001	5.87	0.19
6	29,777,733.27	0.219	0.426	0.007	56.40	2.41
7	12,959,701.94	0.090	0.175	0.005	40.30	1.16
8	57,529,238.63	0.480	0.933	0.009	81.21	4.89
9	100,477,045.20	0.845	1.644	0.016	133.80	8.51
10	48,662,953.56	0.458	0.892	0.012	102.01	4.90
11	4,182,578.70	0.031	0.061	0.001	12.60	0.39
12	30,111,428.64	0.141	0.274	0.008	64.74	1.81
13	8,600,177.58	0.061	0.118	0.003	28.47	0.79
14	5,557,388.88	0.037	0.073	0.003	21.60	0.53
15	7,508,875.54	0.061	0.118	0.001	11.32	0.62
16	2,359,761.77	0.017	0.032	0.001	6.18	0.20
Total	396,690,374.22	3.089	6.010	0.079	679.00	32.88

Table 13: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	1.65	3.20	0.06	475.12	18.70
Alterations	3.09	6.01	0.08	679.00	32.88
Total	4.74	9.21	0.13	1,154.12	51.59

2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 14 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 2,175 metric tons of carbon dioxide equivalent (CO₂e) 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 14: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO ₂ e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO ₂ e)	Total Reduced GHG Emissions (Metric Ton CO ₂ e)	Total Monetary Value of Reduced GHG Emissions (\$)
New Construction & Additions	388.20	695.19	1,083.39	133,417.01
Alterations	390.61	700.57	1,091.18	134,375.94
Total	778.80	1,395.77	2,174.57	267,792.95

2.5.3 Statewide Water Use Impacts

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

2.5.4 Statewide Material Impacts

This measure would potentially result in a relatively minimal increase in materials used in the required controls. These include steel, brass, plastic, epoxy, and copper.

The Statewide CASE Team is continuing to research these potential impacts and will update this section as more information becomes available.

2.5.5 Environmental Impacts

The Statewide CASE Team does not expect the proposed measure would result in any significant environmental benefits and/or adverse environmental effects. Appendix D provides further details on this assessment.

2.5.6 Other Non-Energy Impacts

There are no additional non-energy impacts resulting from this proposed change.

2.6 Circulator Pump Controls - Proposed Language Code

2.6.1 Guide to Markup Language

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

2.6.2 Administrative Code (Title 24, Part 1)

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

Energy Code (Title 24, Part 6) **Section 140.5 – PRESCRIPTIVE REQUIREMENTS FOR SERVICE WATER HEATING HOT WATER SYSTEMS**

(a) **Nonresidential occupancies.** Service water heating hot water systems in nonresidential buildings shall meet the requirements of 1 or 2 below, or meet the performance compliance requirements of Section 140.1.

Exception to Section 140.5(a)1: A water heating hot water system serving an individual bathroom space may be an instantaneous electric water heater.

2. **All other occupancies.** A service water heating hot water system that meets the applicable requirements of Sections 110.1, 110.3, 120.3, and 140.5(c), and 140.5(d).
- (d) **Circulator pump controls.** Pumps serving recirculation systems with more than 160 linear feet of supply and return piping in the recirculated path shall meet 1, 2 and 3 below:
 1. Be equipped with one of the following controls:
 - A. Controls that automatically adjust pump speed in response to an associated control signal. Controls shall meet either i or ii below:
 - i. Single loop or single riser recirculation system pump controls shall meet a. or b.:
 - a. Maintain return temperature setpoint of a maximum temperature of 125 °F
 - b. Differential pressure with thermal balancing valve
 - ii. Multi-loop or multi-riser distribution system pump controls shall have differential pressure control with thermal balancing valves on each riser.
 - B. Controls that activate the pump in response to an associated control signal to meet the designated operating conditions shall meet i or ii below:

- i. Pump control for single loop or single riser recirculation systems using hot water demand-based controls that activate/deactivate the pump shall include a and b:
 - a. Hot water flow sensor or proxy temperature sensor that can indicate draws in combination with recirculation return temperature sensor.
 - b. Hot water recirculation priming timer that automatically activates the pump on a sequential period to reheat the recirculation loop to ensure adequate hot water availability during operating periods.
 - ii. Pump control for multi-loop or multi-riser distribution system recirculation systems using hot water demand-based controls shall not be permitted.
 2. User-defined conditions and operational parameters retained during loss of power and resume operation with the stored settings upon return of power without requiring manual input.
 3. Provide fault indication by means of audible or visual alarm, or electronic notification.

Section 141.0(b)2.N: ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS, TO EXISTING OUTDOOR LIGHTING, AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

N. Service hot water systems shall meet the requirements of Section 140.5, except for the solar water heating requirements.

2.6.3 Reference Appendices

2.6.4 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published. An example of content that the compliance manual will cover is when to select constant return temperature control versus when to select differential pressure control with a thermal balancing valve. For small systems, pumps with constant return temperature control may be too large whereas smaller pumps are available with differential pressure control. An example will be provided based on the prototype analysis the Statewide CASE Team performed.

2.6.5 ACM Reference Manual

The Statewide CASE Team proposes the following changes to Nonresidential and Alternative Calculation Method Reference Manual:

- Section 5.9.1. Service Water Heating System Loads and Configuration: Add return to primary and temperature maintenance heater in series (TMHS) configurations for split heat pump water heating systems.
- Section 5.9.2 Water Heaters: Add modeling rules for split heat pump water heating systems and unitary heat pump / electric resistance hybrid water heaters.
- Section 5.9.3 Recirculation Systems: Add modeling rules for calculating recirculation system heat loss for nonresidential buildings and incorporate a recirculation heat loss adjustment factor to implement the proposed prescriptive requirement of circulator pump controls.
- Appendix 5.4A: In tab “For CSV - 2022 SpcFuncData”, add a column to specify recirculation pipe heat loss density (HotWtrDistHrlyLossDens) for building space types relevant to the nonresidential prototype buildings covered by this CASE study. For other building spaces, recirculation pipe heat loss is assumed to be zero according to current ACM modeling rules.

The following sections provide proposed changes to ACM language.

Section 5.9.1. Service Water Heating System Loads and Configuration

WATER HEATING SYSTEM CONFIGURATION

Applicability: All water heating systems.

Definition: The configuration and layout of the water heating system including the number of water heaters; the size, location, length, and insulation of distribution pipes; recirculation systems and pumps; and any other details about the system that would affect the energy model. [System configuration for split heat pump water heaters includes two options: return to primary and temperature maintenance heater in series.](#)

Units: Data structure.

Input Restrictions: None.

Standard Design: For healthcare facility spaces, the same as proposed. [For school buildings less than 25,000 square feet and less than four floors in climate zones 2 through 15, the standard design shall have a heat pump water heating system. If the proposed design has heat pump water heater\(s\), the standard design shall have the same type and size of heat pump water heater. If the proposed design has split heat pump water heater\(s\), the standard design shall have the return to primary configuration.](#)

For all other spaces, the standard design shall have one gas storage water heater if any of the spaces have a space water heating fuel type of gas (from Appendix 5.4A), [if none of the spaces have a space water heating fuel type of electric, and if the proposed hot water heater is not electric,](#) ~~and the~~ The standard design ~~will~~ [shall](#) have one [electric](#)

water heater if the any of the spaces have a space water heating fuel type of electric ([from Appendix 5.4A](#)) or the proposed hot water heater is electric.

Standard Design: Existing Buildings: Same as proposed if the proposed system is existing.

Section 5.9.2. Water Heaters

WATER HEATER TYPE AND SIZE

Applicability: All water heaters.

Definition: This building descriptor includes information needed to determine the criteria from baseline standards. The choices and the associated rated capacity (heat input rate) are listed in the *2015 Appliance Efficiency Regulations*, except that oil-fired water heaters and boilers are not supported.

Units: List conventional, heat pump split, [unitary heat pump and electric resistance hybrid](#), or heat pump packaged [without electric resistance heating](#).

Input Restrictions: As designed.

Standard Design: For healthcare facility spaces, the same as proposed. ~~For all other spaces, the standard design shall have one gas storage water heater if any of the spaces have a space water heating fuel type of gas (from Appendix 5.4A), and the standard design building will have one electric water heater if the any of the spaces have a space water heating fuel type of electric.~~ For school buildings less than 25,000 square feet and less than four floors in climate zones 2 through 15, the standard design shall have a heat pump water heating system. [If the proposed design has heat pump water heater\(s\), the standard design shall have the same type and size of heat pump water heater.](#)

[For all other spaces, the standard design shall have one gas storage water heater if any of the spaces have a space water heating fuel type of gas \(from Appendix 5.4A\), none of the spaces have a space water heating fuel type of electric, and the proposed hot water heater is not electric. The standard design building shall have one electric water heater if any of the spaces have a space water heating fuel type of electric \(from Appendix 5.4A\) or the proposed hot water heater is electric.](#)

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

SYSTEM COEFFICIENT OF PERFORMANCE (COP)

Applicability: [Heat pump water heaters.](#)

Definition: [System COP is the ratio of the hot water energy delivered by the heat pump water heater system divided by the electric energy used by the system, in the same units. Hourly energy use of a heat pump water heater system is calculated by dividing](#)

the system's hourly heating load, which is the sum of hourly hot water draw energy and hourly recirculation distribution loss, by system COP.

Units: Unitless ratio.

Input Restrictions: Shall not exceed the corresponding COP value provided in NEEA's commercial HPWH Qualified Product List (QPL). , The input value shall not exceed the maximum COP provided in NEEA's QPL for heat pump water heaters not included in list.

Standard Design: For proposed design using split heat pump water heater(s), if the proposed design uses a return to primary configuration, system COP of the Standard Design shall have the same system COP as that of the proposed design; otherwise, system COP of the Standard Design shall be the proposed system COP multiplied by 1.05.

For proposed design using heat pump and electric resistance hybrid water heater(s), the Standard Design shall have a system COP of 1.3. System COP of the proposed design is 1.3 if it meets the requirements provided in 2025 Title 24 Part 6, Section 140.5(a)3; otherwise, system COP of the proposed design is 0.9.

Standard Design: Existing Buildings: Same as proposed if water heater is existing.

Section 5.9.3 Recirculation Systems

This chapter describes the building descriptors for hot water recirculation systems. For nonresidential application, recirculation systems are not modeled. For multifamily, the standard design has a recirculation system when the proposed design does.

Recirculating systems shall follow the rules set forth in Appendix B: Water Heating Calculation Method.

RECIRCULATION PIPE HEAT LOSS DENSITY

Applicability: All building spaces except for High-Rise Residential Living Spaces, Hotel Function Area, and Hotel/Motel Guest Room.

Definition: Hourly recirculation pipe heat loss of each space in the building is calculated by multiplying the recirculation pipe heat loss density by the floor area (square foot) of the space. Hourly recirculation pipe heat loss of the building is the sum of the recirculation pipe heat loss of all spaces in the building.

Units: Btu/hour per square foot.

Input Restrictions: Users input values are not allowed.

Standard Design: For the Standard Design, recirculation pipe heat loss densities shall be determined based on Appendix 5.4A. For the proposed design, if an advanced circulator pump control is installed per Title 24 Part 6, Section 140.5, recirculation pipe

heat loss densities shall be the same as those in the Standard Design. Otherwise, recirculation pipe heat loss densities shall be 3% higher than corresponding values in the Standard Design.

Appendix 5.4A

In tab “For CSV - 2022 SpcFuncData”, add a column with a header of HotWtrDistHrlyLossDens to specify recirculation pipe heat loss density (btu/h per ft²). *The Statewide CASE Team is working on defining appropriate pipe heat loss density values, and will provide a table of values in the Final CASE report.*

2.6.6 Compliance Forms

As discussed in Section 2.1.4.5, the Statewide Case Team would update the NRCC-PLB, NRCI-PLB, LMCC-PLB, and LMCI-PLB, compliance forms to reflect the proposed change. For CBECC, software updates may be required to support NRCC-PRF-E compliance reporting. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

3. Require Return to Primary Configuration

3.1 Require Return to Primary Configuration - Measure Description

3.1.1 Proposed Code Change

This proposed measure would create a prescriptive pathway to require the Return to Primary configuration for split heat pump water heater (HPWH) systems with recirculation in nonresidential buildings. This would include an alternative pathway for products on the Northwest Energy Efficiency Alliance (NEEA) Tier 3 qualified product list, including standardized configurations and manufacturer’s requirements. The proposed measure would update JA14 – Qualification Requirements for Hot Water Systems to include new requirements for the design, installation, equipment, and control start up, and performance data reporting (coefficient of performance (COP), defrost derate, input power, output capacity, refrigerant type, etc.).

This proposed measure would require additions to the compliance forms, changes to the compliance software, and new plan check and building inspector activities.

Table 15 summarizes the scope of the proposed code change. This requirement would apply to additions and alterations with a proposed water heater replacement with split HPWHs. The proposed measure does not require installation of HPWHs.

Table 15: Scope of Proposed Code Change

A indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
Single Family	<input checked="" type="checkbox"/> New Construction	Mandatory
Multifamily	<input checked="" type="checkbox"/> Additions	<input checked="" type="checkbox"/> Prescriptive
<input checked="" type="checkbox"/> Nonresidential (Not Group R uses)	<input checked="" type="checkbox"/> Alterations	Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	<ul style="list-style-type: none"> Part 6, Section 140.5(a) Part 6, Section 141.0(a) Part 6, Section 141.0(b) 	2025-NRCC-PLB-E 2025-NRCI-PLB-E 2025-LMCC-2025-PLB-01-E 2025-LMCI-PLB-E	Section 5.9.1 Service Water Heating System Loads and Configuration

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
	Joint Reference Appendix JA14	NRCC-PRF-E LMCC-PRF-E	
Third Party Verification)		Updates to Compliance Software	
<input checked="" type="checkbox"/> No changes to third party verification		<input type="checkbox"/> No updates	
<input type="checkbox"/> Update existing verification requirements		<input checked="" type="checkbox"/> Update existing feature	
<input type="checkbox"/> Add new verification requirements		<input checked="" type="checkbox"/> Add new feature	

3.1.2 Benefits of Proposed Change

By eliminating the electric resistance (ER) Temperature Maintenance Heater in Series (TMHS), the proposed change would reduce electricity capacity requirement, peak demand, and grid impact, and improve grid reliability. The compact design of the Return to Primary configuration would reduce installation costs, space requirements, and the complexity of installation and start-up. Return to Primary configuration has a higher system (COP) than the TMHS configuration, which would achieve operational savings. Proposed start-up requirements also ensure long-term savings for central HPWH systems.

3.1.3 Background Information

Split HPWH system configurations have evolved since the 2022 code cycle. For the 2022 code update the Statewide CASE Team had minimal lab and field research, and limited the prescriptive code to only TMHS configuration, also known as swing tank configuration, with single- and multi-pass HP setups. The TMHS configuration in Figure 1 shows the temperature maintenance heater piped in series upstream from the primary storage tank. The system pipes the hot water return line into the bottom of the temperature maintenance tank. The system decouples the temperature maintenance heater from the primary system to handle the recirculation loop load, which allows the primary storage tank to handle the hot water loads, maintaining stratification for maximum efficiency in the primary storage tank. The primary role of the electric resistance elements in the temperature maintenance tank is to meet the recirculation heat loss load, but it can also operate as back up for the primary system. During the 2022 code development, industry standard practice considered the TMHS configuration as the most reliable option for all refrigerant types because decoupling the temperature maintenance loop maximizes the reliability of the primary system.

In 2022 and 2023, during the 2025 code development cycle, general industry consensus was that multi-pass HPs work more efficiently as a system in Return to

Primary than TMHS configuration, thus the Statewide CASE Team cleaned up the language to focus the prescriptive requirement to single-pass HPs in TMHS configuration. The 2025 code allows Return to Primary and parallel temperature maintenance tank configurations using the alternative prescriptive pathway with NEEA QPL Tier 2.

In recent years, as HPWH products have matured and more data have become available, recent research has demonstrated that Return to Primary configuration with conventional refrigerants is reliable, more efficient than TMHS configuration, and cost-effective with a reduced footprint. Therefore, the Statewide CASE Team proposes to further adjust the split HPWH system to make single pass Return to Primary the prescriptive requirements, while allowing other split HPWH configurations under the alternative prescriptive pathway if they meet the required minimum system COP.

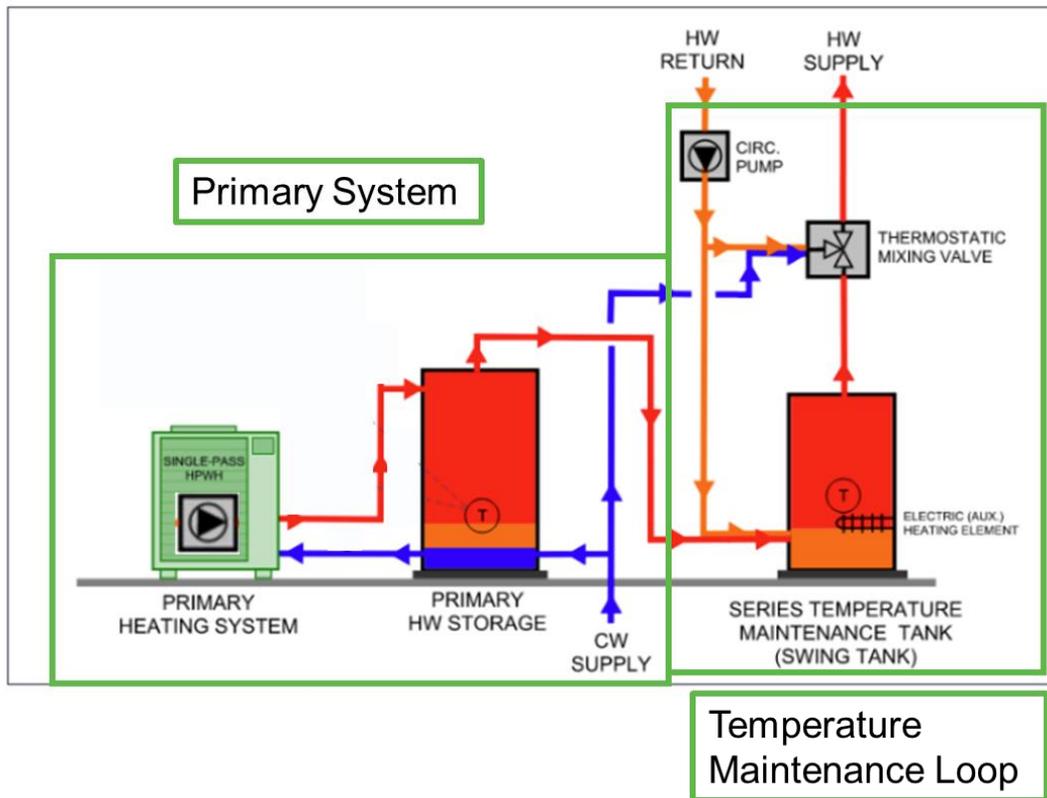


Figure 1: Diagram of the TMHS configuration

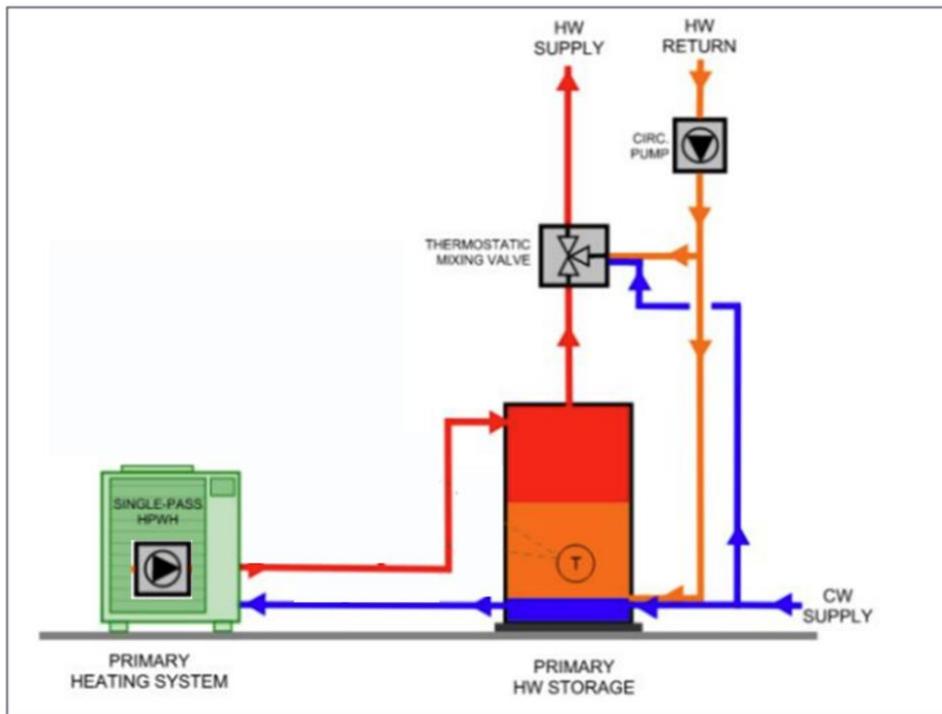


Figure 2: Diagram of the Return to Primary configuration

In Return to Primary configuration, the return water goes back to the primary tank where the primary HPWH heats it, as shown in Figure 2. The primary HPWH simultaneously handles both hot water loads and recirculation heat losses. Because Return to Primary configuration eliminates the need for the temperature maintenance tank, which is often an electric resistance tank, the Statewide CASE Team recommends Return to Primary configuration. Specifically, many nonresidential buildings have relatively low hot water draws compared to recirculation heat losses, such as supermarkets, office buildings, retail, arenas, and assembly, and trigger significant ER usage in the TMHS configuration. In these low draw applications, using Return to Primary configuration would significantly reduce electricity use.

Recent lab tests performed by PG&E Applied Technology Services (PG&E, SCE 2024) characterize the central HPWHs with recirculation and show that Return to Primary with R-134a can maintain reliability while reducing equipment requirements and increasing COP compared to the TMHS configuration. The Association for Energy Affordability (AEA) performed field testing with large CO₂ systems (Brooks, Neal and Young 2024) and found that the Return to Primary configuration operates at a higher COP and higher reliability compared to the TMHS configuration. Additionally, AEA is currently conducting a series of demonstration studies for low global warming potential (GWP) HPWHs with recirculation for a Code Readiness project funded by SCE. If these tests show that the

Return to Primary configuration can maintain sufficient hot water delivery performance with high return temperatures for a broader range of refrigerants, they can further support this measure. The Statewide CASE Team expects to obtain the results in December 2025.

Pending air quality rules by the South Coast Air Quality Management District (SCAQMD) and the Bay Area Air Quality Management District (BAAQMD) will go into effect between 2026 and 2031. Therefore, updating the Energy Code to improve HPWH design, installation, and start up ensures the most energy-efficient HPWH implementation, as well as a successful transition from conventional water heating solutions.

The current nonresidential prescriptive service water heating system requirements do not include requirements specific to split system HPWHs despite the increasing use of central HPWHs in medium to large nonresidential buildings. The current requirements apply only to HPWHs in school buildings less than 25,000 square feet and less than 4 stories in CZs 2 through 15. There are no requirements or guidance for HPWHs in all other occupancies. This measure, which is focused on nonresidential applications, draws on lessons learned from the development of multifamily requirements, including recent research (Evan Green and Ben Larson 2024) (Brooks, Neal and Young 2024) that indicates that Return to Primary is advantageous over the TMHS configuration in many cases. The proposed measure will establish a baseline configuration that ensures adequate hot water delivery and reduces energy use and energy costs associated with split-system HPWH in nonresidential applications.

Although the Return to Primary configuration does not typically require backup heating, in some extreme weather conditions, it might be necessary to add backup heating. This proposed measure would add code language to ensure appropriate configuration and operation of the backup heater, for example, by not having the backup heating element or control sensor at the bottom of the primary tank.

3.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 3.6 Require Return to Primary Configuration - Proposed Language Code of this report for detailed revisions to code language.

3.1.4.1 Energy Code Change Summary

SECTION 100.1 DEFINITIONS AND RULES OF CONSTRUCTION

The proposed measure adds definitions for temperature maintenance heater in series (TMHS) configuration, primary heat pump storage tank, and service hot water systems.

SECTION 140.5 PRESCRIPTIVE REQUIREMENTS FOR SERVICE WATER HEATING SYSTEMS

Subsection 140.5(a): The proposed measure would redefine the hot water systems in nonresidential by replacing the previous *service water heating* terminology in this section with *service water heating systems* to better reflect the system (including heating, storage, and distribution of hot water) rather than only referring to the water heating itself. The proposed measure would add prescriptive requirements and alternative prescriptive pathways for service water heating systems with split HPWH systems.

SECTION 141.0 ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING NONRESIDENTIAL, AND HOTEL/MOTEL BUILDINGS, TO EXISTING OUTDOOR LIGHTING, AND TO INTERNALLY AND EXTERNALLY ILLUMINATED SIGNS

Subsection 141.0(a): The proposed measure would add requirements for projects whose scope includes the addition of split system HPWH(s).

Subsection 141.0(b): The proposed measure would add requirements for projects whose scope includes alterations that replace existing service water heater(s) with split HPWH(s).

3.1.4.2 Reference Appendices Change Summary

Joint Appendix (JA) 14 – Qualification Requirements for Hot Water Systems:

JA14.3.2 Performance Data Reporting: The proposed measure would add new requirements for system COP reporting with associated performance data.

JA14.4 Design Condition Documentation Requirements: The proposed measure would add new requirements for defrost derate design documentation.

The proposed measure would expand JA14 to add new subsections JA14.5 to add HPWH requirements on controls, alarms, loss of power restoration, etc., for manufacturers, designers, and contractors, respectively.

3.1.4.3 Compliance Manuals Change Summary

The proposed measure would update section 4.8.3 of the Nonresidential Compliance Manual, which outlines prescriptive requirements for service water heating systems. The manual would need to provide new guidance on split heat pump water heater installation in a Return to Primary configuration, including system diagrams and key installation and start up considerations.

3.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The proposed measure would add section 5.14 of the nonresidential ACM, which outlines standard and proposed design for service water heating systems if the proposed design is a split HPWH.

3.1.4.5 Compliance Forms Change Summary

The proposed code change would modify the compliance forms listed below.

2025-NRCC-PLB-E: Nonresidential Certificate of Compliance Domestic Water Heating

2025-NRCI-PLB-E: Nonresidential Certificate of Installation Domestic Water Heating

2025-LMCC-PLB-01-E: Low Rise MultiFamily Certification of Compliance Domestic Water Heating System

2025-LMCI-PLB-E: Low Rise MultiFamily Certification of Installation Domestic Water Heating System

2025-NRCC-PRF-E: Domestic Water Heating: Nonresidential Certificate of Compliance Domestic Water Heating

2025-LMCC-PRF-E: Domestic Water Heating: Low-Rise Multifamily Certificate of Compliance Domestic Water Heating

3.1.5 Measure Context

3.1.5.1 Comparable Model Codes or Standards

The proposed measure does not have relevant model codes or standards.

3.1.5.2 Interactions with Other Regulations

The proposed measure does not have interactions with other regulations.

3.2 Require Return to Primary Configuration - Compliance and Enforcement

3.2.1 Compliance Considerations

The Statewide CASE Team summarized the compliance verification activities related to this measure that need to occur during each phase of the project below.

During the design phase, plumbing designers would design the Return to Primary configuration for central HPWH systems based on engineering analysis and manufacturer guidelines. Designers would follow the design, installation, and start up requirements in reference appendices to comply with the proposed measure.

During the permit application phase, plan examiners would perform plan checks, review the plumbing diagram, check the recirculation loop, and verify that the design meets either prescriptive or alternative pathway requirements.

During the construction phase, plumbing contractors would install the central HPWH system as designed and per manufacturer instructions. Contractors would follow the installation and start up requirements in the reference appendices. Electrical contractors would install electrical services as designed. After installation, either the plumbing contractor or a contracted third party would perform necessary start-up functional testing.

During the inspection phase, plumbing contractors would populate NRCI forms for verification. Inspectors would check the forms and make sure the installed system matches the forms.

The proposed measure would add detailed design, installation, start up, and performance requirements for central HPWH in reference appendices to help streamline the compliance process.

3.2.2 Impact on Market Actors

Table 16 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements. There will be a learning curve, but Return to Primary is not a new concept. The Statewide CASE Team does not expect the Return to Primary design and installation to be more difficult compared to TMHS configuration. The challenge for designers and building department staff will be limited experience with the HPWH systems in general.

Table 16: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders ^a	None	None
Design Professionals ^b	Limited awareness of HP products in Return to Primary configuration. Limited experience with HPWH designs and applicability.	Training and best practice for designers. Develop case studies and provide instructional webinars. Provide supplemental guidance and recommendations and context in the compliance manual.

Market Actor	Impact(s)	Suggested Outreach and Education
Construction Team^c	Limited installation experience with the HPWH systems Added time and coordination to install and start up HPWH systems	Training and best practice for contractors. Provide instructional webinars and in-person training.
Building Departments^d	Limited experience with HPWH systems.	Add new plan check and building inspector activities related to compliance with this measure. Provide training to plan checkers and building inspectors related to the proposed changes mandated in each code cycle.
Verification Testers^e	N/A	N/A
Building Owners, Managers, and Occupants	Reduced energy bills and run outs. Improved insights to maintenance needs before they become urgent.	Education on the benefits of return to primary performance.
Manufacturers and Distributors	Lack of sizing or performance data.	Encourage manufacturers to provide readily available product specifications. Add performance data reporting requirement in the reference appendices (COP, defrost derate, input power, output capacity, refrigerant type, etc.).

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

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

market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Design Professionals. Design professionals, specifically plumbing designers, would need to educate themselves on the proper design of Return to Primary configuration. Due to the increasing number of manufacturers that promote Return to Primary configuration, the Statewide CASE Team expects that this education would come primarily from HPWH manufacturers via lunch and learn sessions and specification support in addition to the suggestions in Table 16.

Building Departments. Building department staff would need education regarding Return to Primary configuration. The suggestions in Table 16 intend to address the marginal impact of the measure. The Statewide CASE Team expects that the more significant training need is for education on HPWH in general.

Builders. The proposed change would likely affect commercial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industries equally; instead, it would primarily affect specific subsectors within the industry. Table 17 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

Table 17: Specific Subsectors of the California Commercial Building Industry Impacted by Proposed Change to Code/Standard by Subsector in 2025 (Estimated)

Construction Subsector	Establishments*	Employment	Annual Payroll (Billions \$)
Nonresidential Electrical Contractors	3,245	72,794	7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	5.8

Source: (State of California n.d.)

*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. US Bureau of Labor Statistics, Handbook of Methods. <https://www.bls.gov/opub/hom/cew/concepts.htm>

Manufacturers. There is no California-based business that manufactures HPWH products in California. Harvest Thermal develops controls for Combi HP systems, but it uses HP products manufactured by other manufacturers, and at present largely serves the residential and multi-family residential building markets. SanCO2 is an American distributor of small modular HPWHs based in Japan. ECO2 is the company that makes

the SanCO2 HPWHs. Their headquarters are not in California, but they have offices in California.

3.2.3 Compliance Software Updates

This proposed code change would require CBECC to add the capability to model central heat pump water heaters (CHPWH) for nonresidential buildings.

This proposed code change would require CBECC to update the requirements for compressor cut-off temperatures to better reflect the capabilities of different HPWH products with different refrigerants.

This proposed code change would require CBECC to add heating capacity derating factors to more accurately model defrost conditions for Return to Primary systems with different refrigerant and controls.

CBECC software will need to be updated to support reporting to the NRCC-PRF-E and LMCC-PRF-E forms, to support modeling output reports for the new measure.

The Statewide CASE Team will provide detailed recommendations on software enhancements in summer 2026.

3.2.4 Cost of Enforcement

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

There will be additional costs to ensure compliance with the proposed measure, including training on the new measure and additional labor for enforcement and verification for all projects implementing the measure.

The Statewide CASE Team will be researching and documenting the projected impact on plan checkers and building inspectors, as well as additional administrative costs to manage and properly enforce the measure, including contacting AHJs and other stakeholders for estimates of additional staff time and training costs.

3.3 Require Return to Primary Configuration - Market and Economic Analysis

3.3.1 Market Structure and Availability

3.3.1.1 Current Market Structure and Availability

The current market share of Return to Primary systems is small but growing. The low market share of split system HPWH in general is primarily the reason. The current code

baseline and industry standard practice of TMHS configuration further limits Return to Primary systems. Historically, utility programs in California have incentivized unitary HPWH in nonresidential buildings due to high calculated energy savings. IOUs and other entities are developing new incentive designs to better incentivize split systems in 2026.

The proposed measure will reference the NEEA Advanced Water Heating Specification (AWHS) V8.1 as an alternative prescriptive pathway. A listing in NEEA's commercial HPWH Qualified Product List (QPL) (NEEA 2025) requires manufacturers to submit performance data and estimate an annual system COP using the CHPWH System Performance Calculator in the Product Assessment Datasheet (PADS). NEEA AWHS V8.1 also defines the efficiency tiers, which are the minimum system COP used for listing on the QPL. The Statewide CASE Team leveraged the NEEA QPL list and conducted product research by reviewing 59 HPWH products from 15 manufacturers that can work in central applications. Seven manufacturers have products that can work in Return to Primary configuration. Five of the seven manufacturers explicitly advocated Return to Primary in their product brochures or installation manuals. This indicates rising awareness of Return to Primary configuration in the market. Furthermore, although the Statewide CASE Team is not aware of Return to Primary installations outside research projects, there is widespread awareness of Return to Primary configuration among the portion of the market that is familiar with HPWH as indicated by the inclusion of Return to Primary configuration in the NEEA AWHS8.1.

The Statewide CASE Team reviewed the manufacturer-provided system COP values listed in the NEEA QPL list under mild CZ. For products that work in both TMHS and Return to Primary configuration, Return to Primary configuration performs at the highest COP with a single pass. The multi pass Return to Primary configuration has the lowest system COP. Among all products reported, 40 products can work with Tier 3 efficiency. For the alternative prescription pathway, the Statewide CASE Team is proposing products with Tier 3 or higher COPs.

Additionally, most products use low-GWP refrigerant, which can work at lower ambient temperatures. Figure 3 displays the HP compressor cut-off temperature from all products reviewed, showing that most of the products (80 percent) can work at 23°F or below. The products that have a compressor cut-off temperature above 23°F are mostly older products. The modern products can work at lower temperatures.

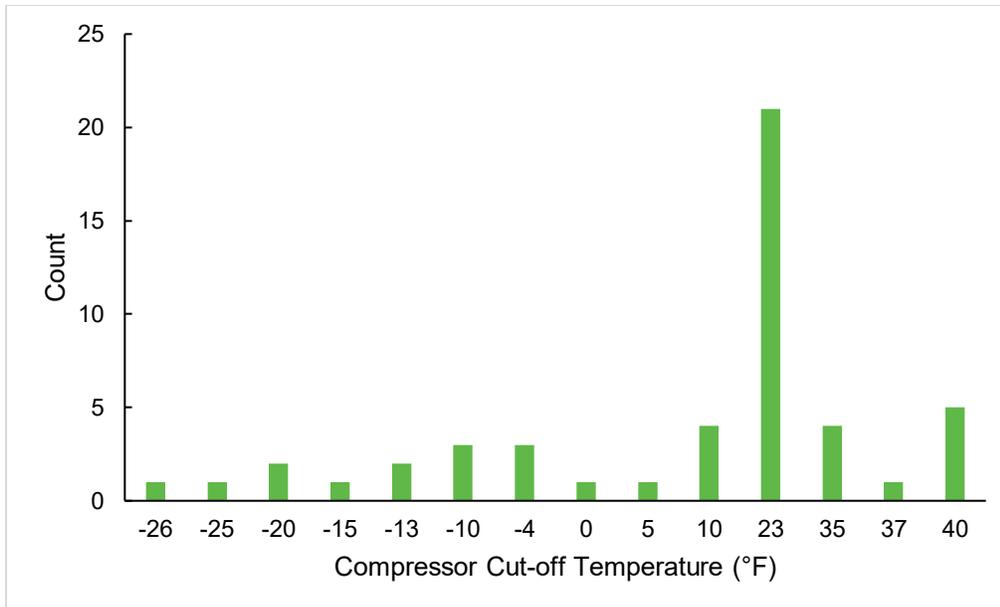


Figure 3: HP Compressor Cut-off Temperature

Product research and lab tests (Evan Green and Ben Larson 2024) both show conventional refrigerant-based HPWHs are primarily installed in the Return to Primary configuration with continuous recirculation. In small central HPWH applications, ongoing field studies show small CO₂ HPWH in the Return to Primary configuration with non-continuous recirculation have a higher COP than TMHS and therefore is a good retrofit option. New modular 120V/240V low-GWP low-cost split system HPWHs are reaching the market and may be good candidates for small nonresidential buildings, such as salons, small retail, outpatient offices, etc.

3.3.1.2 Market Challenges and Solutions

A key market challenge for this proposed measure is that there is no standardized design and installation practice for CHPWH in the Return to Primary configuration due to limited applications on the market. There is also a lack of awareness of Return to Primary performance in nonresidential buildings, and that Return to Primary can be a viable option in many applications.

To address these challenges, the Statewide CASE Team will contact the building community, vendors, and distributors to identify buildings and attain building plans with Return to Primary systems in nonresidential buildings. The Statewide CASE Team will also interview and survey manufacturers, distributors, designers, contractors, and developers to understand design decisions, product availability, reliability, and performance. The Statewide CASE Team also recommends providing more training and education on various Return to Primary designs.

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

3.3.2 Design and Construction Practices

3.3.2.1 Current Design and Construction Practices

Currently, there is no best practice for designing and constructing the proposed measure. However, several lab test and field studies provide information on RtP system configurations.

Data from lab tests (Evan Green and Ben Larson 2024) of multifamily CHPWHs show that the Return to Primary configuration has a higher COP than the TMHS configuration. Figure 4 shows the heating plant COP for both Return to Primary and TMHS configurations with different refrigerants and distribution heat losses. Overall, the Return to Primary configuration has a higher heating plant COP compared to the TMHS configuration. CO₂ HPWHs have a higher COP compared to conventional refrigerant (R-134a). The hot water distribution system heat loss has a larger impact on the TMHS configuration with larger COP degradation as hot water distribution system heat losses increase. With R-134a refrigerant, the heating plant COP remains consistent even with distribution heat loss.

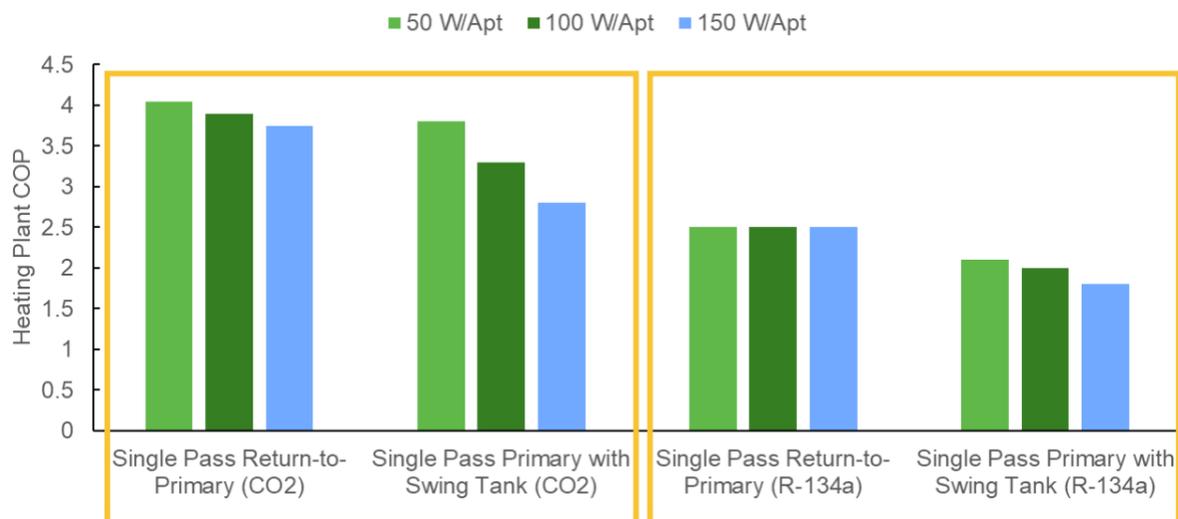


Figure 4: Heating Plant COP from lab tests

Data from field demonstrations (Andrew Brooks 2024) of CHPWH systems and additional field testing (Code Readiness Research Team 2026) of CHPWH systems with continuous recirculation show that Return to Primary performs better than TMHS for both small and large CO₂ systems. Table 18 shows the heating plant COP at various return water temperatures and other key parameters, including number of apartments, distribution heat loss, and. Results show that Return to Primary works reliably with

higher return water temperatures (110°F or above). Site 3 shows slightly higher COP for TMHS, because this site has extremely small distribution heat loss (30W/apt).

Table 18: Heating Plant COP from Field Demonstrations

Site	Number of Apartments	Distribution Heat Loss W/Apt	Return Water Temperature 100°F COP	Return Water Temperature 110°F COP	Return Water Temperature 120°F COP
Site 1 -- Mitsubishi Heat2O TMHS	81	87	2.5	2.3	-
Site 1 -- Mitsubishi Heat2O RtP	81	91	2.8	2.5	-
Site 2 -- WaterDrop TMHS	53	77	-	3.0	-
Site 2 -- WaterDrop RtP	53	82	-	3.3	-
Site 3 -- Mitsubishi Heat2O TMHS	28	30	-	4.1	3.1
Site 3 -- Mitsubishi Heat2O RtP	28	30	-	4.3	3.0

Data from an ongoing, but not yet published, field study show that a small CO2 HPWH in Return to Primary configuration has higher heating plant COP compared to TMHS configuration for small central HPWH applications. Table 19 shows the heating plant COP and key parameters for the two comparable sites.

Table 19: Heating Plant COP from Ongoing Field Study

Site	Equipment	Number of Apartments	Distribution Heat Loss W/Apt	Gallon Per Day	Heating Plant COP
Site 1 – Non-Continuous Recirculation	(2) SanCO2 HPWHs (2) 83 gallon storage tanks	8	26	172	2.37

Site	Equipment	Number of Apartments	Distribution Heat Loss W/Apt	Gallon Per Day	Heating Plant COP
Site 2 – Continuous Recirculation	(4) SanCO2 HPWHs (1) 200 gallon storage tank (1) 80 gallon swing tank	25	16	535	2.13

3.3.2.2 Health and Safety Considerations

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

3.3.2.3 Design and Construction Challenges and Solutions

A key technical challenge is that there is no current standard practice for design, installation, and startup of the Return to Primary configuration in nonresidential buildings. And it is not clear which HPWH in the Return to Primary configuration requires back up heating. The Statewide CASE Team will review field demonstrations and lab test data, conduct interviews and surveys with designers, manufacturers, contractors, and building officials to develop requirements for quality installation and operation, and identify guardrails needed to ensure hot water reliability. The Statewide CASE Team will also modify compliance forms to ensure Return to Primary systems are properly designed and installed.

The Statewide CASE Team will evaluate additional design and construction challenges and solutions that affect Return to Primary system reliability, specific to refrigerant type, defrost derate, back up heating requirements, diagnostics capabilities, and controls, etc. through literature review, product research, plans review, and interviews.

See Table 16 in Section 3.2.2 for a description of workforce training that could support effective design, installation, and commissioning.

3.3.3 Energy Equity and Environmental Justice

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

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice.

This section is still in progress. The Statewide CASE Team is continuing to engage with stakeholders to determine potential impacts on ESJ communities and will update this section with any additional findings.

3.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team will complete this section for the Final CASE Report.

3.3.5 Economic and Fiscal Impacts

The Statewide CASE Team will complete this section for the Final CASE Report.

3.4 Require Return to Primary Configuration - Cost Effectiveness

3.4.1 Cost Effectiveness Methodology

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

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

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

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

3.4.2 Energy and Energy Cost Savings Results

Appendix A presents the methodology and assumptions of the energy and energy cost savings analysis.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit for new constructions and additions are presented in Table 20 through Table 23. Per-unit electricity savings for the first year are expected to range from 0.01 to 0.71 kWh/ft²-yr, depending upon CZ and prototype. Demand reductions are expected to range between 0.0002 kW/ft² and 0.06 kW/ft², depending on CZ and prototype. Because the proposed measure is specific to electric heat pump systems, there are no natural gas savings.

Energy savings (electricity, natural gas, and source energy) and peak demand reductions per-unit for alterations are presented in Table 25 through Table 28. Per-unit electricity savings for the first year are expected to range from 0.02 to 2.53 kWh/ft²-yr, depending upon CZ and prototype. Demand reductions are expected to range between 0.001 kW/ft² and 0.2 kW/ft², depending on CZ and prototype. Because the proposed measure is specific to electric heat pump systems, there are no natural gas peak demand reductions.

Table 24 and Table 29 presents total energy cost savings per unit for newly constructed buildings and additions, and alterations in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV\$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods.

Please note that the energy savings for this proposed measure may be conservative given the following caveats the Statewide CASE Team found for some of the prototype buildings. The Large Office prototype assumes much higher draws compared to recirculation heat losses, which triggers less electric resistance usage of the series temperature maintenance tank, resulting in less base case energy use. For the Restaurant prototype, the average daily water usage during weekdays is 206 gallons, which seems to align with the cafes rather than the restaurant. Based on existing studies (Maya Gantley 2025), the average daily water usage for quick service restaurants ranges from 300 to 700 gallons, and the overall range can be 200 to 2000 gallons.

Table 20: First Year Electricity Savings (kWh) Per Square Foot – Require Return to Primary Configuration – New Construction and Additions

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
Assembly	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.08	0.09	0.09	0.08	0.08	0.09
Grocery	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.07	0.07	0.06	0.08
Large Office	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04
Large Retail	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.001
Large School	0.14	0.14	0.15	0.13	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.14	0.13	0.13	0.11	0.14
Medium Office	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	0.01	0.02
Medium Retail	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.05
Restaurant	1.61	1.56	1.63	1.48	1.60	1.58	1.58	1.54	1.53	1.49	1.44	1.51	1.42	1.45	1.15	1.63
Small School	0.59	0.58	0.62	0.58	0.60	0.62	0.62	0.62	0.61	0.58	0.56	0.60	0.58	0.57	0.50	0.57
Laboratory	0.70	0.70	0.72	0.66	0.71	0.71	0.69	0.67	0.66	0.67	0.64	0.67	0.65	0.65	0.53	0.70

Table 21: First Year Peak Demand Reduction (kW) Per Square Foot – Require Return to Primary Configuration – New Construction and Additions

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
Assembly	0.0104	0.0102	0.0105	0.0101	0.0105	0.0108	0.0108	0.0106	0.0103	0.0102	0.0096	0.0102	0.0098	0.0097	0.0086	0.0099
Grocery	0.0092	0.0089	0.0093	0.0085	0.0091	0.0090	0.0090	0.0088	0.0087	0.0085	0.0082	0.0086	0.0081	0.0083	0.0065	0.0093
Large Office	0.0051	0.0049	0.0051	0.0046	0.0051	0.0050	0.0049	0.0049	0.0049	0.0047	0.0046	0.0048	0.0046	0.0046	0.0037	0.0050
Large Retail	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large School	0.0160	0.0160	0.0167	0.0153	0.0166	0.0168	0.0169	0.0164	0.0164	0.0161	0.0153	0.0160	0.0154	0.0150	0.0129	0.0155
Medium Office	0.0021	0.0019	0.0020	0.0019	0.0020	0.0020	0.0020	0.0019	0.0018	0.0018	0.0018	0.0019	0.0018	0.0018	0.0015	0.0019
Medium Retail	0.0054	0.0052	0.0055	0.0049	0.0053	0.0052	0.0054	0.0052	0.0050	0.0053	0.0053	0.0050	0.0051	0.0050	0.0040	0.0056
Restaurant	0.1839	0.1777	0.1862	0.1694	0.1821	0.1802	0.1799	0.1762	0.1746	0.1697	0.1641	0.1729	0.1623	0.1654	0.1308	0.1856
Small School	0.0669	0.0664	0.0704	0.0660	0.0685	0.0709	0.0713	0.0705	0.0697	0.0667	0.0643	0.0680	0.0663	0.0646	0.0569	0.0653
Laboratory	0.0803	0.0804	0.0817	0.0756	0.0813	0.0806	0.0793	0.0765	0.0758	0.0768	0.0733	0.0760	0.0736	0.0738	0.0605	0.0800

Table 22: First Year Natural Gas Savings (kBtu) Per Square Foot – Require Return to Primary Configuration – New Construction and Additions

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
Assembly	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Grocery	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Medium Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Medium Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Restaurant	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
Small School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Laboratory	n/a	n/a	n/a	n/a	n/a	n/a	n/a									

Table 23: First Year Source Energy Savings (kBtu) Per Square Foot – Require Return to Primary Configuration – New Construction and Additions

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
Assembly	0.15	0.15	0.16	0.15	0.16	0.16	0.16	0.16	0.15	0.15	0.14	0.15	0.15	0.14	0.13	0.15
Grocery	0.14	0.13	0.14	0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.13	0.12	0.12	0.10	0.14
Large Office	0.08	0.07	0.08	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.07
Large Retail	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.004	0.004	0.004	0.002	0.003	0.003	0.003	0.003	0.002
Large School	0.24	0.24	0.25	0.23	0.25	0.25	0.25	0.24	0.24	0.24	0.23	0.24	0.23	0.22	0.19	0.23
Medium Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Medium Retail	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.06	0.08
Restaurant	2.74	2.65	2.78	2.53	2.72	2.69	2.68	2.63	2.60	2.53	2.45	2.58	2.42	2.47	1.95	2.77
Small School	1.00	0.99	1.05	0.98	1.02	1.06	1.06	1.05	1.04	1.00	0.96	1.01	0.99	0.96	0.85	0.97
Laboratory	1.20	1.20	1.22	1.13	1.21	1.20	1.18	1.14	1.13	1.15	1.09	1.13	1.10	1.10	0.90	1.19

Table 24: Total 30-Year LSC Savings (2029 PV\$) Per Square Foot – Require Return to Primary Configuration – New Construction and Additions

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
Assembly	0.79	0.78	0.80	0.77	0.80	0.83	0.83	0.81	0.78	0.78	0.73	0.78	0.75	0.74	0.66	0.76
Grocery	0.70	0.68	0.71	0.65	0.69	0.69	0.69	0.67	0.67	0.65	0.63	0.66	0.62	0.63	0.50	0.71
Large Office	0.39	0.37	0.39	0.35	0.39	0.38	0.37	0.37	0.37	0.36	0.35	0.37	0.35	0.35	0.29	0.38
Large Retail	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01
Large School	1.22	1.23	1.27	1.17	1.27	1.29	1.29	1.25	1.25	1.23	1.17	1.22	1.18	1.14	0.98	1.18
Medium Office	0.16	0.14	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.15	0.14	0.14	0.12	0.15

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
Medium Retail	0.41	0.40	0.42	0.38	0.40	0.40	0.41	0.40	0.38	0.40	0.41	0.38	0.39	0.38	0.31	0.42
Restaurant	14.06	13.58	14.24	12.94	13.89	13.84	13.74	13.43	13.30	12.93	12.53	13.19	12.39	12.64	10.01	14.14
Small School	5.11	5.08	5.39	5.04	5.23	5.44	5.45	5.38	5.31	5.09	4.91	5.18	5.06	4.93	4.36	4.98
Laboratory	6.14	6.14	6.25	5.77	6.20	6.19	6.05	5.83	5.77	5.85	5.59	5.80	5.62	5.64	4.63	6.10

Table 25: First Year Electricity Savings (kWh) Per Square Foot – Require Return to Primary Configuration – Alterations

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
Assembly	0.10	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.09
Grocery	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.06	0.08
Large Office	0.05	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05
Large Retail	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.001
Large School	0.15	0.15	0.16	0.14	0.15	0.16	0.15	0.15	0.15	0.15	0.14	0.15	0.14	0.14	0.12	0.15
Medium Office	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	0.01	0.02
Medium Retail	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.05
Restaurant	1.67	1.61	1.69	1.57	1.65	1.63	1.63	1.60	1.56	1.54	1.49	1.57	1.50	1.50	1.22	1.69
Small School	0.63	0.62	0.65	0.62	0.64	0.65	0.66	0.66	0.64	0.64	0.60	0.62	0.61	0.59	0.53	0.61
Laboratory	0.74	0.70	0.72	0.70	0.75	0.74	0.70	0.71	0.70	0.68	0.68	0.70	0.68	0.68	0.53	0.72

Table 26: First Year Peak Demand Reduction (kW) Per Square Foot – Require Return to Primary Configuration – Alterations

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
Assembly	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.010	0.011	0.010	0.010	0.009	0.010
Grocery	0.010	0.009	0.010	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.007	0.010
Large Office	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.005
Large Retail	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Large School	0.017	0.017	0.018	0.016	0.018	0.018	0.018	0.018	0.017	0.017	0.016	0.017	0.016	0.016	0.014	0.017
Medium Office	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Medium Retail	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.006
Restaurant	0.191	0.184	0.193	0.179	0.188	0.186	0.186	0.182	0.178	0.175	0.170	0.179	0.172	0.171	0.139	0.192
Small School	0.071	0.071	0.074	0.070	0.073	0.074	0.075	0.075	0.073	0.074	0.069	0.071	0.070	0.068	0.061	0.070
Laboratory	0.085	0.080	0.083	0.080	0.086	0.085	0.080	0.081	0.080	0.078	0.077	0.080	0.078	0.078	0.061	0.082

Table 27: First Year Natural Gas Savings (kBtu) Per Square Foot – Require Return to Primary Configuration – Alterations

Protot ype	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
Assem bly	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Grocer y	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Mediu m Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Mediu m Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Restau rant	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Small School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Labora tory	n/a	n/a	n/a	n/a	n/a	n/a	n/a									

Table 28: First Year Source Energy Savings (kBtu) Per Square Foot – Require Return to Primary Configuration – Alterations

Protot ype	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
Assem bly	0.16	0.16	0.17	0.16	0.17	0.17	0.17	0.17	0.17	0.16	0.15	0.16	0.15	0.15	0.14	0.16
Grocer y	0.14	0.14	0.14	0.13	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.10	0.14
Large Office	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.08	0.07	0.07	0.06	0.08
Large Retail	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.004	0.004	0.004	0.002	0.003	0.003	0.003	0.003	0.002
Large Schoo l	0.26	0.26	0.26	0.24	0.26	0.26	0.26	0.26	0.25	0.25	0.24	0.25	0.25	0.24	0.21	0.25
Mediu m Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Mediu m Retail	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.06	0.08
Resta urant	2.84	2.74	2.87	2.67	2.81	2.78	2.77	2.72	2.65	2.62	2.54	2.67	2.56	2.56	2.07	2.87
Small Schoo l	1.06	1.06	1.10	1.05	1.09	1.11	1.12	1.12	1.09	1.10	1.02	1.06	1.04	1.01	0.91	1.04
Labor atory	1.27	1.19	1.23	1.19	1.28	1.27	1.20	1.20	1.19	1.16	1.16	1.20	1.16	1.16	0.91	1.23

Table 29: Total 30-Year LSC Savings (2029 PV\$) Per Square Foot – Require Return to Primary Configuration – Alterations

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
Assembly	0.83	0.85	0.87	0.81	0.87	0.86	0.86	0.85	0.85	0.83	0.79	0.82	0.79	0.77	0.71	0.80
Grocery	0.73	0.70	0.74	0.68	0.72	0.72	0.71	0.69	0.68	0.67	0.65	0.68	0.65	0.66	0.53	0.73
Large Office	0.40	0.39	0.41	0.38	0.41	0.41	0.39	0.39	0.38	0.38	0.38	0.39	0.36	0.38	0.31	0.40
Large Retail	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01
Large School	1.31	1.31	1.36	1.25	1.35	1.36	1.34	1.34	1.30	1.28	1.22	1.30	1.26	1.23	1.06	1.27
Medium Office	0.15	0.16	0.16	0.15	0.16	0.16	0.16	0.15	0.16	0.16	0.15	0.16	0.15	0.15	0.12	0.16
Medium Retail	0.41	0.40	0.42	0.38	0.40	0.40	0.41	0.40	0.38	0.40	0.41	0.38	0.39	0.38	0.31	0.42
Restaurant	14.57	14.07	14.73	13.68	14.37	14.30	14.19	13.89	13.54	13.38	12.98	13.65	13.09	13.10	10.62	14.67
Small School	5.46	5.42	5.65	5.38	5.57	5.71	5.71	5.72	5.57	5.61	5.25	5.44	5.31	5.17	4.66	5.32
Laboratory	6.49	6.09	6.32	6.10	6.54	6.51	6.13	6.14	6.08	5.92	5.91	6.12	5.94	5.97	4.66	6.27

3.4.3 Incremental First Cost

The Statewide CASE Team developed HPWH designs for the base case and measure case in consultation with an experienced HPWH/plumbing design firm. The Statewide CASE Team used the Ecosizer tool to size the base case HP and primary tank system, considering the impacts of CZ on the entering cold water temperature and the ambient design temperature. To reduce analysis complexity, the Statewide CASE Team applied a floor function to the entering cold water temperature to round the entering cold water temperature down to the nearest 10 degree increment. Table 30 tabulates the design data for entering cold water temperature and design outside air temperature for all 16 CA CZs.

For the temperature maintenance load, the Statewide Team used a customized recirculation heat loss calculator separately and determined distribution recirculation heat loss for each prototype (Appendix F). For the base case system, the Statewide CASE Team sized the swing tank to meet the temperature maintenance load. For the measure case, the HP must meet the temperature maintenance load, and the primary tank storage volume remains the same as in the base case. Often, the recirculation load is low enough that the measure case and base case have the same HP selection, but in some cases the measure case requires an additional HP to meet the load.

The Statewide CASE Team selected equipment that can work at the design temperature without back up electric resistance for each climate zone. Lochinvar VAHP060 can work at 25°F ambient temperature and above, which are appropriate for CZs with design temperature above 25°F. Colmac CxV-7 with R-454B refrigerant can work down to 10°F, which are used for CZs with design temperature below 25°F.

Table 30: Design temperature for 16 CZs

Climate Zone	Representative City	Design outside air temperature °F	Entering cold water temperature °F
CZ1	Arcata	28	40
CZ2	Sonoma County	22	50
CZ3	Oakland	32	50
CZ4	Paso Robles	19	50
CZ5	Santa Maria	25	50
CZ6	Los Angeles	37	50
CZ7	San Diego	38	50
CZ8	Fullerton	30	50
CZ9	Burbank Glendale	29	50
CZ10	Riverside	27	50

Climate Zone	Representative City	Design outside air temperature °F	Entering cold water temperature °F
CZ11	Red Bluff	24	50
CZ12	Sacramento	26	50
CZ13	Fresno	24	50
CZ14	Palmdale	12	50
CZ15	Palm Springs	26	60
CZ16	Blue Canyon	13	40

Using these designs, the Statewide CASE Team collected cost data from an experienced contractor, including cost of primary HP, primary storage tank, series temperature maintenance tank, piping and start up. The base case assumed standard startup, while the measure case assumed the proposed startup requirements. For all other components, the Statewide CASE Team assumed they are the same for base case and measure case, such as pumps, expansion tanks, master mixing valves, miscellaneous supplies, electrical supplies, controls, etc.

The Statewide CASE Team also leveraged the RS Means factors to adjust the cost for each climate zone.

Table 31 and Table 32 summarize the equipment cost of analyzed prototypes and all CZs, which is the same for new construction, and additions, and alterations. 33 and Table 34 summarize the labor cost.

Table 31: Equipment Cost Summary for Base Case (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	163,75 1	291,75 0	170,87 0	301,16 2	313,71 0	172,65 0	177,99 0	169,09 1	167,31 1	301,16 2	301,16 2	177,99 0	313,71 0	288,61 3	163,75 1	288,61 3
Medium Office	49,195	91,803	51,334	94,764	98,713	51,869	53,473	50,799	50,265	94,764	94,764	53,473	98,713	90,816	49,195	90,816
Laboratory	81,833	166,86 9	85,391	172,25 2	179,42 9	86,281	88,949	84,502	83,612	172,25 2	172,25 2	88,949	179,42 9	165,07 5	81,833	165,07 5
Restaurant	114,47 1	241,93 5	119,44 8	249,73 9	260,14 5	120,69 2	124,42 5	118,20 4	116,96 0	249,73 9	249,73 9	124,42 5	260,14 5	239,33 3	114,47 1	239,33 3
Small School	201,37 0	254,71 2	210,12 5	340,41 6	273,88 4	177,90 2	183,40 4	207,93 6	205,74 7	262,92 9	262,92 9	218,88 0	273,88 4	326,23 2	168,73 2	326,23 2
Large School	533,36 2	842,75 2	522,49 4	947,42 5	906,18 5	493,52 5	508,78 9	517,05 2	511,60 9	869,93 8	869,93 8	544,26 5	906,18 5	907,94 9	468,08 6	907,94 9
Assembly	201,37 0	254,71 2	210,12 5	340,41 6	273,88 4	177,90 2	183,40 4	207,93 6	205,74 7	262,92 9	262,92 9	218,88 0	273,88 4	326,23 2	168,73 2	326,23 2
RetailLarge	242,28 5	455,28 4	252,81 9	469,97 1	489,55 3	255,45 2	263,35 3	250,18 5	247,55 2	469,97 1	469,97 1	263,35 3	489,55 3	450,38 9	242,28 5	450,38 9
RetailMedium	49,195	91,803	51,334	94,764	98,713	51,869	53,473	50,799	50,265	94,764	94,764	53,473	98,713	90,816	49,195	90,816
Grocery	114,47 1	241,93 5	119,44 8	249,73 9	260,14 5	120,69 2	124,42 5	118,20 4	116,96 0	249,73 9	249,73 9	124,42 5	260,14 5	239,33 3	114,47 1	239,33 3

Table 32: Equipment Cost Summary for Measure Case (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	177,127	272,279	150,771	358,549	292,773	152,341	157,053	149,200	147,630	281,062	281,062	157,053	292,773	343,610	144,489	269,351
Medium Office	44,620	87,178	46,560	89,990	93,740	47,045	48,500	46,075	45,590	89,990	89,990	48,500	93,740	86,241	44,620	86,241
Laboratory	77,258	162,244	80,617	167,478	174,456	81,457	83,976	79,777	78,937	167,478	167,478	83,976	174,456	160,500	77,258	160,500
Restaurant	109,896	237,310	148,731	244,965	255,172	115,868	119,452	147,182	145,632	244,965	244,965	154,928	255,172	234,758	109,896	234,758
Small School	181,749	309,944	189,651	319,942	333,273	191,626	197,553	187,675	185,700	319,942	319,942	197,553	333,273	306,611	149,111	306,611
Large School	543,340	819,846	532,907	1,001,268	881,555	504,046	519,635	527,355	521,804	846,293	846,293	555,111	881,555	959,548	445,426	959,548
Assembly	181,749	309,944	189,651	319,942	333,273	191,626	197,553	187,675	185,700	319,942	319,942	197,553	333,273	306,611	149,111	306,611
RetailLarge	270,348	450,659	248,045	542,684	484,580	250,629	258,380	245,461	242,877	465,197	465,197	258,380	484,580	520,072	237,710	445,814
RetailMedium	44,620	87,178	46,560	89,990	93,740	47,045	48,500	46,075	45,590	89,990	89,990	48,500	93,740	86,241	44,620	86,241
Grocery	109,896	237,310	148,731	244,965	255,172	115,868	119,452	147,182	145,632	244,965	244,965	154,928	255,172	234,758	109,896	234,758

Table 33: Labor Cost Summary for Base Case (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	22,295	30,485	26,618	30,030	29,120	22,068	21,840	22,068	22,068	22,068	22,523	22,750	22,523	22,068	22,068	22,978
Medium Office	10,535	14,405	12,578	14,190	13,760	10,428	10,320	10,428	10,428	10,428	10,643	10,750	10,643	10,428	10,428	10,858
Laboratory	13,230	18,090	15,795	17,820	17,280	13,095	12,960	13,095	13,095	13,095	13,365	13,500	13,365	13,095	13,095	13,635
Restaurant	15,925	21,775	19,013	21,450	20,800	15,763	15,600	15,763	15,763	15,763	16,088	16,250	16,088	15,763	15,763	16,413
Small School	30,135	37,520	35,978	40,590	35,840	27,160	26,880	29,828	29,828	27,160	27,720	30,750	27,720	29,828	27,160	31,058
Large School	52,185	67,670	59,085	70,290	64,640	46,318	45,840	48,985	48,985	48,985	49,995	50,500	49,995	51,653	46,318	53,783
Assembly	30,135	37,520	35,978	40,590	35,840	27,160	26,880	29,828	29,828	27,160	27,720	30,750	27,720	29,828	27,160	31,058
RetailLarge	34,055	46,565	40,658	45,870	44,480	33,708	33,360	33,708	33,708	33,708	34,403	34,750	34,403	33,708	33,708	35,098
RetailMedium	10,535	14,405	12,578	14,190	13,760	10,428	10,320	10,428	10,428	10,428	10,643	10,750	10,643	10,428	10,428	10,858
Grocery	15,925	21,775	19,013	21,450	20,800	15,763	15,600	15,763	15,763	15,763	16,088	16,250	16,088	15,763	15,763	16,413

Table 34: Labor Cost Summary for Measure Case (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	23,030	27,805	24,278	31,020	26,560	20,128	19,920	20,128	20,128	20,128	20,543	20,750	20,543	22,795	20,128	20,958
Medium Office	8,575	11,725	10,238	11,550	11,200	8,488	8,400	8,488	8,488	8,488	8,663	8,750	8,663	8,488	8,488	8,838
Laboratory	11,270	15,410	13,455	15,180	14,720	11,155	11,040	11,155	11,155	11,155	11,385	11,500	11,385	11,155	11,155	11,615
Restaurant	13,965	19,095	19,890	18,810	18,240	13,823	13,680	16,490	16,490	13,823	14,108	17,000	14,108	13,823	13,823	14,393
Small School	28,175	38,525	33,638	37,950	36,800	27,888	27,600	27,888	27,888	27,888	28,463	28,750	28,463	27,888	25,220	29,038
Large School	52,920	64,990	59,963	71,280	62,080	47,045	46,560	49,713	49,713	47,045	48,015	51,250	48,015	52,380	44,378	54,540
Assembly	28,175	38,525	33,638	37,950	36,800	27,888	27,600	27,888	27,888	27,888	28,463	28,750	28,463	27,888	25,220	29,038
RetailLarge	34,790	43,885	38,318	46,860	41,920	31,768	31,440	31,768	31,768	31,768	32,423	32,750	32,423	34,435	31,768	33,078
RetailMedium	8,575	11,725	10,238	11,550	11,200	8,488	8,400	8,488	8,488	8,488	8,663	8,750	8,663	8,488	8,488	8,838
Grocery	13,965	19,095	19,890	18,810	18,240	13,823	13,680	16,490	16,490	13,823	14,108	17,000	14,108	13,823	13,823	14,393

Table 35: Incremental First Cost (Equipment and Labor) Summary (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	14,111	(22,151)	(22,440)	58,378	(23,497)	(22,249)	(22,857)	(21,830)	(21,621)	(22,040)	(22,080)	(22,937)	(22,917)	55,724	(21,202)	(21,282)
Medium Office	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Laboratory	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Restaurant	(6,535)	(7,305)	30,160	(7,414)	31,463	(6,764)	(6,893)	29,705	29,400	30,010	(6,754)	31,253	(6,953)	(6,515)	(6,515)	(6,595)
Small School	(21,581)	56,237	(22,814)	(23,114)	(23,887)	14,452	14,869	(22,201)	(21,987)	(22,414)	57,756	(23,327)	60,132	(21,561)	(21,561)	(21,641)
Large School	10,713	(25,586)	11,290	54,833	11,806	11,248	11,566	11,031	10,923	11,140	(25,625)	11,596	(26,610)	52,327	(24,600)	52,357
Assembly	(21,581)	56,237	(22,814)	(23,114)	(23,887)	14,452	14,869	(22,201)	(21,987)	(22,414)	57,756	(23,327)	60,132	(21,561)	(21,561)	(21,641)
RetailLarge	28,798	(7,305)	(7,114)	73,703	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	70,411	(6,515)	(6,595)
RetailMedium	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Grocery	(6,535)	(7,305)	30,160	(7,414)	31,463	(6,764)	(6,893)	29,705	29,400	30,010	(6,754)	31,253	(6,953)	(6,515)	(6,515)	(6,595)

3.4.4 Incremental Maintenance and Replacement Costs

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

The Statewide CASE Team assumed that the expected useful life of the CHPWH measure is 15 years, and that after this time, the CHPWH equipment would need replacement. The Statewide CASE Team assumed that the supporting infrastructure would not need replacement.

The Statewide CASE Team assumed that the maintenance costs are the same between system configurations, therefore, did not account for any incremental maintenance costs. Table 36 summarizes the replacement cost during the 30-year period of analysis.

Table 36: Incremental Replacement Cost (\$)

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	14,111	(22,151)	(22,440)	58,378	(23,497)	(22,249)	(22,857)	(21,830)	(21,621)	(22,040)	(22,080)	(22,937)	(22,917)	55,724	(21,202)	(21,282)
Medium Office	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Laboratory	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Restaurant	(6,535)	(7,305)	30,160	(7,414)	(7,533)	(6,764)	(6,893)	29,705	29,400	(6,714)	(6,754)	31,253	(6,953)	(6,515)	(6,515)	(6,595)
Small School	(21,581)	56,237	(22,814)	(23,114)	60,349	14,452	14,869	(22,201)	(21,987)	57,741	57,756	(23,327)	60,132	(21,561)	(21,561)	(21,641)
Large School	10,713	(25,586)	11,290	54,833	(27,190)	11,248	11,566	11,031	10,923	(25,585)	(25,625)	11,596	(26,610)	52,327	(24,600)	52,357
Assembly	(21,581)	56,237	(22,814)	(23,114)	60,349	14,452	14,869	(22,201)	(21,987)	57,741	57,756	(23,327)	60,132	(21,561)	(21,561)	(21,641)
RetailLarge	28,798	(7,305)	(7,114)	73,703	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	70,411	(6,515)	(6,595)
RetailMedium	(6,535)	(7,305)	(7,114)	(7,414)	(7,533)	(6,764)	(6,893)	(6,664)	(6,615)	(6,714)	(6,754)	(6,973)	(6,953)	(6,515)	(6,515)	(6,595)
Grocery	(6,535)	(7,305)	30,160	(7,414)	(7,533)	(6,764)	(6,893)	29,705	29,400	(6,714)	(6,754)	31,253	(6,953)	(6,515)	(6,515)	(6,595)

3.4.5 Cost Effectiveness

For preliminary cost effectiveness analysis, the Statewide CASE Team selected several representative CZs and prototypes (Large Office, Medium Office, and Laboratory).

Table 37 presents the results of the per-unit cost-effectiveness analyses for new construction/additions and alterations and Table 38 represents results for alterations, respectively. Appendix A presents the assumptions on the cost-effectiveness analysis.

For new construction and additions, the proposed measure saves money over the 30-year period of analysis relative to the existing conditions. The proposed code change is cost effective in every analyzed CZ for both new constructions and additions, and alterations.

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 proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including 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-cost ratio (BCR) is considered infinite. Costs and other savings are discounted at a real (inflation-adjusted) three percent rate. If there are no total incremental PV costs, the BCR is infinite.

Table 37: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
CZ01	4.99	-1.61	infinite
CZ02	3.27	0.80	4.11
CZ03	1.95	1.13	1.73
CZ04	1.88	-0.32	infinite
CZ05	3.95	-0.27	infinite
CZ06	2.36	-0.45	infinite
CZ07	3.69	-0.73	infinite
CZ08	2.19	2.09	1.05
CZ09	2.18	2.04	1.07

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
CZ10	2.46	-0.20	infinite
CZ11	3.35	-0.18	infinite
CZ12	1.98	1.11	1.79
CZ13	3.61	-0.19	infinite
CZ14	3.37	-1.04	infinite
CZ15	1.64	-0.76	infinite
CZ16	2.50	-0.70	infinite
Total	2.23	1.02	2.19

Table 38: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
CZ01	5.23	-1.61	infinite
CZ02	3.43	0.80	4.31
CZ03	2.03	1.13	1.80
CZ04	1.99	-0.32	infinite
CZ05	4.13	4.10	1.01
CZ06	2.46	-0.45	infinite
CZ07	3.82	-0.73	infinite
CZ08	2.29	2.09	1.10
CZ09	2.24	2.04	1.10
CZ10	2.58	2.42	1.06
CZ11	3.51	-0.18	infinite
CZ12	2.08	1.11	1.88
CZ13	3.81	-0.19	infinite
CZ14	3.51	-1.04	infinite
CZ15	1.79	-0.79	infinite
CZ16	2.63	-0.70	infinite
Total	2.33	1.28	1.82

3.5 Require Return to Primary Configuration - Statewide Impacts

3.5.1 Statewide Energy and Energy Cost Savings

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

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

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 39) and alterations (Table 40) by CZ. Table 41 presents first-year statewide savings from new construction, additions, and alterations.

Table 39: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	14,752	0.01	0.00	-	0.01	\$0.08
2	458,726	0.18	0.02	-	0.30	\$1.54
3	2,909,302	0.68	0.08	-	1.16	\$5.96
4	1,508,939	0.34	0.04	-	0.58	\$2.99
5	56,809	0.03	0.00	-	0.04	\$0.23
6	1,615,222	0.45	0.05	-	0.76	\$3.90
7	325,709	0.14	0.02	-	0.24	\$1.22
8	3,002,211	0.77	0.09	-	1.31	\$6.69
9	4,788,797	1.22	0.14	-	2.08	\$10.61
10	1,698,625	0.49	0.06	-	0.83	\$4.24
11	108,946	0.04	0.00	-	0.07	\$0.37
12	943,646	0.22	0.02	-	0.37	\$1.90
13	175,472	0.07	0.01	-	0.13	\$0.65
14	94,301	0.04	0.00	-	0.06	\$0.32
15	286,866	0.05	0.01	-	0.09	\$0.48
16	69,872	0.02	0.00	-	0.03	\$0.18
Total	18,058,193	4.75	0.54	-	8.08	\$41.36

Table 40: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2026 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	41,575	0.02	0.00	-	0.03	\$0.16
2	1,340,894	0.45	0.05	-	0.76	\$3.91
3	6,729,440	1.36	0.16	-	2.31	\$11.86
4	3,719,918	0.74	0.08	-	1.26	\$6.45
5	143,322	0.05	0.01	-	0.09	\$0.44
6	3,570,355	0.76	0.09	-	1.29	\$6.65
7	877,969	0.29	0.03	-	0.50	\$2.54
8	8,315,764	1.59	0.18	-	2.70	\$13.81
9	14,669,889	2.78	0.32	-	4.73	\$24.19
10	6,439,552	1.41	0.16	-	2.41	\$12.31
11	311,519	0.09	0.01	-	0.16	\$0.82
12	2,723,138	0.58	0.07	-	0.99	\$5.07
13	555,773	0.18	0.02	-	0.31	\$1.58
14	332,861	0.09	0.01	-	0.15	\$0.79
15	867,013	0.14	0.02	-	0.23	\$1.20
16	253,947	0.06	0.01	-	0.10	\$0.51
Total	50,892,930	10.59	1.21	-	18.03	\$92.29

Table 41: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	4.75	0.54	-	8.08	41.36
Alterations	10.59	1.21	-	18.03	92.29
Total	15.34	1.75	-	26.11	133.64

3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 42 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 1,381 metric tons of carbon dioxide equivalent (CO₂e) 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 42: First-Year Statewide GHG Emissions Impacts

Construction Type	Reduced GHG Emissions from Electricity Savings (Metric Tons CO ₂ e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO ₂ e)	Total Reduced GHG Emissions (Metric Ton CO ₂ e)	Total Monetary Value of Reduced GHG Emissions (\$)
New Construction & Additions	427	-	427	52,631
Alterations	954	-	954	117,469
Total	1,381	-	1,381	170,100

3.5.3 Statewide Water Use Impacts

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

3.5.4 Statewide Material Impacts

The proposed measure would eliminate the use of swing tank but would add extra HP for some cases. The Statewide CASE Team calculated the per sq ft incremental material impacts for each prototype and CZ, including the HP and swing tank. The Statewide CASE Team applied the statewide sq ft impacted by the proposed measure to obtain the total statewide material impacts (Table 43).

Table 43 Annual Statewide Impacts on Material Use

Material	Impact (I, D, of NC) ^a	First Year ^b Statewide Impacts (pounds)	Embodied GHG emissions saved (MT CO ₂ e)
Copper	I	72,905	-93
Steel	D	286,972	158
Insulation	I	2,871	-3
Plastic	I	18,226	-15
Refrigerants	I	5,118	-3742

Material	Impact (I, D, of NC) ^a	First Year ^b Statewide Impacts (pounds)	Embodied GHG emissions saved (MT CO ₂ e)
Glass	D	36,825	24
Total	-		-3,671

a. Material Increase (I), Decrease (D), or No Change (NC) compared to base case (lbs/yr).

b. First year savings from all buildings completed statewide in 2029.

3.5.5 Environmental Impacts

The direct environmental impacts include a positive impact resulting from energy savings and GHG reduction, and a negative impact from increased use of materials and greater embodied carbon. Appendix D provides further details on this assessment.

3.5.6 Other Non-Energy Impacts

The proposed measure would help reduce grid impact and improve grid reliability with reduced peak demand. The compact design of Return to Primary configuration would save installation cost and space requirements, reduce complexity with equipment and controls installation, and start-up.

3.6 Require Return to Primary Configuration - Proposed Language Code

3.6.1 Guide to Markup Language

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

3.6.2 Administrative Code (Title 24, Part 1)

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

3.6.3 Energy Code (Title 24, Part 6)

SECTION 100.1 – Definitions and Rules of Construction

Service Hot Water Systems heat, store, and distribute hot water to the point of use for sanitary purposes for human occupancy, other than for comfort heating.

Temperature Maintenance Heater in Parallel Configuration is a water heater that is in parallel with the primary heat pump generation and storage system. The role of this heater is to meet the temperature maintenance load.

Temperature Maintenance Heater in Series Configuration is a water heater that is in series with, and downstream from the primary heat pump generation and storage system. The primary role of this heater is to meet the temperature maintenance load.

SECTION 140.5(a) Prescriptive Requirements for Service Water Heating Hot Water Systems

Nonresidential occupancies. Service water-heating hot water systems in nonresidential buildings shall meet the requirements of 1 or 2 and 3 below, or meet the performance compliance requirements of Section 140.1.

1. **School buildings less than 25,000 square feet and less than 4 stories in Climate Zones 2 through 15.** A heat pump water-heating system that meets the applicable requirements of Sections 110.1, 110.3 and 120.3.

Exception to Section 140.5(a)1 A water-heating system serving an individual bathroom space may be an instantaneous electric water heater.

2. **All other occupancies.** A service water-heating system that meets the applicable requirements of Sections 110.1, 110.3, 120.3 and 140.5(c).
3. Split heat pump water heating systems in all nonresidential occupancies shall meet the requirements of A or B below:

A. Installation shall follow the manufacturer's design and installation requirements and:

i. The primary heat pump water heater shall be a single-pass heat pump water heater.

ii. The recirculation system hot water return shall directly connect to the primary heat pump storage tanks. For parallel storage tanks, the cold water inlet and recirculation system hot water return inlet shall be balanced.

iii. In all heat pump operating modes, the maximum heat pump water heater compressor cut-off ambient air temperature shall be less than or equal to 23°F.

iv. Manufacturer, design, installation and startup documentation shall be provided in accordance with JA14.3, JA14.4, and JA14.5.

B. Installation shall follow NEEA Advanced Water Heater Specification (AWHS) v8.1 for commercial heat pump water heater Tier 3 or higher.

i. For a Temperature Maintenance Heater in Series Configuration, the system shall satisfy the following additional requirements:

a. The primary storage tank temperature setpoint shall be at least 135°F.

b. The temperature maintenance tank temperature setpoint shall be at least 10°F lower than the primary thermal storage tank temperature setpoint.

c. The fuel source for the temperature maintenance tank shall be electricity.

ii. For a Temperature Maintenance Heater in Parallel Configuration, electric heat pump water heater shall be the heat source.

Section 141.0(b)2.N Alterations

N. Service water-heating systems shall meet the requirements of Section 140.5(a)2 and (b), except for the solar water heating requirements. Additionally, split heat pump water heaters with recirculation shall meet the requirements Section 140.5(a)3.

3.6.4 Reference Appendices

JA1 – Definitions

Heat Pump Water Heater System COP is calculated by dividing the heat energy in the water (cold supply water + recirculated hot water) delivered to the distribution system divided by the total energy supplied to the heater for any selected period.

Primary Heat Pump Storage Tank is a tank that is primarily heated by a separate detached heat pump unit(s). The primary heat pump storage tank is also used as temperature maintenance maintains the temperature in the recirculation loop in tank in Return to Primary configuration.

Return to Primary Configuration is a heat pump water heater configuration where the hot water from the recirculation loop hot water return is returned piped to the cold-water supply inlet pipe or directly upstream of the primary heat pump storage tank(s) or directly to a dedicated recirculation return inlet of the primary heat pump storage tank(s).

JA14 – SECTION JA14.3.2 Performance Data Reporting

The following performance specifications shall be submitted to the Energy Commission or refer to the Product Assessment Datasheet (PADS) included in NEEA AWH8.1:

- a) Water heater input power;
- b) Water heater output capacity; and
- c) Water heater COP–Heat Pump Water Heater–System COP referencing the equivalent or colder climate zone from the four IECC CZs in NEEA Advanced Water Heater Specification, computed based on the approved method³ of the Specification.
- d) The performance data shall be provided in accordance with the Product

³ See Section 3.4.1 and Appendix F of the NEEA advanced Water Heating Specification.

~~Assessment Datasheet (PADS) included in NEEA AWH8.1. Inlet ambient air temperature: Maximum, minimum, and two midpoint temperatures of the manufacturer specified operating range.~~

~~e) Inlet water temperature: Maximum, minimum, and two midpoint temperatures of the manufacturer specified operating range.~~

~~f) Outlet water temperature: Maximum, midpoint, and minimum of outlet water (setpoint) temperatures of the manufacturer specified operating range.~~

For conditions where defrost strategies operate, reported data shall include at least one complete defrost cycle, or alternatively, for each model submitted for approval, provide a description of the defrost strategy, including method, cycle length, and process.

JA14 – SECTION JA14.4 Design Condition Documentation Requirements

The Central HPWH system shall be capable of supplying hot water at the design outlet water temperature under specified operating ranges for:

- a. Minimum and maximum ambient air temperature;
- b. Minimum and maximum cold-water temperature;
- c. Minimum and maximum building demand at design draw and recovery conditions and duration; and
- d. Recirculation loop heat loss.

Design documentation shall specify the operating conditions at which the primary heat pump water heater can supply hot water at the design outlet water temperature without engaging the auxiliary heating mechanism.

Design documentation shall document defrost derate factors for calculating output capacity on design day.

JA 14 – SECTION JA14.5 Design, installation and start up documentation requirements

JA 14.5.1 Requirements for Manufacturers

Manufacturers shall verify the location of controlling temperature sensors in storage tanks to prevent HP short cycling.

Manufacturers shall verify HPs have integrated alarms upon failure of HP to start.

JA 14.5.2 Design Documentation Requirements for Designers

Designers shall provide construction documentation to include the following information for HPWH:

- HPWH system piping diagram, including side view of heating plant schematic, and details for all check valves, balancing valves, mixing valves, and isolation valves

- Add heating plant details to the Plumbing Specifications section
- Mixing valve outlet temperature and return water temperature
- Heat pump ON temperature setpoint
- Heat pump OFF temperature setpoint
- Series temperature maintenance tank temperature setpoint
- Sequence of staging of temperature maintenance heater if there are multiple temperature maintenance heaters
- Back up water heater temperature setpoint
- Back up water heater staging
- Sequence of operation if there are multiple HPWHs

JA 14.5.3 Installation and Start Up Documentation Requirements for Contractors

Contractors shall follow the start up process after the HPWH installation:

HPWH Control

Step 1: Record the heat pump ON temperature setpoint. If multiple heat pumps exist, confirm the setpoint is the same for all units. Confirm the setpoint is per approved construction documents.

Step 2: Record the heat pump OFF temperature setpoint. If multiple heat pumps exist, confirm the setpoint is the same for all units. Confirm the setpoint is per approved construction documents.

Step 3: If a master mixing valve is installed, record the mixing setpoint temperature. Confirm setpoint is per approved construction documents.

Step 4: Simulate a condition where the water temperature at the heat pump ON sensor is below the ON setpoint.

(a) Verify and document the lead heat pump energizes.

(b) If there are multiple heat pumps installed, repeat Step 4(a) for all heat pumps and confirm unit staging is per the approved sequence of operation.

Step 5: Simulate a condition where the water temperature at the heat pump OFF sensor is above the OFF setpoint. Verify and document the heat pump(s) de-energize.

Step 6: Restore system to “as-found” operating conditions.

Series temperature maintenance tank Control

Step 1: Record the series temperature maintenance tank ON temperature setpoint. If series temperature maintenance tank has multiple stages, record ON setpoint(s) for each stage. Confirm setpoint is per approved construction documents.

Step 2: Record the series temperature maintenance tank OFF temperature setpoint. If series temperature maintenance tank has multiple stages, record OFF setpoint(s) for each stage. Confirm setpoint is per approved construction documents.

Step 3: Record the series temperature maintenance tank temperature setpoint.

Step 4: Record the heat pump supply water temperature setpoint. If multiple heat pumps exist, confirm setpoint is the same for both units. Confirm setpoint is per approved construction documents.

Step 5: Simulate a condition where the water temperature at the series temperature maintenance tank ON sensor is below the ON setpoint.

- (a) Verify and document the series temperature maintenance tank energizes.
- (b) If there are multiple stages installed, repeat steps 5(A) for the other stages and confirm unit staging is per the approved sequence of operation.

Step 6: Simulate a condition where the water temperature at the series temperature maintenance tank OFF sensor is above the OFF setpoint. Verify and document the series temperature maintenance tank de-energizes.

Step 7: Restore system to “as-found” operating conditions.

3.6.5 Compliance Manuals

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

3.6.6 ACM Reference Manual

Section 5.9.1 Service Water Heating Hot Water System Loads and Configuration Water Heating System Configuration

Applicability: All water heating systems.

Definition: The configuration and layout of the water heating system, including the number of water heaters; the size, location, length, and insulation of distribution pipes; recirculation systems and pumps; and any other details about the system that would affect the energy model.

Units: Data structure.

Input Restrictions: None.

Standard Design: For healthcare facility spaces, the standard design is the same as proposed. ~~For multifamily spaces the rules in Chapter 6 Multifamily Building Descriptors Reference of the Nonresidential ACM Reference Manual shall be followed.~~

For all other spaces, if any of the spaces have a water heater fuel type of gas (from Appendix 5.4A) water heater, the standard design for that space shall ~~have be~~ one gas storage water heater. ~~if any of the spaces have a Space Water Heating Fuel Type of Gas (from Appendix 5.4A); and If any of the spaces have a water heater fuel type of electric~~, the standard design for that space ~~building will have on~~ shall be an electric water heater ~~if the any of the spaces have a Space Water Heating Fuel Type of Electric~~.
For electric water heaters with recirculation, if the water heater is a central split HPWH, the standard design shall be central split HPWH piped in return to primary configuration.

Standard Design: Existing Buildings: Same as proposed if proposed system is existing.

3.6.7 Compliance Forms

As discussed in Section 3.1.4.5, the 2025-NRCC-PLB-E, 2025-NRCI-PLB-E, 2025-LMCC-PLB-01-E, 2025-LMCI-PLB-E, 2025-NRCC-PRF-E and 2025-LMCC-PRF-E compliance forms would be updated to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

4. Requirements for Unitary HP/ER Hybrid Heaters

4.1 Requirements for Unitary HP/ER Hybrid Heaters - Measure Description

4.1.1 Proposed Code Change

This proposed measure would add prescriptive requirements to Title 24, Part 6 to ensure that unitary Heat Pump / Electric Resistance (HP/ER) hybrid water heaters are specified and installed in a way that minimizes electric resistance use. The proposed measure would apply to new construction, alterations, and additions in nonresidential buildings.

The measure would require unitary HP/ER HPWHs to be installed according to the manufacturer’s design and installation requirements for ventilation and set a minimum compressor cutoff temperature for both heat pump-only and hybrid (heat pump and electric resistance) operating modes. The measure would require sizing based on expected operational conditions and installation of multiple water heaters in a manner that would balance the loads on each water heater. Additionally, the measure would require that the HP/ER HPWH can operate in heat pump-only mode under the Heating Design Day 0.6 percent dry bulb temperature if the HPWH is located in an unconditioned space or an indirectly conditioned space, or if the HPWH is located in a space that has a louver to outdoors.

Table 44 summarizes the scope of the proposed code change.

Table 44: Scope of Proposed Code Change

A indicates the proposed code change is relevant.

Building Type(s)	Construction Type(s)	Type of Change
<input type="checkbox"/> Single Family	<input checked="" type="checkbox"/> New Construction	<input type="checkbox"/> Mandatory
<input type="checkbox"/> Multifamily	<input checked="" type="checkbox"/> Additions	<input checked="" type="checkbox"/> Prescriptive
<input checked="" type="checkbox"/> Nonresidential (Not Group R uses)	<input checked="" type="checkbox"/> Alterations	<input type="checkbox"/> Performance

Application Climate Zones	Energy Code Sections	Compliance Forms	Sections of ACM Reference Manuals
Climate Zones 1-16	<ul style="list-style-type: none"> Part 6, Sections 100.1, 140.5(a), 141.0(b) 	N/A	Nonresidential & Multifamily ACM Appendix B: Water Heating Calculation Method

	<ul style="list-style-type: none"> Nonresidential Reference Appendix Section 		
Third Party Verification)		Updates to Compliance Software	
<input checked="" type="checkbox"/> No changes to third party verification		<input type="checkbox"/> No updates	
<input type="checkbox"/> Update existing verification requirements		<input checked="" type="checkbox"/> Update existing feature	
<input type="checkbox"/> Add new verification requirements		<input checked="" type="checkbox"/> Add new feature	

4.1.2 Benefits of Proposed Change

The proposed change would decrease energy usage and costs when unitary HP/ER HPWHs are installed in nonresidential buildings. Additionally, the proposed change would improve user satisfaction with hot water delivery and reduce the risk of unwanted side effects such as overly cooled mechanical spaces and related condensation issues in those spaces. This proposed measure is appropriate at this time due to the growth in electrification programs and rulings from the South Coast Air Quality Management District (SCAQMD) and the Bay Area Air Quality Management District (BAAQMD) that are leading to increased use of HPWHs.

While HPWHs theoretically provide tremendous energy savings compared to electric resistance water heaters, field studies have demonstrated certain installation practices and control approaches that negate those benefits (Garcia, et al. 2024, Staller, Chu, et al. 2026). First, many HPWHs have less efficient electric resistance elements built into the units as a backup to provide faster heating, and these field studies have demonstrated a higher use of electric resistance than expected to provide hot water. Since use of the product’s ER heater is not as efficient as use of its heat pump, energy bills are much higher than anticipated. These same issues that increase the cost of providing hot water also limit the hot water delivery capabilities of the system, thereby risking dissatisfaction from end users if hot water is delivered at a temperature lower than desired. Finally, inappropriate installation and control of the units can lead to overly cold ambient spaces since heat pumps have a cooling effect on their surrounding space. This cooling effect may lead to condensation on surfaces within that space, risking the potential for mold and other durability issues. The proposed measure would reduce the chances of these unwanted side effects by requiring proper control of the equipment to minimize the use of electric resistance when not needed, and specifying installation practices that allow the units to operate more often in heat pump mode.

4.1.3 Background Information

Heat pump water heaters generate hot water by using a refrigeration cycle that moves heat from the surroundings into the water. By using a refrigeration system, they are capable of adding thermal energy to the water in excess of the input energy that the

customer pays for. While the efficiency of an electric resistance heater is no greater than one, a heat pump water heater can achieve coefficients of performance (i.e., efficiency) greater than one. For example, a 120-gallon commercially available HPWH meant for commercial buildings has a rated COP of 4.3, meaning that it is rated to use 23 percent of the energy that an electric resistance water heater would require to deliver the same amount of hot water in the same application. In addition to the energy savings, a heat pump can generate the same amount of hot water as electric resistance but with a much smaller power draw.

To create an equivalent amount of hot water, heat pumps currently have a higher first cost than electric resistance elements. Having two modes of heating water creates different potential paths to ensure adequate hot water supply at a reasonable first cost. One step is to increase the storage tank size of the water heater. Doing so provides a larger buffer for times when hot water demand is great, with the tank being able to recover to operating temperature gradually via the heat pump when hot water demand is low. Another step is to add electric resistance elements to the tank for times when the tank is running out of hot water and shorter recovery time is needed. This configuration is known as “hybrid” mode, where the tank can run using a heat pump for high efficiency but also can utilize resistance heating to meet higher demand periods. Typically, manufacturers program a controller in the HPWH to specify the conditions when it uses the heat pump, the resistance element(s), or both. Controls on water heaters often give the user the option to choose different operating modes. For example, “efficiency” mode may disable the electric resistance elements to prohibit their use, and “resistance” mode could be available to run the water heater without the heat pump. However, the user does not necessarily have control over when the electric resistance elements will operate when in hybrid mode.

A critical issue affecting the performance of heat pumps is the ambient air temperature. Heat pumps pull heat from the surrounding air via an evaporator and transfer it to the water, similar to how an air conditioner moves heat from indoor spaces to the outdoors. The impact on the environment surrounding the evaporator is the same: cooling of the surrounding air. While the heat pump impacts the surrounding air, the temperature of the air also has an impact on the performance of the heat pump. As air temperature decreases, the efficiency and capacity of the heat pump to heat water decreases. For this reason, manufacturers typically set an ambient cutoff temperature to prevent the heat pump from operating in an ineffective mode. Below this cutoff temperature, the water heater would typically revert to electric resistance heating to provide hot water. This interplay between the heat pump and the surrounding air can be critical to performance. As the HPWH operates, it cools the surrounding air. As the surrounding air drops in temperature, the capability and efficiency of the HPWH drops. To account for this relationship, manufacturers will typically specify required air volumes around the

water heater to ensure an adequate supply of thermal energy and to reduce the risk of a drop in air temperature due to the HPWH operation.

In some instances, the heat pump unit of the water heater can be located away from the storage tank (i.e., a “split system”), but water heaters are available with the heat pump integrated with the storage tank. These units are known as “unitary” heat pump water heaters. Unitary water heaters promise a simpler installation since they do not require a contractor to assemble the heat pump system in the field. A challenge, however, is to ensure that there is sufficient air volume surrounding the water heaters to ensure that the heat pump does not overly cool the space to the point that the heat pump no longer works and the control scheme triggers electric resistance heating.

A final aspect of commercial water heating that is relevant to this proposed measure is the configuration of the plumbing system delivering hot water to end uses in commercial buildings. The units under consideration in this proposed measure are generally installed as central heat pump water heaters, meaning that the equipment is centrally located in the building and serves multiple spaces and end uses throughout the building. The water heaters can be plumbed directly to end uses such that water leaves the water heater only when it is drawn at an end fixture, but oftentimes a commercial building’s plumbing system includes a circulating loop that leaves the water heater, travels through the building to bring hot water near end uses, and returns unused hot water to the tanks. This latter approach is one design approach that can get hot water closer to end uses so the user does not have a large delay as hot water travels from the water heater to the end uses. Some designers need to install multiple water heaters to meet demand. When this approach is taken, installers must take steps to ensure that the load on each water heater is approximately equal. These steps include setting the thermostat temperatures to be the same and balancing the flow among the multiple water heaters.

This proposal originates from the results of a CalNEXT Field Study of Master Mixing Valve whose goal was to determine the energy efficiency potential of a master mixing valve (Garcia, et al. 2024). The CalNEXT team monitored a water heating system comprised of two hybrid HPWH piped in parallel, with continuous recirculation in a 51-unit hotel in San Diego, CA. During monitoring, the CalNEXT team identified several issues causing poor system performance, including an imbalance between the two HPWHs due to different hot water set points. One HPWH was set to 120°F while the other was set to 140°F, which, combined with the continuous recirculation, led to constant activation of one HPWH in electric resistance mode, while the second HPWH never activated. Changing the hot water temperature setpoints for both water heaters to 130°F resulted in about 40 percent energy savings.

At the end of the Master Mixing Valve study, the CalNEXT team observed the HPWH water heating system was operating at a system Coefficient of Performance (COP) of

0.86, which is lower than expected. Based on results in the study that examined other water heating technologies, one would expect that the COP of the system would be approximately one half that of the rated water heater COP due to losses in the circulation systems. With the rated value of the water heater being 4.3 and accounting for deviations from this rating for real-world effects (e.g., different inlet water and ambient conditions, some use of ER), the Statewide CASE Team estimates that the system COP when water is heated by this HPWH should be approximately 1.5 to 2. The CalNEXT team's observations of low system COP led to a new, ongoing Code Readiness field demonstration study to investigate improvements to unitary HP/ER hybrid water heaters in nonresidential buildings and evaluate the energy savings impacts. Based on the nonresidential building site screenings for this project, the Code Readiness team learned that most of the hybrid heaters are running under hybrid mode (HP + ER) instead of HP only mode, and the ER is on for the majority of the operation. The Code Readiness team attributes the excessive use of ER to a number of possible factors. First, ambient temperatures in the spaces surrounding the unitary HP/ER water heaters are low, with preliminary results showing that the ambient temperatures can drop below 50°F. Another factor is that high setpoint temperatures may lead to increased ER use, and there was a range of setpoints for these installed systems. Staller et al (2026) found temperatures of the ambient around unitary HP/ER water heaters below 50°F when the equipment is installed in spaces with inadequate ventilation.

Unitary HP/ER HPWHs are increasingly installed in central systems with continuous recirculation with support from federal, state, local, and utility incentive programs. Field studies have shown that many of these installations exhibit inefficiencies that can be addressed with relatively simple measures (Garcia, et al. 2024, Staller, Initial Results from Integrated HPWH Retrofit Projects in Non-Residential Buildings 2025, Lindsey 2022). The Statewide CASE Team is, therefore, proposing this measure to require such approaches to installing unitary HP/ER water heaters.

4.1.4 Modifications to Energy Code Documents

This section provides descriptions of how the proposed code change will affect each Energy Code document. See Section 4.6 Requirements for Unitary HP/ER Hybrid Heaters - Proposed Language Code of this report for detailed revisions to code language.

4.1.4.1 Energy Code Change Summary

SECTION 140.5 – PRESCRIPTIVE REQUIREMENTS FOR SERVICE WATER HEATING SYSTEMS

Subsection 140.5(a): The proposed measure adds requirements for unitary heat pump/electric resistance hybrid water heaters to be specified and installed in new construction in a way that minimizes electric resistance use.

SECTION 141.0 – PRESCRIPTIVE REQUIREMENTS FOR SERVICE WATER HEATING SYSTEMS

Subsection 141.0(b)2.N. : The proposed measure adds requirements for unitary heat pump/electric resistance hybrid water heaters to be specified and installed in additions and alterations in a way that minimizes electric resistance use.

4.1.4.2 Reference Appendices Change Summary

The proposed measure would update JA14 – “Qualification Requirements for Central Heat Pump Water Heater Systems” to specify requirements for sizing unitary HP/ER water heaters and for installing systems involving multiple HP/ER water heaters.

4.1.4.3 Compliance Manuals Change Summary

The proposed measure will update section 4.8.3 of the Compliance Manual to explain room size, ventilation requirements, heat pump capacity derating and compressor cutoff temperature concepts.

4.1.4.4 Alternative Calculation Method Reference Manual Change Summary

The proposed measure would update Non-residential and Multifamily ACM: Appendix B Water Heating Calculation Method to include default and measure performance as well as performance pathway penalty.

4.1.4.5 Compliance Forms Change Summary

The proposed code change would modify the compliance forms listed below:

2025-LMCC-PLB-01-E: Low-rise Multifamily Certificate of Compliance Domestic Water Heating

2025-LMCC-PRF-01: Low-rise Multifamily Performance Compliance Method

2025-LMCI-PLB-E: Low-rise Multifamily Certificate of Installation Domestic Water Heating System

2025-NRCI-PLB-E: Nonresidential Certificate of Installation Domestic Water Heating

2025 NRCC-PLB-E: Nonresidential Certification of Compliance Domestic Water Heating

2025 NRCC-PRF-01: Nonresidential Performance Compliance Method

4.1.5 Measure Context

4.1.5.1 Comparable Model Codes or Standards

American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) 90.1 is relevant to the proposed code change described here. However, the Statewide CASE Team is not aware of any efforts within ASHRAE 90.1, AHRI, or other industry groups to specify installation and operational requirements that would minimize the use of electric resistance heat in installations involving unitary heat pump water heaters capable of operating in hybrid mode in non-residential applications.

4.1.5.2 Interactions with Other Regulations

The Statewide CASE Team is not aware of any federal, state, or local regulatory requirements that address the same topic as the proposed change.

4.2 Requirements for Unitary HP/ER Hybrid Heaters - Compliance and Enforcement

4.2.1 Compliance Considerations

The Statewide CASE Team foresees that building designers would comply with the proposed measure via self-attestation and self-testing.

During the design phase, designers would check drawings to ensure that the space available to the unitary hybrid heat pump water heaters meets the requirements of the proposed measure. In the absence of sufficient air volume, the architects and plumbing designers would attest to the availability of sufficient makeup air to meet the proposed measure. Plumbing designers would also attest that the unitary HP/ER water heaters meet the compressor cutoff requirements and overall design requirements according to manufacturer data. Architects, engineers, and plumbing designers would conduct this self-attestation for new construction, additions and alterations.

During the installation phase, plumbers would attest that the water heaters are set to the same setpoint temperature and that the units are set to the correct operating mode.

4.2.2 Impact on Market Actors

Table 45 summarizes impacts on market actors and suggests outreach and education that might be helpful to support market actors as they prepare for the effective date of the requirements.

Table 45: Impacts on Market Actors and Suggested Training and Education Opportunities

Market Actor	Impact(s)	Suggested Outreach and Education
Builders^a	Possible impacts due to requiring more space to meet the ventilation space requirements.	Train the design professionals who consult for builders on selection of proper system type (e.g., split systems where meeting ventilation space requirements is challenging).
Design Professionals^b	Required knowledge of design requirements, perform additional design calculations (derating capacity and/or COP)	Improve compliance manual as a training source, and develop other resources
Construction Team^c	New device and equipment configuration requirements (set points and flow balancing)	Improve compliance manual as a training source, and develop other resources
Building Departments^d	Review plans and compliance forms and be able to determine if design/install is meeting the new requirements	Educate on what to look for in plan check and during inspection
Verification Testers^e	None	N/A
Building Owners, Managers, and Occupants	Reduced energy bills. Increased installation costs and lost floor area.	Educate on why the measure is important and how it saves on energy costs.
Manufacturers and Distributors	Increased data reporting burden	Educate manufacturers on the need for equipment performance data to allow designers to properly size systems

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

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

market actors and additional quantitative analyses of its potential impacts on building industry subsectors.

Builders. The proposed change would likely affect commercial builders; however, it would likely not impact firms focused on the construction or retrofitting of industrial buildings, utility systems, public infrastructure, or other heavy construction. The proposed change would not affect all firms and workers in the commercial building industry equally; instead, it would primarily affect specific subsectors within the industry. Table 46 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report. The proposed measure would require sufficient air volume around a unitary HP/ER water heater or that the mechanical system provides sufficient makeup air into the space. This requirement may cause a builder to devote more space to the water heater room. There are alternative approaches, however, that could allow the builder to meet the requirements of the proposed change without major changes to the building footprint, and the Statewide CASE Team proposes to add best practice examples to the Compliance Manual.

Table 46: Specific Subsectors of the California Commercial 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 Electrical Contractors	3,245	72,794	7.8
Nonresidential Plumbing & HVAC Contractors	2,270	55,182	5.8

Source: (State of California n.d.) (State of California n.d.)

*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. US Bureau of Labor Statistics, Handbook of Methods. <https://www.bls.gov/opub/hom/cew/concepts.htm>

Manufacturers. The proposed code change would require manufacturers to increase the data that they report for their unitary HP/ER water heaters, including information such as compressor cutoff temperature, minimum ambient operating temperature, and capacity at different ambient air conditions. The Statewide CASE Team is not aware of any heat pump water heater manufacturer based in California.

4.2.3 Compliance Software Updates

The proposed code change would require CBECC to add new user inputs and new calculations for the performance pathway. CEC would need to add inputs to CBECC to allow designers and installers to specify the system COP of their proposed system to

compare to the baseline system COP. CEC would need to incorporate energy penalties and derating factors into CBEC to provide a proper energy budget for a given installation. CEC would need to add the capability to report results to the NRCC-PRF-E form. The Statewide CASE Team will compile data to develop those energy penalties and derating factors.

The Statewide CASE Team will provide detailed recommendations on software enhancements in summer 2026.

4.2.4 Cost of Enforcement

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

There will be additional costs for more time to ensure compliance with the proposed measure, including training on the new measure and additional labor for enforcement and verification for all projects implementing the measure.

The Statewide CASE Team will be researching and documenting the projected impact on plan checkers and building inspectors as well as additional administrative costs to manage and properly enforce the measure, including contacting AHJs and other stakeholders for estimates of additional staff time and training costs.

4.3 Requirements for Unitary HP/ER Hybrid Heaters - Market and Economic Analysis

4.3.1 Market Structure and Availability

4.3.1.1 Current Market Structure and Availability

Recently passed rulings by the SCAQMD and the BAAQMD are driving the adoption of electric water heaters in nonresidential applications, and the cost savings associated with heat pump technology compared to electric resistance water heaters will mean that many of these electric water heaters will be HPWHs. The Statewide CASE Team expects that most of these HPWH's will be HP/ER units to provide a backup to guard against running out of hot water. The market adoption of unitary HP/ER water heaters is increasing in nonresidential central systems with continuous recirculation such as supermarkets with support from utility incentive programs (Statewide Midstream Water Heating Program 2025). The current market share of these units is currently low but is growing with incentives. Unitary HP/ER water heaters are most common in supermarkets and food service facilities, but the Statewide CASE Team believes that market adoption is broader than these segments but with relatively low penetration.

Field studies such as the CalNEXT Field Study of Master Mixing Valves have shown that many of these systems exhibit inefficiencies that relatively simple requirements can address (Garcia, et al. 2024). The Statewide CASE Team believes that there is a lack of awareness and attention to these problems, for alterations, new construction, and additions. Utility incentive programs do not require installation practices that alleviate the inefficiencies of unitary HP/ER water heaters, and contractors and designers are generally unaware of what is needed to achieve an energy-efficient installation. Given the growing adoption of these systems, the Statewide CASE Team believes that current system inefficiencies will persist if the Energy Code does not mandate proper design and control strategies.

The proposed measure will impact manufacturers of unitary HP/ER water heaters. The proposed measure would require units to have compressor cutoff temperatures no higher than a specified value which may require re-design of their products and improved reporting of those cutoff values for use by designers and code officials. The Statewide CASE Team believes that current unitary heat pump water heaters are capable of meeting the proposed requirements and will not require re-design. The manufacturers will also need to provide clear requirements on the amount of air volume in the space where the unitary HP/ER water heaters are installed to operate their water heaters without overly cooling the surrounding space. The Statewide CASE Team believes that manufacturers already provide such information. The Statewide CASE Team is aware of one model of unitary heat pump water heaters meant for central recirculation systems that the proposed measure would impact (manufactured by A.O. Smith), but it may also impact other manufacturers who make water heaters (e.g., Rheem, Bradford White). The Statewide CASE Team reviewed manufacturers' literature on unitary HP/ER water heaters appropriate for nonresidential applications and determined that they provide information on the required volume of air surrounding the water heaters. The Statewide CASE Team determined that manufacturers do not currently report compressor cutoff temperatures and would need to adjust product literature to provide that information. Field inspectors would need this information from manufacturers to determine if the installed equipment meets the designer's specifications and whether those specifications comply with the proposed measure.

The proposed measure would impact building and plumbing designers and installers. Plumbing designers and installers would need to confirm that the compressor cutoff temperatures of installed equipment meet the specifications. Designers of new buildings, additions, and alterations would need to assess the air volume requirements and possibly modify the mechanical room to ensure adequate supply air for the HPWH's. If the units use outdoor air, designers would need to confirm the HPWH's ability to operate at the specified local design temperatures.

The proposed measure applies to situations where a designer would specify a unitary HP/ER water heater in a building but does not require the designer to use such equipment. If the designer cannot meet these requirements for unitary HP/ER water heaters, that designer can opt for different types of water heaters to meet the demand from the building.

4.3.1.2 Market Challenges and Solutions

A key market challenge for the measure is the small number of unitary HPWH's currently on the market. The Statewide CASE Team has engaged with water heater manufacturers and program implementers to assess the market for this type of equipment. The proposed measure may limit designers in their options for meeting the requirements until manufacturers bring more water heaters to the market. The Statewide CASE Team expects manufacturers will bring more units to the market as California and other jurisdictions transition away from fossil fuel-fired water heaters. Engagement with programs in California has demonstrated the viability of this technology, and these provisions will ensure the expected energy savings.

Another market challenge is the lack of experience in the design and contractor space. These products are relatively new, so familiarity is lacking. The Statewide CASE Team has seen a good number of installations associated with incentive programs, but it is not clear how many units designers and installers specify and install outside of these programs. Educational materials for the design and contracting community will increase market uptake of the technology and ensure that the proposed measure will lead to unitary HP/ER water heater systems that meet their intended performance.

See Section 4.2 for a description of workforce trainings that may be needed to ensure effective design, installation, and commissioning.

4.3.2 Design and Construction Practices

4.3.2.1 Current Design and Construction Practices

The current practice for installing unitary HPWH's in nonresidential applications generally does not consider special installation and startup procedures specific to heat pump water heaters. Hence, the Statewide CASE Team expects little difference between the design practice for unitary HP/ER water heaters and those for other types of water heaters, e.g., fossil fuel-fired or electric resistance. In retrofit applications, which will make up the majority of installations, designers and installers often seek to install a drop-in replacement for the existing water heater without making changes to the surrounding infrastructure. The Statewide CASE Team believes that designers and installers give little consideration to manufacturer guidelines, startup procedures, compressor cutoff temperatures, and balancing flow between multiple water heaters in both new construction and retrofits/alterations. *The Statewide CASE Team will further*

explore this issue through review of plans and interviews with water heater system designers and installers.

4.3.2.2 Health and Safety Considerations

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

The Statewide CASE Team believes that the proposed measure will improve the health and safety of hot water systems and the indoor environment compared to installations of unitary HP/ER water heaters that would not follow these proposed provisions. The proposed measure would ensure that the HPWH has adequate ventilation and is configured appropriately to improve the ability of the water heater to maintain a sufficiently high temperature within the service water heating system to reduce the risk of pathogen growth. Additionally, the proposed measure would decrease the risk that the unitary HP/ER water heaters would overly cool the surrounding space and, therefore, increase the potential for mold growth on surfaces where moisture condenses.

4.3.2.3 Design and Construction Challenges and Solutions

A number of design and construction challenges may arise in implementing the proposed measure. Some of these challenges relate to the water heaters themselves. First, the number of unitary HPWH's meant for commercial applications is currently limited, so designers may not have many options when looking for units that meet compressor cutoff requirements or have manufacturer specifications that align with the building in which the designer installs the units. The Statewide CASE Team is aware of one unitary HP/ER water heater in the commercial category according to DOE regulations (AO Smith Model CHP-120). Some water heaters categorized as Consumer units could be used in nonresidential applications. The Statewide CASE Team identified at least ten manufacturers who make unitary heat pump water heaters with rated storage volumes of 80 gallons or greater that could be used in nonresidential applications. Additionally, the goal of operating the systems primarily in heat pump mode, as a designer and installer would expect, is dependent upon water heater control algorithms that are out of the purview of the designer. A third challenge related to the water heaters is that the designer may not have easy access to data on compressor cutoff temperatures or the ability to control those cutoff temperatures. To overcome these challenges, the proposed measure focuses on performance and is agnostic to

control algorithms or water heater models. The Statewide CASE Team also conducted research to identify established test procedures such as those developed by the Northwest Energy Efficiency Alliance that can characterize compressor cutoffs.

Another design and construction challenge relates to the ventilation requirements. Some spaces, particularly in alterations, may lack the volume needed and would require some amount of outdoor air brought into the space. Such design and construction of the space may be complex. In addition to guidance provided by manufacturers on the proper installation of unitary HP/ER water heaters, the Statewide CASE Team identified guidance from the Energy Trust of Oregon (Ecotope 2023), the Northwest Energy Efficiency Alliance (NEEA, Advanced Water Heating Specification 2024), and the United States Environmental Protection Agency (EPA 2025) that could assist designers and installers in meeting the proposed requirements.

See Table 3 in Section 4.2.2 for a description of workforce trainings that could support effective design, installation, and commissioning.

4.3.3 Energy Equity and Environmental Justice

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

The Statewide CASE Team assessed the potential impacts of the proposed measure, and based on a preliminary review, the measure is unlikely to have significant impacts on energy equity or environmental justice.

This section is still in progress. The Statewide CASE Team is continuing to engage with stakeholders to determine potential impacts on ESJ communities, and will update this section with any additional findings.

4.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team will complete this section for the Final CASE Report.

4.3.5 Economic and Fiscal Impacts

The Statewide CASE Team will complete this section for the Final CASE Report.

4.4 Requirements for Unitary HP/ER Hybrid Heaters - Cost Effectiveness

4.4.1 Cost Effectiveness Methodology

The Statewide CASE Team collaborated with CEC staff to confirm that the cost-effectiveness methodology aligns with CEC guidelines, including cost inclusion

parameters. The 2028 CASE Methodology Report and Appendix A provide reproducibility details.

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

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

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

4.4.2 Energy and Energy Cost Savings Results

Table 47 through Table 50 present energy savings (electricity and source energy) and peak demand reductions per unit. Per-unit savings for the first year are expected to range from 0.01 to 0.62 (kWh/ft²)/yr, depending upon CZ. Demand reductions are expected to range between 0.02 (kW/ft²)/yr and 1.21 (kW/ft²)/yr, depending on CZ. Because the proposed measure is specific to electric heat pump systems, there are no natural gas savings.

Table 51 presents total per-unit energy cost savings for newly constructed buildings and additions in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV\$). The LSC methodology allows peak electricity savings to be valued more than electricity savings during non-peak periods. Table 51 presents a breakdown of total LSC savings from electricity savings for the prototypical buildings.

Table 47: First Year Electricity Savings (kWh) Per Square Foot – Unitary HP/ER Hybrid Heaters – New Construction and Additions

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
Assembly	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Grocery	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Retail	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.09	0.10	0.09	0.10	0.10	0.09	0.10	0.08	0.12
Large School	0.13	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.13
Medium Office	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Medium Retail	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.04	0.06
Mixed-use Retail	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.12	0.17
Restaurant	0.62	0.59	0.58	0.57	0.58	0.55	0.54	0.53	0.54	0.53	0.54	0.56	0.53	0.54	0.46	0.61
Small School	0.14	0.14	0.14	0.13	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.11	0.14
Strip Mall	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.12	0.17

Table 48: First Year Peak Demand Reduction (kW) Per Square Foot – Unitary HP/ER Hybrid Heaters – New Construction and Additions

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
Assembly	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.03	0.05

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
Grocery	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
Large Office	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.04	0.06
Large Retail	0.24	0.22	0.21	0.21	0.21	0.19	0.19	0.18	0.19	0.18	0.19	0.20	0.18	0.19	0.15	0.23
Large School	0.25	0.23	0.23	0.23	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.22	0.21	0.21	0.18	0.24
Medium Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Medium Retail	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.09	0.12
Mixed-use Retail	0.33	0.31	0.31	0.30	0.31	0.29	0.29	0.28	0.28	0.28	0.29	0.30	0.28	0.29	0.24	0.32
Restaurant	1.20	1.14	1.13	1.11	1.14	1.06	1.05	1.04	1.04	1.03	1.05	1.09	1.03	1.06	0.90	1.18
Small School	0.28	0.27	0.27	0.26	0.27	0.25	0.25	0.25	0.25	0.25	0.25	0.26	0.25	0.25	0.22	0.28
Strip Mall	0.33	0.31	0.31	0.30	0.31	0.29	0.29	0.28	0.28	0.28	0.29	0.30	0.28	0.29	0.24	0.32

Table 49: First Year Natural Gas Savings (kBtu) Per Square Foot – Unitary HP/ER Hybrid Heaters – New Construction and Additions

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
Assembly	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Grocery	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Large School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Medium Office	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Medium Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Mixed-use Retail	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Restaurant	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Small School	n/a	n/a	n/a	n/a	n/a	n/a	n/a									
Strip Mall	n/a	n/a	n/a	n/a	n/a	n/a	n/a									

Table 50: First Year Source Energy Savings (kBtu) Per Square Foot – Unitary HP/ER Hybrid Heaters – New Construction and Additions

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
Assembly	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04
Grocery	0.05	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
Large Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Retail	0.13	0.12	0.12	0.11	0.12	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.11	0.08	0.13

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large School	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.12
Medium Office	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	0.01	0.02
Medium Retail	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06	0.07	0.06	0.07
Mixed-use Retail	0.21	0.20	0.20	0.19	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.16	0.20
Restaurant	0.96	0.92	0.91	0.89	0.91	0.85	0.84	0.83	0.83	0.82	0.85	0.88	0.83	0.86	0.73	0.95
Small Office	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Strip Mall	0.21	0.20	0.20	0.19	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.16	0.20

Table 51: Total 30-Year LSC Savings (2029 PV\$) Per Square Foot – Unitary HP/ER Hybrid Heaters – New Construction and Additions

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
Assembly	0.23	0.21	0.21	0.20	0.21	0.18	0.18	0.19	0.19	0.18	0.18	0.20	0.18	0.18	0.15	0.23
Grocery	0.26	0.25	0.25	0.24	0.25	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.23	0.23	0.20	0.26
Large Office	0.25	0.23	0.22	0.21	0.22	0.20	0.20	0.19	0.19	0.19	0.20	0.21	0.19	0.20	0.16	0.24
Large Retail	0.90	0.83	0.82	0.78	0.83	0.71	0.71	0.70	0.72	0.69	0.72	0.77	0.70	0.71	0.55	0.87
Large School	0.94	0.88	0.88	0.85	0.88	0.80	0.80	0.78	0.79	0.78	0.80	0.84	0.78	0.80	0.66	0.91
Medium Office	0.12	0.12	0.12	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.12
Medium Retail	0.47	0.45	0.45	0.43	0.45	0.41	0.41	0.40	0.41	0.40	0.41	0.43	0.40	0.40	0.35	0.47
Mixed-use Retail	1.32	1.25	1.24	1.20	1.25	1.13	1.13	1.12	1.14	1.11	1.13	1.19	1.12	1.12	0.96	1.29

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
Restaurant	5.27	5.01	4.98	4.83	4.98	4.61	4.58	4.56	4.59	4.53	4.59	4.78	4.51	4.59	3.91	5.22
Small School	1.09	1.04	1.04	1.01	1.04	0.98	0.97	0.96	0.96	0.95	0.97	1.00	0.96	0.97	0.85	1.06
Strip Mall	1.32	1.25	1.24	1.20	1.25	1.13	1.13	1.12	1.14	1.11	1.13	1.19	1.12	1.12	0.96	1.29

Table 52: First Year Electricity Savings (kWh) Per Square Foot – Unitary HP/ER Hybrid Heaters – Alterations

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
Assembly	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Grocery	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Retail	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.09	0.10	0.09	0.10	0.10	0.09	0.10	0.08	0.12
Large School	0.13	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.13
Medium Office	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Medium Retail	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.04	0.06
Mixed-use Retail	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.12	0.17
Restaurant	0.62	0.59	0.58	0.57	0.59	0.55	0.54	0.54	0.54	0.53	0.54	0.56	0.53	0.55	0.47	0.61
Small School	0.15	0.14	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.11	0.14
Strip Mall	0.17	0.16	0.16	0.15	0.16	0.15	0.15	0.14	0.15	0.14	0.15	0.15	0.14	0.15	0.12	0.17

Table 53: First Year Peak Demand Reduction (kW) Per Square Foot – Unitary HP/ER Hybrid Heaters – Alterations

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
Assembly	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.03	0.05
Grocery	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
Large Office	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.04	0.06
Large Retail	0.24	0.22	0.21	0.21	0.21	0.19	0.19	0.18	0.19	0.18	0.19	0.20	0.18	0.19	0.15	0.23
Large School	0.25	0.23	0.23	0.23	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.22	0.21	0.22	0.18	0.24
Medium Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Medium Retail	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.09	0.12
Mixed-use Retail	0.33	0.31	0.31	0.30	0.31	0.29	0.29	0.28	0.28	0.28	0.29	0.30	0.28	0.29	0.24	0.32
Restaurant	1.21	1.15	1.14	1.11	1.14	1.07	1.06	1.04	1.05	1.04	1.06	1.10	1.04	1.06	0.91	1.19
Small School	0.28	0.27	0.27	0.26	0.27	0.26	0.25	0.25	0.25	0.25	0.25	0.26	0.25	0.26	0.22	0.28
Strip Mall	0.33	0.31	0.31	0.30	0.31	0.29	0.29	0.28	0.28	0.28	0.29	0.30	0.28	0.29	0.24	0.32

Table 54: First Year Natural Gas Savings (kBtu) Per Square Foot – Unitary HP/ER Hybrid Heaters – Alterations

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
Assembly	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grocery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Large Office	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Retail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Large School	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medium Office	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medium Retail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mixed-use Retail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Restaurant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small School	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strip Mall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 55: First Year Source Energy Savings (kBtu) Per Square Foot – Unitary HP/ER Hybrid Heaters – Alterations

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
Assembly	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.04
Grocery	0.05	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
Large Office	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Large Retail	0.13	0.12	0.12	0.11	0.12	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.10	0.11	0.08	0.13
Large School	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.12
Medium Office	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	0.01	0.02
Medium Retail	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06	0.07	0.06	0.07

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
Mixed-use Retail	0.21	0.20	0.20	0.19	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.16	0.20
Restaurant	0.97	0.92	0.91	0.89	0.91	0.85	0.85	0.83	0.84	0.83	0.85	0.88	0.84	0.86	0.73	0.95
Small School	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.14	0.15	0.13	0.16
Strip Mall	0.21	0.20	0.20	0.19	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.16	0.20

Table 56: Total 30-Year LSC Savings (2029 PV\$) Per Square Foot – Unitary HP/ER Hybrid Heaters – Alterations

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
Assembly	0.23	0.22	0.21	0.20	0.21	0.18	0.18	0.19	0.20	0.19	0.19	0.20	0.18	0.18	0.15	0.23
Grocery	0.26	0.25	0.25	0.24	0.25	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.23	0.23	0.20	0.26
Large Office	0.25	0.23	0.22	0.21	0.22	0.20	0.20	0.19	0.19	0.19	0.20	0.21	0.19	0.20	0.16	0.24
Large Retail	0.90	0.83	0.82	0.78	0.83	0.71	0.71	0.70	0.72	0.69	0.72	0.77	0.70	0.71	0.55	0.87
Large School	0.95	0.89	0.88	0.85	0.88	0.81	0.81	0.79	0.79	0.79	0.80	0.84	0.79	0.80	0.67	0.91
Medium Office	0.12	0.12	0.12	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.09	0.12
Medium Retail	0.47	0.45	0.45	0.43	0.45	0.41	0.41	0.40	0.41	0.40	0.41	0.43	0.40	0.40	0.35	0.47
Mixed-use Retail	1.32	1.25	1.24	1.20	1.25	1.13	1.13	1.12	1.14	1.11	1.13	1.19	1.12	1.12	0.96	1.29
Restaurant	5.30	5.04	5.00	4.85	5.01	4.64	4.61	4.59	4.62	4.56	4.62	4.80	4.53	4.62	3.94	5.25
Small School	1.11	1.06	1.06	1.03	1.06	1.00	0.99	0.97	0.98	0.97	0.99	1.02	0.98	0.99	0.87	1.08
Strip Mall	1.32	1.25	1.24	1.20	1.25	1.13	1.13	1.12	1.14	1.11	1.13	1.19	1.12	1.12	0.96	1.29

4.4.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices as compared to the cost of an equivalent baseline project. The Statewide CASE Team considers first costs in evaluating overall measure cost-effectiveness. Incremental first costs are based on data currently available and can change over time as markets evolve and professionals become more familiar with new technology and building practices.

The proposed measure could lead to increases in the first cost of newly installed water heating equipment if the proposed sizing provisions require a water heater with a higher heating rate or larger storage volume. The Statewide CASE Team collected pricing for different sizes of water heaters for use in estimating the incremental first costs. Other provisions in the proposed changes may allow use of the same water heater but with different setup procedures and would not involve any changes to first costs. Additionally, the proposed code change would permit a building owner to install water heaters that are not unitary HP/ER HPWHs. The Statewide CASE Team assumes that the alternative water heater will have a comparable installation price.

The proposed measure could necessitate alterations to the design of the room holding the unitary HP/ER water heaters to accommodate the proposed air volume requirements for new construction, additions, and alterations. The Statewide CASE Team does not believe that a building designer would add floor space solely to accommodate a unitary HP/ER water heater when other options are available to meet water heating demands. Additionally, the Statewide CASE Team does not believe that reallocation of floor space to accommodate the unitary HP/ER water heater would change the first cost. The Statewide CASE Team does consider a feasible option for providing the required volume to include the addition of a louvered door and louvers in walls to provide access to air in adjacent rooms. A manual for one unitary HP/ER water heater which has a rated heat pump output of 41,669 Btu/h indicates a required louver area of 4 square feet for each unit (A.O. Smith 2025). The Statewide CASE Team used an online sizing calculator (A.O. Smith 2025) to estimate the number of these unitary HP/ER water heaters that a building would need to meet hot water demands. The units considered have a rated storage volume of 119 gallons and a thermal output of 82,615 Btu/h in hybrid mode. For the Large Office prototype, the calculator estimates that the building would require three water heaters. For the Medium Office with Laboratories, the calculator estimated a total of four to seven water heaters depending upon CZ. The calculator estimated that the Small School prototype would require two water heaters. The calculator estimated that the Large School prototype would require up to fourteen water heaters; the Statewide CASE Team would expect that a designer would specify a different water heating approach for this type of building instead of installing such a large amount of unitary HP/ER water heaters. The calculator estimated that all other

modeled buildings would require one unitary HP/ER water heater. For buildings that require a single water heater, the louvered door would provide sufficient area, and the Statewide CASE Team assumed an installation cost of \$2000 for the door (Jingjuan “Dove” Feng 2023). The Statewide CASE Team assumed that each additional water heater requires the placement of louvers in a wall at a cost of \$2000 for each additional water heater. The cost analysis considers these additional first costs for a designer to meet the proposed measure. While the proposed requirements could lead building owners to opt for non-unitary heat pump water heaters, the Statewide CASE Team will continue to collect data on the costs required to modify spaces for installing unitary HP/ER water heaters.

The proposed measure could require additional water heaters given the requirements to derate the output of each water heater if the sizing from the manufacturer does not match the conditions expected in the building. The Statewide CASE Team used the same online sizing calculator discussed in the previous paragraph along with a spreadsheet calculator to estimate the number of water heaters required if the output were derated by 20 percent. The Statewide CASE Team found that the Medium Office with Laboratory prototype would require three additional water heaters to serve the laboratory spaces in certain CZs. The calculations estimated that the Large School prototype would require an additional water heater in certain CZs. The calculations estimated that no other prototypes would require additional water heaters.

The proposed measure could require additional costs for replumbing to accomplish a reverse return configuration if multiple water heaters are installed in parallel. The Statewide CASE Team estimated a cost of \$925 per additional water heater beyond the first one for alterations based on discussions with a plumbing contractor. There would be no difference in first cost to accomplish this configuration for new construction.

4.4.4 Incremental Maintenance and Replacement Costs

The Statewide CASE Team believes that there will be no incremental maintenance costs associated with this proposed measure. The major change will involve installation of passive louvers in the space and setup routines which would not require maintenance. The Stateside CASE Team believes that the proposed measure could increase replacement costs if it requires a larger water heater. The analysis assumes that the replacement of the water heater will occur at 15 years and applies a three percent discount rate to determine the present value. The incremental cost of the replacement water heater in present-day money is the same as that found in Section 4.4.3.

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

4.4.5 Cost Effectiveness

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.

Table 57 and Table 58 present the results of the per-unit cost-effectiveness analyses for new construction/additions and alterations, respectively. 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 proposed residual value is greater than current residual value at the end of the 30-year period of analysis. Costs represent the total incremental PV cost, including 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-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.

Results of the per-unit cost-effectiveness analyses are presented in Table 57 and Table 58 for new construction/additions and alterations, respectively.

Table 57: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction and Additions

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	0.92	0.30	3.10
2	0.65	0.38	1.70
3	0.55	0.39	1.41
4	0.55	0.44	1.26
5	0.87	0.48	1.80
6	0.58	0.32	1.85
7	0.75	0.44	1.69
8	0.56	0.27	2.05
9	0.56	0.28	2.02
10	0.66	0.32	2.04
11	0.75	0.43	1.76
12	0.56	0.26	2.14

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
13	0.78	0.48	1.64
14	0.71	0.40	1.76
15	0.54	0.26	2.04
16	0.71	0.20	3.50
Total	0.58	0.33	1.79

Table 58: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	0.99	0.36	3.12
2	0.67	0.41	1.72
3	0.60	0.35	1.42
4	0.60	0.40	1.27
5	0.91	0.46	1.81
6	0.63	0.29	1.86
7	0.78	0.42	1.70
8	0.59	0.26	2.06
9	0.61	0.26	2.04
10	0.69	0.31	2.05
11	0.79	0.41	1.77
12	0.62	0.25	2.16
13	0.82	0.45	1.65
14	0.75	0.39	1.77
15	0.56	0.22	2.05
16	0.76	0.21	3.52
Total	0.63	0.30	1.80

4.5 Requirements for Unitary HP/ER Hybrid Heaters - Statewide Impacts

4.5.1 Statewide Energy and Energy Cost Savings

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

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

The tables below present the first-year statewide energy and LSC savings from newly constructed buildings and additions (Table 59) and alterations (Table 60) by climate zone. Table 61 presents first-year statewide savings from new construction, additions, and alterations.

Table 59: Statewide Energy and LSC Impacts – New Construction and Additions

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	11,170	0.00	0.00	-	0.00	\$0.01
2	397,512	0.03	0.06	-	0.04	\$0.26
3	2,076,922	0.15	0.28	-	0.18	\$1.14
4	1,059,177	0.08	0.15	-	0.09	\$0.59
5	40,449	0.00	0.01	-	0.01	\$0.04
6	1,118,693	0.08	0.16	-	0.11	\$0.65
7	232,131	0.02	0.04	-	0.03	\$0.17
8	2,095,233	0.15	0.29	-	0.19	\$1.16
9	3,212,615	0.23	0.45	-	0.29	\$1.81
10	1,189,241	0.10	0.19	-	0.13	\$0.79
11	77,564	0.01	0.01	-	0.01	\$0.06
12	667,461	0.05	0.09	-	0.06	\$0.38
13	124,940	0.01	0.02	-	0.02	\$0.10
14	74,730	0.01	0.01	-	0.01	\$0.05
15	181,434	0.01	0.02	-	0.02	\$0.10
16	49,254	0.00	0.01	-	0.01	\$0.04
Total	12,608,527	0.93	1.82	-	1.17	\$7.33

Table 60: Statewide Energy and LSC Impacts – Alterations

Climate Zone	Statewide New Construction & Additions Impacted by Proposed Change in 2029 (Million Square Feet)	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction	First-Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
1	56,614	0.01	0.01	-	0.01	\$0.06
2	1,873,797	0.16	0.31	-	0.20	\$1.26
3	9,421,184	0.72	1.41	-	0.87	\$5.63
4	5,129,804	0.40	0.78	-	0.48	\$3.08
5	210,655	0.02	0.05	-	0.03	\$0.19
6	4,998,695	0.41	0.79	-	0.50	\$3.13
7	1,298,534	0.13	0.25	-	0.17	\$1.02
8	11,362,313	0.86	1.68	-	1.07	\$6.75
9	19,856,189	1.54	3.00	-	1.90	\$12.10
10	8,998,243	0.79	1.54	-	0.99	\$6.21
11	453,675	0.05	0.09	-	0.06	\$0.36
12	4,003,276	0.32	0.62	-	0.38	\$2.47
13	816,878	0.08	0.16	-	0.11	\$0.67
14	516,086	0.05	0.10	-	0.07	\$0.39
15	1,361,824	0.10	0.19	-	0.12	\$0.76
16	359,604	0.04	0.07	-	0.04	\$0.28
Total	70,717,371	5.68	11.06	-	7.00	\$44.35

Table 61: Statewide Energy and LSC Impacts – New Construction, Additions, and Alterations

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First -Year Natural Gas Savings (Million Therms)	First-Year Source Energy Savings (Million kBtu)	30-Year Present Valued LSC Savings (Million 2029 PV\$)
New Construction & Additions	0.9	1.8	-	1.2	7
Alterations	5.7	11.1	-	7.0	44
Total	6.6	12.9	-	8.2	52

4.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 62 presents the estimated first-year reduction in GHG emissions resulting from the proposed code change. In this initial year, the Statewide CASE Team expects to avoid 432 metric tons of carbon dioxide equivalent (CO₂e) 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 62: First-Year Statewide GHG Emissions Impacts

Measure	Reduced GHG Emissions from Electricity Savings (Metric Tons CO ₂ e)	Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO ₂ e)	Total Reduced GHG Emissions (Metric Ton CO ₂ e)	Total Monetary Value of Reduced GHG Emissions (\$)
Unitary HP/ER Hybrid Heaters	432	0	432	53,259
Total	432	0	432	53,259

4.5.3 Statewide Water Use Impacts

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

4.5.4 Statewide Material Impacts

The proposed code change would potentially increase the amount of material used by requiring more unitary HP/ER HPWHs. See Appendix D for more details.

4.5.5 Environmental Impacts

The Statewide CASE Team does not believe that the proposed measure would result in any significant environmental benefits and/or adverse environmental effects. Appendix D provides further details on this assessment.

4.5.6 Other Non-Energy Impacts

The proposed measure would result in a greater likelihood that a unitary HP/ER HPWH would meet the hot water demands of a nonresidential building by creating the conditions for the equipment to deliver hot water at its expected capacity. The proposed measure would decrease the risk that the space containing the water heaters would be overcooled and reduce the chance of unwanted condensation on surfaces within that space.

4.6 Requirements for Unitary HP/ER Hybrid Heaters - Proposed Language Code

4.6.1 Guide to Markup Language

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

4.6.2 Administrative Code (Title 24, Part 1)

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

4.6.3 Energy Code (Title 24, Part 6)

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

(b) Definitions.

Unitary HP Efficiency Mode is the condition when the unitary hybrid heater operates in “heat pump only” mode.

Unitary HP Electric Mode is the condition when the unitary hybrid heater operates with only electric resistance heating active and with the heat pump turned off.

Unitary HP Hybrid Mode is the condition when the unitary hybrid heater operates with both heat pump and electric resistance heating methods based on the needs of the user and thermal capacity in the tank.

SECTION 140.5(a) Nonresidential occupancies. Service hot water systems in nonresidential buildings shall meet the requirements of (1 or 2) and 3 below, or meet the performance compliance requirements of Section 140.1:

- 1) School buildings less than 25,000 square feet and less than 4 stories in climate zones 2 through 15. A heat pump water heating system that meets the applicable requirements of Sections 110.1, 110.3, and 120.3.
- 2) All other occupancies. A service hot water system that meets the applicable requirements of Sections 110.1, 110.3, 120.3, and 140.5(b)
- 3) For integrated unitary heat pump water heating systems with integrated electric resistance heating elements serving all nonresidential occupancies:
 - A) The water heating system shall be sized to meet the requirements of JA14.6.1
 - B) The water heating system shall meet the installation requirements of JA14.6.2
 - C) The water heating system shall meet the requirements of i or ii:
 - i. meet the following requirements,

- (a) The minimum heat pump water heater compressor cut-off temperature shall be equal to or lower than 40°F ambient air temperature in efficiency mode and equal to or lower than 47°F in hybrid mode.
 - (b) If the primary heat pump water heater is a unitary system without direct ducting to the outside, the system shall comply with the manufacturer's minimum air volume requirements. If multiple unitary heat pump water heaters are installed in a space, then the minimum air volume shall be the sum of the air volume requirements for each unitary heat pump water heater installed in the space.
 - (c) If outside air is used to meet the heat source requirements whether by installation outdoors, providing vents to the outdoors, or ducting outdoor air to the unit, the primary heat pump water heater shall be able to operate in heat pump mode under Heating Design Drybulb (0.6%) as described in Table 2.3 from JA2.
- (ii) meet the requirements of NEEA Advanced Water Heater Specification for integrated commercial heat pump water heater Tier 2 or higher, and have noncontinuous recirculation system

SECTION 141.0(b) Alterations

2. Prescriptive approach

N. Service water-heating systems shall meet the requirements of Section 140.5(a)2 and 3(b), except for the solar water heating requirements.

4.6.4 Reference Appendices

JA 14.6: Requirements of Unitary HP/ER water heaters **JA 14.6.1 Sizing of Unitary HP/ER water heaters.** Unitary HP/ER water heaters shall be sized based on manufacturer specifications for Unitary HP Hybrid Mode to meet the calculated water demand. The designer shall size the Unitary HP/ER water heaters considering the following conditions:

- Defrost cycles, if applicable.
- The nominal voltage of the electric supply in the building
- Ambient temperature of 47°F, or an ambient temperature that the designer determines to be appropriate.
- The average hourly maximum power output given the water heater's control algorithm for the heat pump and the ER elements.

In the absence of data necessary to meet these requirements, the designer shall decrease the manufacturer's reported delivery capacity by 20%.

JA 14.6.2: Installation and Setup of Unitary HP/ER water heaters in central systems with recirculation. If multiple unitary HP/ER water heaters are configured in a parallel arrangement to deliver water to the supply of a recirculation system, the installer shall:

- a) ensure that the temperature setpoint for storage and/or water supply is the same for all units to within 1°F and is set according to approved construction documents, and ensure that heat pump ON temperature setpoint, if controllable, is the same for all units to within 1°F and is set according to approved construction documents, and ensure that the heat pump OFF temperature setpoint, if controllable, is the same for all units to within 1°F and is set according to approved construction documents, and
- b) configure the plumbing to and from the recirculation loop in a reverse return configuration or in another manner such that the flow at both the minimum flow rate and maximum flow rate expected to be delivered into the recirculation system is balanced between the tanks to within 10%.

4.6.5 Compliance Manuals

The Statewide CASE Team will provide CEC with recommended revisions to compliance manuals after the 45-Day Language is published. Table 45 describes outreach and education that the Statewide CASE Team proposes to design professionals and the construction team on implementing the measure. These revisions will provide examples for derating capacity and penalizing the energy performance of unitary HP/ER water heaters based on expected ambient conditions.

4.6.6 ACM Reference Manual

The Statewide CASE Team will provide CEC with recommended revisions to the ACM Reference Manual. These revisions will establish a baseline for unitary HP/ER water heaters and will document calculations for estimating the energy usage when a designer chooses to pursue a performance path for compliance. The Statewide CASE Team will assume that the water heating plant COP for an installation that meets the prescriptive requirement will vary from 1.8 to 2.9 depending upon the prototype and that the corresponding water heating plant COP for a base case would be between 1.3 and 2.1 depending upon the prototype.

4.6.7 Compliance Forms

As discussed in Section 4.1.4.5, the 2025-LMCC-PLB-01-E, 2025-LMCC-PRF-01, 2025-LMCI-PLB-E, 2025-NRCI-PLB-E, 2025 NRCC-PLB-E, and 2025 NRCC-PRF-01 compliance forms would be updated to reflect the proposed change. The Statewide CASE Team can support the CEC in implementing these updates if the proposed change is adopted.

5. Bibliography

2025. DNV Energy Services. Accessed 11 25, 2025. <https://www.statewide-waterheating.com/eligibility/>.
- n.d. Accessed 2026. <https://github.com/cse-sim/cse>.
- A.O. Smith. 2025. *CHP-120 Fully Integrated Heat Pump*. Accessed December 2, 2025. <https://www.hotwater.com/product-literature/AOS1006.html>.
- . 2025. *Pro-Size*. Accessed December 2, 2025. https://sizing.hotwater.com/en_US/.
- Andrew Brooks, John Neal, and Nick Young, Association for Energy Affordability. 2024. "Eliminating the Swing Tank and Other Design Considerations in Large-Capacity CO₂ Heat Pump Water Heating." 9. [https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Eliminating%20the%20Swing%20Tank%20and%20Other%20Design%20Considerations%20in%20Large-Capacity%20CO₂%20Heat%20Pump%20Water%20Heating.pdf](https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Eliminating%20the%20Swing%20Tank%20and%20Other%20Design%20Considerations%20in%20Large-Capacity%20CO2%20Heat%20Pump%20Water%20Heating.pdf).
- Brooks, Andrew, John Neal, and Nick Young. 2024. *Eliminating the Swing Tank and Other Design Considerations in Large-Capacity CO₂ Heat Pump Water Heating*. 2024 ACEEE Summer Study on Energy Efficiency in Buildings. [https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Eliminating%20the%20Swing%20Tank%20and%20Other%20Design%20Considerations%20in%20Large-Capacity%20CO₂%20Heat%20Pump%20Water%20Heating.pdf](https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Eliminating%20the%20Swing%20Tank%20and%20Other%20Design%20Considerations%20in%20Large-Capacity%20CO2%20Heat%20Pump%20Water%20Heating.pdf).
- California Energy Commission. 2022. "Final Staff Workshop on Energy Accounting for the 2025 Building Energy Efficiency Standards." *California Energy Commission*. Prepared for the California Energy Commission. November 10. <https://www.energy.ca.gov/event/workshop/2022-11/final-staff-workshop-energy-accounting-2025-building-energy-efficiency>.
- Code Readiness Research Team. 2026. "Central HPWH Return to Primary Field Demonstrations." 2 20. <https://www.etcc-ca.com/reports/code-readiness-multifamily-central-heat-pump-water-heater-research-data-brief-preliminary>.
- Commision, California Energy. 2022. *California Commercial End-Use Surveey (CEUS): End-Use Data Preadsheet*. Sacramento.
- Conservation Applied Research and Development (CARD). 2018. "Evaluation of new DHW System Controls in Hospitality and Commercial Buildings."
- Dean, Jesse, Anoop Honnekeri, and Greg Barker. 2018. *High-Performance Circulator Pump Demonstration*. National Renewable Energy Laboratory.

- Ecotope. 2023. *Central Heat Pump Water Heater Design Guide*. Energy Trust of Oregon. https://www.energytrust.org/wp-content/uploads/2023/04/New-Buildings_Design-Guide-for-Central-Heat-Pump-Water-Heaters.pdf.
- EPA, US. 2025. "Product Specification for Commercial Heat Pump Water Heaters." *Energystar.gov*. Accessed February 25, 2026. <https://www.energystar.gov/sites/default/files/2025-01/ENERGY%20STAR%20Version%201.0%20Commercial%20Heat%20Pump%20Water%20Heaters%20Draft%201%20Specification.pdf>.
- Evan Green, Ecotope, and Larson Energy Research, Mehdi Zeyghami, ATS, Helen Davis, Energy Solutions Ben Larson. 2024. "PG&E and SCE HPWH Laboratory Testing and Software Updates for Multifamily Applications." August 26. https://ecotope-publications-database.ecotope.com/2024_032_Final_Report_MF_HPWH_Lab_Testing_V2.pdf.
- Federal Reserve Economic Data (FRED). n.d. *Data series relied on: Net Domestic Private Investment, Corporate Profits After Taxes*. Accessed September 18, 2022. <https://fred.stlouisfed.org> .
- Garcia, Jose, Amin Delagah, Matthew Stevens, and Daniel Hacking. 2024. *Field Study of Master Mixing Valve Energy Potential*. CalNEXT. https://calnext.com/wp-content/uploads/2024/11/ET22SWE0047_Field-Study-of-Master-Mixing-Valve-Energy-Efficiency-Potential_Final-Report.pdf.
- Jingjuan "Dove" Feng, Amin Delagah, Jose Garcia, James Haile. 2023. "Multifamily Domestic Hot Water." 8. https://title24stakeholders.com/wp-content/uploads/2023/08/2025_T24_CASE-Report-_MF-DHW-Final-1.pdf.
- Klein, Gary, Jim Lutz, Yanda Zhang, and John Koeller. 2021. *Code Changes and Implications of Residential Low-Flow Hot Water Fixtures*. Publication Number: CEC-500-2021-043: California Energy Commission.
- Lindsey, Doug. 2022. "Field Evaluation of a 120-Gallon Integrated HPWH." *ACEEE Hot Water Forum 2022*.
- Matthew Stevens, Amin Delagah. 2025. "Multifamily Central Heat Pump Water Heater Field Study." 5 2.
- Maya Gantley, Amin Delagah, Matt Stevens, Daniel Hacking. 2025. "Overcoming Key Barriers to Electrification of Foodservice Hot Water in California." 11 21. file:///C:/Users/ychu/AppData/Local/Microsoft/Windows/INetCache/Content.Outlook/MPYVOJZ5/CalNEXT%20Report_Foodservice%20HW%20Final%20Report_20251121_.pdf.
- National Institutes of Standard and Technology. 2022. "Standard Building Plumbing System Models - Basis of Design."

- NEEA. 2024. *Advanced Water Heating Specification*. Portland, OR: Northwest Energy Efficiency Alliance. <https://neea.org/wp-content/uploads/2025/03/Advanced-Water-Heating-Specification.pdf>.
- . 2025. "Commercial/Multifamily HPWH Systems Qualified Products List." 12. <https://neea.org/wp-content/uploads/2025/03/commercial-HPWH-qualified-products-list.pdf>.
- NEEA. 2019. *Extended Motor Products Savings Validation Research on Clean Water Pumps and Circulators*. Portland: Northwest Energy Efficiency Alliance.
- OEHHA. 2022. *SB 535 Disadvantaged Communities*. Accessed 2025. <https://oehha.ca.gov/calenviroscreen/sb535>.
- PG&E, SCE. 2024. "PG&E and SCE HPWH Laboratory Testing and Software Updates for Multifamily Applications." https://ecotope-publications-database.ecotope.com/2024_032_Final_Report_MF_HPWH_Lab_Testing_V2.pdf.
- SBW Consulting, Inc. 2022. *Water-Energy Calculator 2.0 Project Report*. Project Report, San Francisco: California Public Utility Commission.
- Stakeholder, Public. 2025. "Statewide CASE Team Workshop." October 23.
- Staller, Jeff. 2025. "Initial Results from Integrated HPWH Retrofit Projects in Non-Residential Buildings." *ACEEE Hot Water and Hot Air Forum 2025*.
- Staller, Jeff, Yiyi Chu, Shrusti Koli, and Amin Delagah. 2026. *120-gallon Hybrid Commercial HPWH Field Demonstrations: Preliminary Data Findings*. Data Brief, Energy Transition Coordinating Council. Accessed February 22, 2026. <https://www.etcc-ca.com/reports/code-readiness-commercial-hybrid-hpwh-heater-research-data-brief-preliminary-findings-field>.
- State of California. n.d. *Employment Development Department, Quarterly Census of Employment and Wages (data search tool)*. Accessed September 1, 2022. <https://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=industry>.
- The Statewide CASE Team. 2025. "Meeting Notes." November 10. https://energysolutionsonline.sharepoint.com/:w:/r/teams/extranet/2028-t24/_layouts/15/doc2.aspx?sourcedoc=%7BD908EB7F-22F9-4399-987B-05E518A5160A%7D&file=Meeting%20Notes%20-%202028_T24_Utility-Sponsored%20Stakeholder%20Meeting%204.docx&action=default&mob.
- . 2023. "Multifamily Domestic Hot Water." 8. https://title24stakeholders.com/wp-content/uploads/2023/08/2025_T24_CASE-Report-_MF-DHW-Final-1.pdf.
- . 2025. "Return-to-Primary Configuration for Central HPWHs in NR Buildings." October 23. https://energysolutionsonline.sharepoint.com/:p:/r/teams/extranet/2028-t24/_layouts/15/Doc.aspx?sourcedoc=%7B9691FD79-FBC5-4DE5-BDA4-

19FD65F70307%7D&file=2028%20T24%20Stakeholder%20Meeting%201_Return%20to%20Primary%2010_23.pptx&wdLOR=c3C64C0D1-5AA4-45C9-A.

—. 2025. "Return-to-Primary Proposal Summary." October 17.

https://energysolutionsonline.sharepoint.com/:w:/r/teams/extranet/2028-t24/_layouts/15/Doc.aspx?sourcedoc=%7BDDBF22F26-0241-4063-8A38-1138E2B74D44%7D&file=2028%20T24%20Measure%20Summary_Require%20Return%20to%20Primary%20Configuration_Updated_10_20.docx&act.

Zhang, Yanda. 2013. *Multifamily Central Domestic Hot Water Distribution Systems*. Heschong Mahone Group, Publication Number: CEC-500-2013-011: California Energy Commission.

Appendix A: Assumptions for Cost-Effectiveness Analysis

Circulator Pump Controls

Key Assumptions for Energy Savings Analysis

The Statewide CASE Team used building data from the 2025 Energy Code Accounting Methodology Report for the 2025 Building Energy Efficiency Standards for the new and existing construction floor area assumptions in the energy analysis. The Statewide CASE Team made assumptions for base case pump size and power based on subject matter experts experience. The Statewide CASE Team used an assumed 3 percent plant savings and will update the estimate when more data is available. For the base case The Statewide CASE Team used a single speed ECM and constant return temperature as the control strategy for the proposed case.

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 63 presents the prototype buildings used in the analysis.

Table 63: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
OfficeLarge	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%.
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%
OfficeMediumLab	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%
OfficeSmall	1	5,502	1-story, 5-zone office building with pitched roof and unconditioned attic. WWR–24%

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
RestaurantFastFood	1	2,501	Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic.
SchoolSmall	1	24,413	Elementary school with WWR–36%
SchoolLarge	2	210,866	High school with WWR–35% and SRR–1.4%
RetailLarge	1	240,000	Big-box type retail building with WWR–12% and SRR–0.82%
Assembly	1	315,339	The main assembly prototype comprises five different assembly buildings i.e. Dodge building types: religious Worship, sports & recreation, library, exhibits & events, and transportation terminals.
Warehouse	1	52,045	Similar to small office
RetailMixedUse	1	9,375	Similar to office (small, medium, or large)
RetailMedium	1	24,563	Similar to office (small, medium, or large)
RetailStripMall	1	9,375	Similar to office (small, medium, or large) plus restaurant
Grocery	1	50,002	6-Zone Grocery Store DEER prototype model provided by Southern California Edison
RefWarehouse	1	100,000	Similar to small office
Horticulture	1	100,000	Similar to small office

There is an existing Title 24, Part 6 requirement that covers service water heating systems and applies to both new construction/additions and alterations, so the Standard Design is minimally compliant with the 2025 Title 24 requirements. To be minimally compliant with the 2025 code, a system must be capable of automatically turning off. The Statewide CASE Team modified the Standard Design so it calculated energy impacts of the most common current design practice or industry standard practice. For circulator pump controls, the most common current design practice is to install a timeclock and/or aquastat to meet existing code requirements in Title 24, Part 6, Section 110.3. In many cases, the installer sets up the

time clock and aquastat, and it is not connected, activated, or they are adjusted in a way to be bypassed so the pump still runs continuously as discussed in 2.1.3 Background Information. Since the CBECC software cannot directly model central HPWH systems in nonresidential buildings, the Statewide CASE Team developed an alternative methodology to obtain a preliminary energy savings analysis, which combines both CBECC modeling and post processing. The Statewide CASE Team used variable speed ECM and constant return temperature as the control strategy for the proposed case.

Table 64: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeLarge	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	10259 (NC), 10763 (AL); 56.69	9933 (NC), 10436 (AL); 24.33
OfficeMedium	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	2386 (NC), 2503 (AL); 13.18	2310 (NC), 2427 (AL); 5.66
OfficeMediumLab	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	6028 (NC), 6270 (AL); 48.67 (NC),131.2 (AL)	5866 (NC), 6101 (AL); 15.71 (NC),16.12(AL)
OfficeSmall	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
RestaurantFastFood	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	2945 (NC),3062 (AL); 24.31(NC),165 .18(AL)	2873 (NC),2987 (AL); 23.66(NC),24. 88(AL)
SchoolSmall	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	15827 (NC),16878(A L); 11.82	15394 (NC),16414(A L); 41.02(NC), 43.85(AL)

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
SchoolLarge	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	31653 (NC),33755 (AL); 23.64	30787 (NC),32827 (AL); 82.04(NC),87.7(AL)
Assembly	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	15827 (NC),16878(AL); 11.82	15394 (NC),16414(AL); 41.02(NC),43.85(AL)
RetailLarge	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
Warehouse	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
RetailMixedUse	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
RetailMedium	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
RetailStripMall	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
Grocery	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	2945 (NC),3062 (AL); 24.31(NC),165.18(AL)	2873 (NC),2987 (AL); 23.66(NC),24.88(AL)
RefWarehouse	All CZs	Hot water systems	Recirculation heat loss (Btu/h);	1021; 13.18	994; 5.66

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
			Pump power (W)		
Horticulture	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66
VehicleService	All CZs	Hot water systems	Recirculation heat loss (Btu/h); Pump power (W)	1021; 13.18	994; 5.66

Note: NC here refers to new constructions and additions, AL here refers to alterations. If not specified, the number will be the same for NC and AL.

The energy impacts of the proposed code change do not vary by climate zone. Since savings do not vary by climate zone, the Statewide CASE Team used the statewide LSC hourly factors when calculating energy and LSC impacts.

Require Return to Primary Configuration

Key Assumptions for Energy Savings Analysis

The Statewide CASE Team simulated the energy impacts in all CZs and applied the CZ-specific LSC hourly factors when calculating energy and energy cost impacts.

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 65 presents the prototype buildings used in the analysis. For Small Office, Mixed-use Retail, Strip Mall, Refrigerated Warehouse, Controlled-environment Horticulture, and Vehicle Service prototypes, the base case system is a Sanden CO2 which already meets NEEA Tier 3 requirements, so we are not considering savings from these prototypes and didn't analyze it for this proposed measure.

Table 65: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Large Office	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%.
Medium Office	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%.
Laboratory	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%.
Restaurant	1	2,501	Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic.
Small School	1	24,413	Elementary school with WWR–36%.
Large School	2	210,866	High school with WWR–35% and SRR–1.4% The Large School is a prescriptively-compliant building. CBECC will create heat pump systems in the Standard Design, but the baseline should be the central gas system as appears in the Proposed Design.
Assembly	1	315,339	The main assembly prototype comprises five different assembly buildings i.e. Dodge building types: Religious Worship, Sports & Recreation, Library, Exhibits & Events, and Transportation Terminals. The CBECC model is separated into individual building files before using the Standard design. The CBECC standard design is modeled with SZVAVHP for Library and all other assembly building types are modeled with SZVAVAC systems. Gas hot water system is used as the Standard design SWH.
RetailLarge	1	240,000	Big-box type retail building with WWR–12% and SRR–0.82%
RetailMedium	1	24,563	Similar to a Target or Walgreens.7% WWR on the front façade, none on other sides. SRR–2.1%.
Grocery	1	50,002	6-Zone Grocery Store DEER prototype model provided by Southern California Edison

Current Energy Code does not have existing requirements that cover split HPWH with recirculation for nonresidential buildings. The Statewide CASE Team modified the Standard Design so that it calculated energy impacts of the most common current design practice, or industry standard practice. For the return to primary measure, the most common current design practice for both new construction and additions and alterations is a split HPWH system with the TMHS configuration. Therefore, the proposed measure assumes TMHS configuration for standard design. The proposed design is the return to primary configuration.

The current CBECC software cannot directly model split HPWH systems in nonresidential buildings. Instead, the Statewide CASE Team originally planned to use California Simulation Engine (CSE) (26ht), the backend engine to model central HPWH systems for multifamily buildings, to model split HPWH system for nonresidential prototypes with modified hourly draw profiles. However, the Statewide CASE Team found inconsistent results between the CSE modeling and lab, field test results. Table 66 demonstrates the energy use and savings from CSE modeling and lab and field test results. CSE modeling results show very low savings (less than 1%) for Return to Primary compared to TMHS configuration, while lab data shows much large savings (18%). For CO2 refrigerants, CSE modeling shows negative savings from TMHS to Return to Primary, however, filed data shows 8 percent or ten percent positive savings.

Table 66: Comparing CSE Results with Lab and Field Data

	System Description	SHW Annual Consumption kWh	Savings kWh	Saving %
CBECC Modeling using 36-unit multifamily prototype	Generic R134a TMHS	52,963	/	/
	Generic R134a Return to Primary	52,505	458	0.86%
	SanCO2 TMHS	31,502	/	/
	SanCO2 Return to Primary	33,692	(2,190)	-7%
	Mitsubishi TMHS	36,030	/	/
	Mitsubishi Return to Primary	41,171	(5,140)	-14%
Lab 44 apartments test	Colmac CxA-15 R134a TMHS	65,116	/	/

	System Description	SHW Annual Consumption kWh	Savings kWh	Saving %
	Colmac CxA-15 R134a Return to Primary	53,400	11,717	18%
AEA 81 apartments field test	Mitsubishi Heat2O TMHS	121,910	/	/
	Mitsubishi Heat2O Return to Primary	112,420	9,490	8%
AEA 53 apartments field test	WaterDrop TMHS	25,185	/	/
	WaterDrop Return to Primary	22,630	2,555	10%

Based on the findings in Table 66, the Statewide CASE Team concluded that the CSE modeling is not accurate to model Return to Primary. Therefore, the Statewide CASE Team developed an alternative methodology to obtain energy savings combining both CBECC modeling and post processing. First, the Statewide CASE Team used CBECC for the selected nonresidential prototypes in all CZs to obtain SHW load. Then, the Statewide CASE Team used a recirculation heat loss spreadsheet calculator (The Statewide CASE Team 2023) to calculate the distribution heat losses for selected prototype, including Medium Office, Laboratory, Small Office, Restaurant, Small School. For the remaining prototypes, the Statewide CASE Team estimated the distribution heat loss based on the calculated data for the selected prototypes. After that, the Statewide CASE Team leveraged NEEA CHPWH System Performance Calculator and provided water usage and distribution heat loss for each prototype to obtain system COP for both the standard and proposed design. The system COP varies by CZ.

Lastly, the Statewide CASE Team used SHW load and system COP to back calculate the SHW consumption of both the standard and proposed design. Table 67 presents the system COP in the Standard Design and Proposed Design for both new construction/additions, and alterations.

Table 67: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value for New Construction	Proposed Design Parameter Value for New Construction	Standard Design Parameter Value for Alteration	Proposed Design Parameter Value for Alteration
OfficeLarge	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
OfficeMedium	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
OfficeMediumLab	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
RestaurantFastFood	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
SchoolSmall	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
SchoolLarge	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
Assembly	All CZs	Split HPWH System with	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value for New Construction	Proposed Design Parameter Value for New Construction	Standard Design Parameter Value for Alteration	Proposed Design Parameter Value for Alteration
		Recirculation					
RetailLarge	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
RetailMedium	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ
Grocery	All CZs	Split HPWH System with Recirculation	System COP	Vary by CZ	Vary by CZ	Vary by CZ	Vary by CZ

The Statewide CASE Team assumed both standard design and proposed design use conventional refrigerant (R-134a) and used performance data for a representative system since R-134a refrigerant is the standard design of central HPWH system in 2025 code cycle.

Requirements for Unitary HP/ER Hybrid Heaters

Key Assumptions for Energy Savings Analysis

The Statewide CASE Team simulated the energy impacts in every CZ and applied the CZ-specific LSC hourly factors when calculating energy and energy cost impacts. For the base case, the Statewide CASE team used data available from a recent Code Readiness study to develop values for the water heating plant COP for the base case and measure case.

The proposed measure addresses two main ways that the efficiency of the service water heating system will meet expected performance: 1) through proper sizing, installation, and setup, and 2) through proper ambient air conditions. To account for these issues, the Statewide CASE Team used field data presented by (Garcia, et al. 2024) and laboratory data to estimate the efficiency of systems that are sized and installed properly as well as the degradation in delivery capacity when systems are not sized and installed properly. To size

for the base case, the Statewide Case Team used a commercially available sizing tool to determine the number of water heaters that would be installed if the designer did not plan for degradation of the operation due to low ambient temperatures or excessive electric resistance use. To size for the measure case, the capacity of the water heaters was decreased by 20 % in accordance with the proposed measure.

To account for the expected improvements from the proposed code changes that would ensure that unitary HP/ER water heaters have adequate air to operate in heat pump mode, the Statewide CASE Team assessed the performance of one type of unit installed in a simulated food service facility as a function of ambient temperature. Field data suggested that typical ambient temperatures around unitary HP/ER water heaters would be approximately 50°F if the water heater were not installed properly (Staller, Chu, et al. 2026). The laboratory tested these HPWH’s at ambient temperatures of 67.5°F and 50°F and over a range of daily usage and recirculation rates. Up to three water heaters could be run at the same time depending upon the daily usage. To identify the equipment COP’s for each prototype, the Statewide CASE Team identified tests that approximated the daily hot water demand and setpoint parameters for each prototype. For the Base Case, the Statewide CASE Team estimated the equipment COP to be the average of water heaters run at an ambient temperature of 50°F. For the Measure Case, the Statewide CASE Team estimated the equipment COP to be the average of water heaters run at an ambient temperature of 67.5°F.

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 68 presents the prototype buildings used in the analysis. The proposed measure applies to alterations, and each prototype simulation estimates the savings for alterations.

Table 68: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Large Office	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%.
Medium Office	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%.
Laboratory	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%.

Prototype Name	Number of Stories	Floor Area (Square Feet)	Description
Restaurant	1	2,501	Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic.
Small School	1	24,413	Elementary school with WWR–36%.
Large School	2	210,866	High school with WWR–35% and SRR–1.4% The Large School is a prescriptively-compliant building. CBECC will create heat pump systems in the Standard Design, but the baseline should be the central gas system as appears in the Proposed Design.
Assembly	1	315,339	The main assembly prototype comprises five different assembly buildings i.e. Dodge building types: Religious Worship, Sports & Recreation, Library, Exhibits & Events, and Transportation Terminals. The CBECC model is separated into individual building files before using the Standard design. The CBECC standard design is modeled with SZVAVHP for Library and all other assembly building types are modeled with SZVAVAC systems. Gas hot water system is used as the Standard design SWH.
RetailLarge	1	240,000	Big-box type retail building with WWR–12% and SRR–0.82%
RetailMedium	1	24,563	Similar to a Target or Walgreens. 7% WWR on the front façade, none on other sides. SRR–2.1%.
Grocery	1	50,002	6-Zone Grocery Store DEER prototype model provided by Southern California Edison

The current Energy Code does not have existing requirements that cover the service water heating system. The Statewide CASE Team modified the Standard Design so that it calculated energy impacts of the most common current design practice, or industry standard practice. For the HP/ER measure, the most common current design practice for both new construction/additions and alterations assumes the central HP/ER system is in a room without sufficient makeup air and that installers give no special consideration to setpoint temperatures and proper plumbing configurations for multi-tank systems. The result of these assumptions is that the baseline case operates with a lower efficiency than one would expect of a water heater operating purely in heat pump mode. Table 69 presents the different central HPWH designs in the Standard Design and Proposed Design.

Since the CBECC software cannot directly model central HPWH systems in nonresidential buildings, the Statewide CASE Team developed an alternative methodology to obtain a preliminary energy savings analysis, which combines both CBECC modeling and post-processing. First, the Statewide CASE Team determined typical COPs of a water heating plant that meets the requirements of the proposed measure by examining field and laboratory

data for each prototype. The Statewide CASE Team then modeled each prototype given calculated distribution system losses in accordance with Appendix G and hot water demand in the building to obtain overall energy use by the water heating system. The Statewide CASE Team also determined water heating plant COPs for baseline installations based on field data and laboratory data. To estimate the amount of energy that would be used for the base case, the Statewide CASE Team multiplied the calculated energy use for the proposed measure by the ratio of the COP for the proposed measure to the COP for the baseline installment.

Table 69: Modifications Made to Standard Design in Each Prototype to Simulate Proposed Code Change

Prototype ID	Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
OfficeLarge	All CZs	Central HPWH System	COP	1.3	1.8
OfficeMedium	All CZs	Central HPWH System	COP	1.9	2.2
OfficeMediumLab	All CZs	Central HPWH System	COP	1.8	2.3
RestaurantFastFood	All CZs	Central HPWH System	COP	1.9	2.5
SchoolSmall	All CZs	Central HPWH System	COP	1.6	1.95
SchoolLarge	All CZs	Central HPWH System	COP	1.3	1.8

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

Appendix B: Purpose and Necessity of Proposed Code Changes

Introduction

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

See Sections 2.6, 3.6, and 4.6 of this report for marked-up code language.

Circulator Pump Controls

Purpose and Necessity of Changes to Title 24, Part 1

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

Purpose and Necessity of Changes to Title 24, Part 6

Section: 140.5(d)

Purpose: The purpose of this change is to add requirements that recirculation pumps shall use ECMs capable of variable speed operation and respond to the specified digital controls.

Necessity: The necessity for this change is to require digital controls on pumps in service water heating systems and better define what digital controls are.

Section: 141.0(b)2.N

Purpose: The purpose of this change is to add a reference back to the added section 140.5(d).

Necessity: The necessity of this change is to ensure that the sections covering additions and alterations reference back to the sections added requiring pump controls.

Require Return to Primary Configuration

Purpose and Necessity of Changes to Title 24, Part 1

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

Purpose and Necessity of Changes to Title 24, Part 6

Section: 100.1

Purpose: The purpose of this change is to add definitions for TMHS configuration and primary heat pump storage tank. Additionally, the change will expand the existing service water heating definition and add the new definition for service water heating systems.

Necessity: The necessity for this change is to 1) update the naming convention of HPWH with swing tank configuration since TMHS configuration is more accurate; 2) add definition of the primary heat pump storage tank to help better understand one of the main CHPWH system components; 3) expand the existing service water heating definition and add a definition for service water heating systems since the existing service water heating definition only focus on heating plant itself, but does not mention storage and distribution of the hot water.

Section: 140.5(a)

Purpose: This change would add prescriptive and alternative pathways for service water heating systems with split HPWH systems installations. This change would also include additions and alterations through existing cross reference in Section 141.0(a) and Section 141.0(b) that refers to this section.

Necessity: The necessity for this change is to 1) better reflect the service water heating system (including heating, storage, and distribution of hot water) rather than only the water heating itself; 2) provide standard for installation of split HPWH systems to ensure performance.

Purpose and Necessity of Changes to the Reference Appendices

Section: JA14.3.2

Purpose: The purpose of this change is to add new requirements for system COP reporting with associated performance data.

Necessity: The necessity for this change is to ensure manufacturers provide appropriate performance data with vetted approach.

Section: JA14.4

Purpose: The purpose of this change is to add new requirements for defrost derate design documentation.

Necessity: The necessity for this change is to encourage CHPWH system sizing using derate data to account for capacity degradation in defrost conditions.

Section: JA14.5

Purpose: The purpose of this change is to add new subsections to add HPWH requirements on design, installation and start up documentation for manufacturers, designers, and contractors.

Necessity: The necessity for this change is to ensure CHPWH systems include all necessary functional features.

Requirements for Unitary HP/ER Hybrid Heaters

Purpose and Necessity of Changes to Title 24, Part 1

There are no proposed changes to Title 24, Part 1

Purpose and Necessity of Changes to Title 24, Part 6

Section: 100.1(b)

Purpose: The purpose of this change is to add new definitions to differentiate unitary hybrid heat pump water heater operating modes.

Necessity: The addition is necessary to provide clear and consistent definitions of operational modes of unitary heat pump water heaters.

Section: 140.5(a)3

Purpose: The purpose of this change is to improve the efficiency of unitary HP/ER hybrid water heaters by minimizing the electric resistance heating. The Statewide CASE Team intentionally included additions through an existing cross reference in section 141.0(a) that refers to this section.

Necessity: The addition is necessary to ensure that contractors install unitary HP/ER hybrid water heaters with sufficient ventilation to operate in HP mode, that the HP system can operate in winter conditions if designers choose to use outside air to satisfy the ventilation requirements, that designers size the systems to reduce ER use, and that installers configure plants involving multiple unitary HP/ER water heaters properly.

Section: 141.0(b)2.N.

Purpose: The purpose of this change is to include the unitary hybrid heat pump water heater requirement for alterations of nonresidential buildings.

Necessity: The addition is necessary to ensure consistency within the code.

Purpose and Necessity of Changes to the Reference Appendices

Purpose: The purpose of the first change is to size unitary HP/ER water heater installations to enable sufficient hot water delivery and to minimize ER use. The purpose of the second change is to require installations of multiple unitary HP/ER water heaters to minimize excessive use of electric resistance heating when the water heaters are plumbed in parallel.

Necessity: The addition is necessary to ensure sufficient hot water delivery to end uses without requiring excessive electric resistance use due to undersizing and to balance the hot water load across multiple unitary HP/ER water heaters so that one unit is not bearing the majority of the hot water demand and is, thus, forced to resort to ER heating to meet demand.

Appendix C: Assumptions for Statewide Savings Estimates

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

Circulator Pump Controls

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 first estimated the percentage of nonresidential floorspace that will have SHW with recirculation for each prototype based on plans review and engineering judgement for both new construction and additions and alterations (Table 75).

The Statewide CASE Team estimated the percentage of newly constructed floorspace (sq ft) that the proposed code change would impact. Table 70 shows the assumed percentage of affected floorspace by building type. If a proposed code change does not apply to a specific building type, the Statewide CASE Team assumes that zero percent of the floorspace would be impacted. If the assumed percentage is non-zero, but less than 100 percent, the proposal is expected to affect some—but not all—buildings. Table 71 represents the assumed percentage of affected floorspace by climate zone. The estimated percent of buildings impacted by this measure was informed by California Commercial End-Use Survey end use data.

Table 70: Percentage of nonresidential sq ft having SHW with recirculation

Prototype Name	New Construction/Additions	Alteration
OfficeLarge	95%	95%
OfficeMedium	95%	95%
OfficeMediumLab	95%	95%
OfficeSmall	75%	75%
RestaurantFastFood	95%	30%
SchoolSmall	95%	95%
SchoolLarge	95%	95%
Assembly	60%	50%

Prototype Name	New Construction/Additions	Alteration
RetailLarge	75%	75%
RetailMixedUse	75%	75%
RetailMedium	75%	75%
RetailStripMall	75%	75%
Warehouse	75%	75%
Grocery	75%	65%
RefWarehouse	75%	75%
Horticulture	75%	75%
VehicleService	75%	75%

For the SHW with recirculation, the Statewide CASE Team then estimated the percentage of nonresidential floorspace that have electric systems based on BAAQMD and SCAQMD rules. To achieve that, the Statewide CASE Team first estimated the percentage of population that will be impacted by air quality rules for each CZ, and then mapped it to the percentage of nonresidential floorspace for each prototype under each CZ based on CEC’s construction forecast. For the CZ or prototypes that the air quality rules don’t apply, the Statewide CASE Team assumed 1%. Table 71 demonstrates the percentage of floorspace impacted by Air Quality Management Rules.

Table 71: Percentage of sq ft that will be impacted by Air Quality Management District (AQMD) Rules

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
OfficeLarge	0.0 %	0.0 %	11.7 %	11.1 %	0.0 %	6.1 %	1.0 %	10.4 %	12.9 %	2.3 %	1.0 %	0.9 %	0.0 %	0.9 %	0.5 %	1.5 %
OfficeMedium	0.5 %	11.3 %	5.5 %	5.8 %	1.0 %	5.7 %	1.0 %	8.4 %	11.0 %	7.5 %	1.0 %	5.1 %	1.0 %	1.7 %	13.0 %	3.7 %
OfficeMedium Lab	1.0 %	4.5 %	5.2 %	5.6 %	1.0 %	2.0 %	1.0 %	2.3 %	2.9 %	2.3 %	1.0 %	0.8 %	1.0 %	1.0 %	2.0 %	1.1 %
OfficeSmall	1.0 %	10.1 %	0.8 %	1.0 %	1.0 %	0.7 %	1.0 %	0.8 %	1.2 %	2.6 %	1.0 %	1.0 %	1.0 %	1.0 %	5.0 %	1.1 %
RestaurantFastFood	1.0 %	1.9 %	1.3 %	1.3 %	1.0 %	1.6 %	1.0 %	2.5 %	2.8 %	2.6 %	1.0 %	0.6 %	1.0 %	1.0 %	2.5 %	1.1 %
SchoolSmall	1.0 %	6.4 %	1.8 %	1.8 %	1.0 %	1.5 %	1.0 %	1.8 %	2.3 %	2.3 %	1.0 %	1.4 %	1.0 %	0.5 %	2.0 %	1.5 %
SchoolLarge	1.0 %	2.6 %	3.1 %	3.1 %	1.0 %	2.5 %	1.0 %	4.1 %	4.3 %	4.8 %	1.0 %	1.8 %	1.0 %	0.7 %	4.0 %	2.2 %
Assembly	1.0 %	9.2 %	6.4 %	4.4 %	1.0 %	3.8 %	1.0 %	7.3 %	6.3 %	7.3 %	1.0 %	2.6 %	1.0 %	1.2 %	6.0 %	3.0 %
RetailLarge	0.0 %	0.0 %	4.4 %	4.3 %	1.0 %	3.3 %	1.0 %	4.2 %	5.7 %	4.1 %	1.0 %	2.4 %	1.0 %	0.7 %	9.0 %	2.2 %

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
RetailMixedUse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RetailMedium	1.0%	8.2%	3.2%	3.5%	1.0%	2.9%	1.0%	4.4%	4.9%	5.3%	1.0%	1.1%	1.0%	0.9%	6.0%	3.0%
RetailStripMall	0.0%	3.5%	2.0%	1.8%	1.0%	2.7%	1.0%	5.0%	3.7%	8.7%	1.0%	1.1%	1.0%	1.6%	5.0%	2.2%
Warehouse	1.0%	8.7%	8.7%	8.8%	1.0%	6.5%	1.0%	9.9%	10.4%	8.7%	1.0%	5.2%	1.0%	1.8%	18.5%	5.2%
Grocery	1.0%	1.2%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.5%	1.0%
RefWarehouse	0.0%	0.0%	1.0%	1.0%	1.0%	1.0%	0.0%	1.0%	1.0%	1.0%	0.0%	1.0%	1.0%	1.0%	0.5%	1.0%
Horticulture	0.4%	1.9%	1.3%	0.3%	1.0%	1.2%	0.0%	0.1%	0.1%	1.8%	1.0%	0.6%	1.0%	0.0%	2.5%	0.0%
VehicleService	0.0%	1.9%	2.2%	2.8%	1.0%	2.6%	1.0%	4.1%	6.3%	3.7%	1.0%	0.7%	1.0%	1.0%	3.0%	1.9%

For the areas where air quality rules apply, the Statewide CASE Team assumed the percentage of the floorspace that will meet the rules with electric systems (Table 72).

Table 72: Percentage of NR sq ft under AQMD rules met with electric systems

Prototype Name	New Construction/Additions	Alteration
OfficeLarge	50%	50%
OfficeMedium	70%	70%
OfficeMediumLab	50%	50%
OfficeSmall	90%	90%
RestaurantFastFood	20%	20%
SchoolSmall	0%	0%
SchoolLarge	10%	10%
Assembly	10%	10%
RetailLarge	10%	10%
RetailMixedUse	70%	70%
RetailMedium	70%	70%
RetailStripMall	70%	70%
Warehouse	90%	90%
Grocery	20%	20%
RefWarehouse	90%	90%
Horticulture	90%	90%
VehicleService	80%	80%

Consolidating all the above assumptions, the Statewide CASE Team obtained the percentage of nonresidential floorspace impact by this proposed measure for new construction and additions (Table 73) and alterations (Table 74) per prototype per system configuration.

Table 73: New construction NR floorspace impacted by system configuration

Prototype Name	Gas	Electric Resistance	Swing Tank	Unitary Heat Pump
OfficeLarge	50%	29%	17%	11%
OfficeMedium	30%	55%	10%	14%
OfficeMediumLab	50%	16%	7%	10%
OfficeSmall	10%	21%	0.1%	2%
RestaurantFastFood	80%	5%	14%	5%
SchoolSmall	0%	0%	16%	11%
SchoolLarge	90%	4%	26%	7%
Assembly	90%	4%	20%	13%
RetailLarge	90%	3 %	24%	6%
RetailMixedUse	30%	0%	0%	0 %
RetailMedium	30%	25%	4%	7%
RetailStripMall	30%	22%	4%	6%
Warehouse	10%	66%	0.4%	7%
Grocery	80%	2%	2%	8%
RefWarehouse	10%	8%	0%	1%
Horticulture	10%	9%	0%	1%
VehicleService	20%	20%	0.3%	5%

Table 74: Alteration NR floorspace impacted by system configuration

Prototype Name	Gas	Electric Resistance	Swing Tank	Unitary Heat Pump
OfficeLarge	50%	2%	1%	1%
OfficeMedium	30%	4%	1%	1%
OfficeMediumLab	50%	1%	0.3%	1%
OfficeSmall	10%	1%	0%	0.2%
RestaurantFastFood	80%	0.1%	0.3%	0.1%
SchoolSmall	0%	0%	1%	1%
SchoolLarge	90%	0.2%	2%	1%
Assembly	90%	0.2%	1%	1%

Prototype Name	Gas	Electric Resistance	Swing Tank	Unitary Heat Pump
RetailLarge	90%	0.2%	0.6%	1 %
RetailMixedUse	30%	0%	0%	0%
RetailMedium	30%	2%	0.2%	0.5%
RetailStripMall	30%	1%	0.2%	0.4%
Warehouse	10%	4%	0.15%	0.3%
Grocery	80%	0.1%	0.1%	0.5%
RefWarehouse	10%	0.5%	0%	0 %
Horticulture	10%	0.6%	0%	0 %
VehicleService	20%	1%	0.2%	0.2%

Require Return to Primary Configuration

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 first estimated the percentage of nonresidential floorspace that will have SHW with recirculation for each prototype based on plans review and engineering judgement for both new construction and additions and alterations (Table 75).

Table 75: Percentage of nonresidential sq ft having SHW with recirculation

Prototype Name	New Construction/Additions	Alteration
Large Office	95%	95%
Medium Office	95%	95%
Laboratory	95%	95%
Restaurant	95%	30%
Small School	95%	95%
Large School	95%	95%
Assembly	60%	50%
RetailLarge	75%	75%
RetailMedium	75%	75%
Grocery	75%	65%

For the SHW with recirculation, the Statewide CASE Team then estimated the percentage of nonresidential floorspace that have heat pump systems based on BAAQMD and SCAQMD rules. To achieve that, the Statewide CASE Team first estimated the percentage of

population that will be impacted by air quality rules for each CZ, and then mapped it to the percentage of nonresidential floorspace for each prototype under each CZ based on CEC's construction forecast. For the CZ or prototypes that the air quality rules don't apply, the Statewide CASE Team assumed 1%. Table 76 demonstrates the percentage of floorspace impacted by Air Quality Management Rules.

Table 76: Percentage of sq ft that will be impacted by Air Quality Management District (AQMD) Rules

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.0%	0.0%	11.7%	11.1%	0.0%	6.1%	1.0%	10.4%	12.9%	2.3%	1.0%	0.9%	0.0%	0.9%	0.5%	1.5%
Medium Office	0.5%	11.3%	5.5%	5.8%	1.0%	5.7%	1.0%	8.4%	11.0%	7.5%	1.0%	5.1%	1.0%	1.7%	13.0%	3.7%
Laboratory	1.0%	4.5%	5.2%	5.6%	1.0%	2.0%	1.0%	2.3%	2.9%	2.3%	1.0%	0.8%	1.0%	1.0%	2.0%	1.1%
Restaurant	0.0%	1.9%	1.3%	1.3%	1.0%	1.6%	1.0%	2.5%	2.8%	2.6%	1.0%	0.6%	1.0%	1.0%	2.5%	1.1%
Small School	1.0%	6.4%	1.8%	1.8%	1.0%	1.5%	1.0%	1.8%	2.3%	2.3%	1.0%	1.4%	1.0%	0.5%	2.0%	1.5%
Large School	1.0%	2.6%	3.1%	3.1%	1.0%	2.5%	1.0%	4.1%	4.3%	4.8%	1.0%	1.8%	1.0%	0.7%	4.0%	2.2%
Assembly	1.0%	9.2%	6.4%	4.4%	1.0%	3.8%	1.0%	7.3%	6.3%	7.3%	1.0%	2.6%	1.0%	1.2%	6.0%	3.0%
RetailLarge	0.0%	0.0%	4.4%	4.3%	1.0%	3.3%	1.0%	4.2%	5.7%	4.1%	1.0%	2.4%	1.0%	0.7%	9.0%	2.2%
RetailMedium	1.0%	8.2%	3.2%	3.5%	1.0%	2.9%	1.0%	4.4%	4.9%	5.3%	1.0%	1.1%	1.0%	0.9%	6.0%	3.0%
Grocery	1.0%	1.2%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.5%	1.0%

For the areas where air quality rules apply, the Statewide CASE Team assumed the percentage of the floorspace that will meet the rules with heat pumps (Table 77).

Table 77: Percentage of NR sq ft under AQMD rules will meet them with heat pumps

Prototype Name	New Construction/Additions	Alteration
Large Office	50%	50%
Medium Office	30%	30%
Laboratory	50%	50%
Restaurant	80%	80%
Small School	100%	100%
Large School	90%	90%
Assembly	90%	90%
RetailLarge	90%	90%
RetailMedium	30%	30%
Grocery	80%	80%

Among all SHW with recirculation and heat pump systems, the Statewide CASE Team estimated the percentage of nonresidential floorspace that will have split heat pump systems.

Table 78: Percentage of sq ft having split heat pump systems

Prototype Name	New Construction/Additions	Alteration
Large Office	60%	50%
Medium Office	40%	30%
Laboratory	40%	30%
Restaurant	75%	65%
Small School	60%	50%
Large School	80%	70%
Assembly	60%	50%
RetailLarge	80%	30%
RetailMedium	40%	30%
Grocery	20%	10%

Consolidating all the above assumptions, the Statewide CASE Team obtained the percentage of nonresidential floorspace impact by this proposed measure for new construction and additions (Table 79) and alterations (Table 80) per prototype per CZ.

Table 79: Percentage of sq ft Impacted by Return to Primary Measure – New Construction and Additions

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.00%	0.00%	3.32%	3.17%	0.00%	1.74%	0.29%	2.97%	3.67%	0.64%	0.29%	0.27%	0.00%	0.25%	0.14%	0.42%
Medium Office	0.06%	1.29%	0.63%	0.66%	0.11%	0.65%	0.11%	0.96%	1.25%	0.86%	0.11%	0.58%	0.11%	0.20%	1.48%	0.42%
Laboratory	0.19%	0.85%	0.99%	1.06%	0.19%	0.38%	0.19%	0.44%	0.55%	0.43%	0.19%	0.15%	0.19%	0.19%	0.38%	0.21%
Restaurant	0.57%	1.07%	0.76%	0.76%	0.57%	0.92%	0.57%	1.42%	1.62%	1.50%	0.57%	0.32%	0.57%	0.57%	1.43%	0.63%
Small School	0.57%	3.63%	1.05%	1.03%	0.57%	0.87%	0.57%	1.01%	1.30%	1.28%	0.57%	0.81%	0.57%	0.31%	1.14%	0.84%
Large School	0.68%	1.77%	2.12%	2.09%	0.68%	1.70%	0.68%	2.78%	2.96%	3.30%	0.68%	1.26%	0.68%	0.51%	2.74%	1.52%
Assembly	0.32%	2.98%	2.06%	1.42%	0.32%	1.22%	0.32%	2.35%	2.04%	2.38%	0.32%	0.83%	0.32%	0.40%	1.95%	0.96%
RetailLarge	0.00%	0.00%	2.39%	2.33%	0.54%	1.80%	0.54%	2.28%	3.10%	2.19%	0.54%	1.28%	0.54%	0.38%	4.86%	1.20%
RetailMedium	0.09%	0.74%	0.29%	0.32%	0.09%	0.26%	0.09%	0.39%	0.44%	0.47%	0.09%	0.10%	0.09%	0.08%	0.54%	0.27%
Grocery	0.12%	0.14%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.12%	0.06%	0.12%

Table 80: Percentage of sq ft Impacted by Return to Primary Measure -- Alterations

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.00%	0.00%	0.18%	0.18%	0.00%	0.10%	0.02%	0.16%	0.20%	0.04%	0.02%	0.01%	0.00%	0.01%	0.01%	0.02%
Medium Office	0.00%	0.06%	0.03%	0.03%	0.01%	0.03%	0.01%	0.05%	0.06%	0.04%	0.01%	0.03%	0.01%	0.01%	0.07%	0.02%
Laboratory	0.01%	0.04%	0.05%	0.05%	0.01%	0.02%	0.01%	0.02%	0.03%	0.02%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%
Restaurant	0.01%	0.02%	0.01%	0.01%	0.01%	0.02%	0.01%	0.03%	0.03%	0.03%	0.01%	0.01%	0.01%	0.01%	0.03%	0.01%
Small School	0.03%	0.20%	0.06%	0.06%	0.03%	0.05%	0.03%	0.06%	0.07%	0.07%	0.03%	0.04%	0.03%	0.02%	0.06%	0.05%
Large School	0.04%	0.10%	0.12%	0.12%	0.04%	0.10%	0.04%	0.16%	0.17%	0.19%	0.04%	0.07%	0.04%	0.03%	0.16%	0.09%
Assembly	0.02%	0.14%	0.10%	0.07%	0.02%	0.06%	0.02%	0.11%	0.09%	0.11%	0.02%	0.04%	0.02%	0.02%	0.09%	0.04%
RetailLarge	0.00%	0.00%	0.06%	0.06%	0.01%	0.05%	0.01%	0.06%	0.08%	0.05%	0.01%	0.03%	0.01%	0.01%	0.12%	0.03%
RetailMedium	0.00%	0.04%	0.01%	0.02%	0.00%	0.01%	0.00%	0.02%	0.02%	0.02%	0.00%	0.01%	0.00%	0.00%	0.03%	0.01%
Grocery	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%

Table 81 presents the projected nonresidential new construction that the proposed code change will impact in 2026. Table 82 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2026.

Table 81: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2029, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	0.69	0.36	0.00	0.28	0.03	0.58	1.00	0.08	0.01	0.04	0.00	0.01	0.00	0.00	3.10
Medium Office	0.00	0.05	0.13	0.08	0.00	0.11	0.01	0.19	0.34	0.10	0.00	0.09	0.01	0.01	0.03	0.00	1.15
Laboratory	0.00	0.03	0.21	0.12	0.00	0.06	0.02	0.09	0.15	0.05	0.01	0.02	0.01	0.01	0.01	0.00	0.79
Restaurant	0.00	0.04	0.16	0.09	0.01	0.15	0.05	0.28	0.44	0.18	0.02	0.05	0.03	0.02	0.03	0.01	1.55
Small School	0.00	0.13	0.22	0.12	0.01	0.14	0.05	0.20	0.36	0.16	0.02	0.13	0.03	0.01	0.02	0.01	1.60
Large School	0.00	0.06	0.44	0.24	0.01	0.28	0.06	0.55	0.81	0.40	0.02	0.20	0.04	0.02	0.05	0.02	3.20
Assembly	0.00	0.11	0.43	0.16	0.01	0.20	0.03	0.46	0.56	0.29	0.01	0.13	0.02	0.01	0.04	0.01	2.46
RetailLarge	0.00	0.00	0.50	0.27	0.01	0.29	0.05	0.45	0.85	0.26	0.02	0.21	0.03	0.01	0.09	0.01	3.04
RetailMedium	0.00	0.03	0.06	0.04	0.00	0.04	0.01	0.08	0.12	0.06	0.00	0.02	0.00	0.00	0.01	0.00	0.47
Grocery	0.00	0.01	0.03	0.01	0.00	0.02	0.01	0.02	0.03	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.18
TOTAL	0.01	0.44	2.86	1.48	0.05	1.57	0.32	2.90	4.67	1.59	0.11	0.92	0.17	0.09	0.28	0.07	17.5

Table 82: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2029 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	1.85	1.03	0.00	0.73	0.09	1.88	3.59	0.35	0.03	0.15	0.00	0.03	0.01	0.02	9.75
Medium Office	0.00	0.13	0.31	0.19	0.01	0.25	0.03	0.54	1.10	0.42	0.01	0.29	0.02	0.02	0.10	0.02	3.45
Laboratory	0.00	0.09	0.49	0.31	0.01	0.14	0.05	0.25	0.49	0.21	0.02	0.07	0.04	0.02	0.02	0.01	2.23
Restaurant	0.00	0.04	0.14	0.08	0.01	0.13	0.06	0.30	0.52	0.27	0.02	0.06	0.04	0.02	0.03	0.01	1.72
Small School	0.01	0.41	0.59	0.33	0.03	0.37	0.17	0.64	1.27	0.69	0.06	0.44	0.12	0.04	0.08	0.04	5.30
Large School	0.01	0.21	1.23	0.71	0.04	0.75	0.22	1.85	3.04	1.88	0.08	0.73	0.15	0.07	0.21	0.07	11.24
Assembly	0.01	0.28	0.95	0.38	0.01	0.43	0.08	1.24	1.66	1.07	0.03	0.38	0.06	0.04	0.12	0.03	6.79
RetailLarge	0.00	0.00	0.60	0.34	0.01	0.34	0.07	0.65	1.37	0.53	0.03	0.32	0.05	0.02	0.16	0.02	4.51
RetailMedium	0.00	0.08	0.14	0.09	0.00	0.10	0.02	0.22	0.39	0.23	0.01	0.05	0.02	0.01	0.04	0.01	1.42
Grocery	0.00	0.01	0.03	0.02	0.00	0.03	0.02	0.04	0.06	0.03	0.01	0.03	0.01	0.01	0.00	0.00	0.31
TOTAL	0.04	1.25	6.34	3.49	0.13	3.26	0.82	7.62	13.49	5.68	0.29	2.52	0.49	0.29	0.77	0.23	46.71

Requirements for Unitary HP/ER Hybrid Heaters

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 first estimated the percentage of nonresidential floorspace that will have commercial SHW systems for each prototype based on plans review and engineering judgement for both new construction and additions and alterations (Table 83).

Table 83: Percentage of nonresidential sq ft with commercial SWH systems

Prototype Name	New Construction/Additions	Alteration
Large Office	100%	100%
Medium Office	75%	75%
Laboratory	75%	75%
Small Office	0%	0%
Restaurant	75%	75%
Small School	95%	95%
Large School	100%	100%
Assembly	100%	100%
Large Retail	100%	100%
Mixed-use Retail	75%	75%
Medium Retail	75%	75%
Strip Mall	75%	75%
Non-refrigerated Warehouse	0%	0%
Grocery	75%	75%
Refrigerated Warehouse	0%	0%
Controlled-environment Horticulture	0%	0%
Vehicle Service	0%	0%

To determine the number of heat pump installations, the Statewide CASE Team estimated the percentage of nonresidential floorspace that will have electric water heating systems based on BAAQMD and SCAQMD rules. To achieve that estimate, the Statewide CASE Team first estimated the percentage of population that will be impacted by air quality rules for each CZ, and then mapped it to the percentage of nonresidential floorspace for each prototype under each CZ based on CEC’s construction forecast. For the CZ or prototypes to which the air quality rules do not apply, the Statewide CASE Team assumed 1% of the square footage would have electric water heaters. Table 84 demonstrates the percentage of

floorspace impacted by Air Quality Management Rules among those building prototypes that are expected to have commercial water heating systems.

Table 84: Percentage of sq ft that will be impacted by Air Quality Management District (AQMD) Rules

Prototype	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.0 %	0.0 %	11.7 %	11.1 %	0.0 %	6.1 %	1.0 %	10.4 %	12.9 %	2.3 %	1.0 %	0.9 %	0.0 %	0.9 %	0.5 %	1.5 %
Medium Office	0.5 %	11.3 %	5.5 %	5.8 %	1.0 %	5.7 %	1.0 %	8.4 %	11.0 %	7.5 %	1.0 %	5.1 %	1.0 %	1.7 %	13.0 %	3.7 %
Laboratory	1.0 %	4.5 %	5.2 %	5.6 %	1.0 %	2.0 %	1.0 %	2.3 %	2.9 %	2.3 %	1.0 %	0.8 %	1.0 %	1.0 %	2.0 %	1.1 %
Restaurant	1.0 %	1.9 %	1.3 %	1.3 %	1.0 %	1.6 %	1.0 %	2.5 %	2.8 %	2.6 %	1.0 %	0.6 %	1.0 %	1.0 %	2.5 %	1.1 %
Small School	1.0 %	6.4 %	1.8 %	1.8 %	1.0 %	1.5 %	1.0 %	1.8 %	2.3 %	2.3 %	1.0 %	1.4 %	1.0 %	0.5 %	2.0 %	1.5 %
Large School	1.0 %	2.6 %	3.1 %	3.1 %	1.0 %	2.5 %	1.0 %	4.1 %	4.3 %	4.8 %	1.0 %	1.8 %	1.0 %	0.7 %	4.0 %	2.2 %
Assembly	1.0 %	9.2 %	6.4 %	4.4 %	1.0 %	3.8 %	1.0 %	7.3 %	6.3 %	7.3 %	1.0 %	2.6 %	1.0 %	1.2 %	6.0 %	3.0 %
Large Retail	0.0 %	0.0 %	4.4 %	4.3 %	1.0 %	3.3 %	1.0 %	4.2 %	5.7 %	4.1 %	1.0 %	2.4 %	1.0 %	0.7 %	9.0 %	2.2 %
Mixed-use Retail	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Medium Retail	1.0 %	8.2 %	3.2 %	3.5 %	1.0 %	2.9 %	1.0 %	4.4 %	4.9 %	5.3 %	1.0 %	1.1 %	1.0 %	0.9 %	6.0 %	3.0 %
Strip Mall	0.0 %	3.5 %	2.0 %	1.8 %	1.0 %	2.7 %	1.0 %	5.0 %	3.7 %	8.7 %	1.0 %	1.1 %	1.0 %	1.6 %	5.0 %	2.2 %
Grocery	1.0 %	1.2 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	1.0 %	0.5 %	1.0 %

For the areas where air quality rules apply, the Statewide CASE Team assumed the percentage of the floorspace that will meet the rules with heat pumps (Table 85).

Table 85. Percentage of NR sq ft under AQMD rules that will use heat pump water heaters.

Prototype Name	New Construction/Additions	Alteration
Large Office	50%	50%
Medium Office	30%	30%
Laboratory	50%	50%
Restaurant	80%	80%
Small School	100%	100%

Prototype Name	New Construction/Additions	Alteration
Large School	90%	90%
Assembly	90%	90%
Large Retail	90%	90%
Mixed-use Retail	30%	30%
Medium Retail	30%	30%
Strip Mall	30%	30%
Grocery	80%	80%

Among all Commercial Service Hot Water Systems with heat pump systems, the Statewide CASE Team estimated the percentage of nonresidential floorspace that will have unitary systems (Table 86).

Table 86. Percentage of sq ft having unitary heat pump water heaters.

Prototype Name	New Construction/Additions	Alteration
Large Office	40%	40%
Medium Office	60%	60%
Laboratory	60%	60%
Restaurant	25%	25%
Small School	40%	40%
Large School	20%	20%
Assembly	40%	40%
Large Retail	20%	20%
Mixed-use Retail	60%	60%
Medium Retail	60%	60%
Strip Mall	60%	60%
Grocery	80%	80%

Table 87 presents the projected nonresidential new construction that the proposed code change will impact in 2029. Table 88 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2029.

Table 87: Estimated New Nonresidential Construction Impacted by Proposed Code Change in 2029, by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	0.49	0.25	0.00	0.20	0.02	0.41	0.71	0.05	0.01	0.03	0.00	0.01	0.00	0.00	2.17
Medium Office	0.00	0.05	0.15	0.09	0.00	0.13	0.01	0.22	0.41	0.12	0.00	0.11	0.01	0.01	0.03	0.01	1.36
Large Retail	0.00	0.00	0.17	0.09	0.00	0.10	0.02	0.15	0.28	0.09	0.01	0.07	0.01	0.00	0.03	0.00	1.01
Medium Retail	0.00	0.04	0.09	0.05	0.00	0.06	0.01	0.12	0.18	0.09	0.00	0.02	0.01	0.00	0.02	0.00	0.70
Strip Mall	0.00	0.02	0.06	0.03	0.00	0.06	0.01	0.13	0.14	0.14	0.00	0.02	0.01	0.01	0.01	0.00	0.64
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.00	0.02	0.12	0.06	0.00	0.07	0.02	0.14	0.21	0.11	0.01	0.05	0.01	0.00	0.01	0.00	0.84
Small School	0.00	0.09	0.15	0.08	0.01	0.09	0.03	0.13	0.24	0.10	0.01	0.09	0.02	0.01	0.01	0.01	1.07
Assembly	0.00	0.12	0.48	0.18	0.01	0.22	0.03	0.51	0.62	0.32	0.01	0.15	0.02	0.01	0.04	0.01	2.74
Laboratory	0.00	0.04	0.24	0.14	0.00	0.07	0.02	0.10	0.18	0.06	0.01	0.03	0.01	0.01	0.01	0.00	0.93
Restaurant	0.00	0.01	0.04	0.02	0.00	0.04	0.01	0.07	0.12	0.05	0.00	0.01	0.01	0.00	0.01	0.00	0.41
Grocery	0.00	0.02	0.10	0.05	0.01	0.08	0.04	0.09	0.13	0.06	0.01	0.08	0.03	0.01	0.00	0.00	0.73
TOTAL	0.0	0.4	2.1	1.1	0.0	1.1	0.2	2.1	3.2	1.2	0.1	0.7	0.1	0.1	0.2	0.0	12.6

Table 88: Estimated Existing Nonresidential Floorspace Impacted by Proposed Code Change in 2029 (Alterations), by Climate Zone and Building Type (Million Square Feet)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16	All
Large Office	0.00	0.00	1.94	1.08	0.00	0.77	0.09	1.98	3.78	0.37	0.03	0.16	0.00	0.03	0.01	0.02	10.26
Medium Office	0.00	0.24	0.58	0.36	0.01	0.46	0.06	1.00	2.03	0.77	0.02	0.53	0.04	0.04	0.18	0.03	6.35
Large Retail	0.00	0.00	1.86	1.06	0.04	1.06	0.23	2.02	4.25	1.66	0.08	0.98	0.16	0.07	0.49	0.07	14.02
Medium Retail	0.00	0.18	0.33	0.22	0.01	0.23	0.06	0.52	0.91	0.54	0.02	0.12	0.04	0.02	0.08	0.02	3.30
Strip Mall	0.00	0.08	0.21	0.11	0.01	0.21	0.06	0.60	0.68	0.89	0.02	0.11	0.04	0.04	0.07	0.02	3.15
Mixed-use Retail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large School	0.01	0.10	0.56	0.32	0.02	0.34	0.10	0.83	1.37	0.85	0.03	0.33	0.07	0.03	0.09	0.03	5.07
Small School	0.01	0.41	0.59	0.33	0.03	0.37	0.17	0.64	1.27	0.69	0.06	0.44	0.12	0.04	0.08	0.04	5.30
Assembly	0.01	0.57	1.90	0.77	0.03	0.86	0.16	2.48	3.33	2.14	0.06	0.76	0.11	0.09	0.24	0.07	13.57
Laboratory	0.01	0.16	0.91	0.57	0.02	0.27	0.10	0.47	0.90	0.38	0.03	0.14	0.06	0.04	0.05	0.02	4.10
Restaurant	0.00	0.05	0.19	0.11	0.01	0.17	0.08	0.40	0.70	0.36	0.03	0.08	0.05	0.03	0.05	0.01	2.32
Grocery	0.01	0.09	0.36	0.21	0.03	0.27	0.20	0.41	0.63	0.35	0.07	0.36	0.13	0.08	0.02	0.03	3.26
TOTAL	0.1	1.9	9.4	5.1	0.2	5.0	1.3	11.4	19.9	9.0	0.5	4.0	0.8	0.5	1.4	0.4	70.7

Appendix D: Environmental Analysis

Circulator Pump Controls

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of this 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 direct environmental impacts include a positive impact resulting from energy savings and GHG reduction, and a negative impact from increased use of materials and embodied carbon in the controls.

Direct Environmental Benefits

The savings detailed and summarized in Appendix A demonstrate the electrical energy savings for this proposed change, and consequentially the presence of a reduction in GHG.

Direct Adverse Environmental Impacts

This proposal would result in an adverse environmental impact from an increased use of materials for the pump controls including steel, brass, plastic, epoxy, and copper, and consequentially an increase in embodied carbon. The Statewide Case Team is conducting further analysis to quantify this and this will be complete by the time the Statewide CASE Team posts the draft report for public comment.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team determined this measure would not result in indirect environmental benefits.

Indirect Adverse Environmental Impacts

The Statewide CASE Team determined this measure would not result in indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team 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 this measure would result in significant direct or indirect adverse environmental impacts and therefore, did not develop any mitigation measures.

Reasonable Alternatives to Proposal

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

The Statewide CASE Team considered limiting compliance to pumps with fully integrated controls. However, this approach raised concerns about federal preemption and would reduce the range of products available to designers and contractors. While requiring integrated controls could reduce environmental impacts it would also limit opportunities and constrain the market to fewer compliant product options. This proposed approach allows both integrated and external digital controls, which preserves flexibility and avoids restricting the market to a small number of products.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

Require Return to Primary Configuration

Potential Significant Environmental Effect of Proposal

The Statewide CASE Team has considered the environmental benefits and adverse impacts of this 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 direct environmental impacts include a positive impact resulting from energy savings and GHG reduction, and a negative impact from increased use of materials and greater embodied carbon.

Direct Environmental Benefits

The savings detailed and summarized in Appendix A demonstrate the energy savings for this proposed change, and consequentially the presence of a reduction in GHG.

Direct Adverse Environmental Impacts

This proposed measure would result in an adverse environmental impact from an increased use of certain materials, such as copper and refrigerant, and consequentially

an increase in embodied carbon. Statewide Material Impacts section illustrates the embodied GHG emissions from the materials used for the proposed measure.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team determined this measure would not result in indirect environmental benefits.

Indirect Adverse Environmental Impacts

The Statewide CASE Team determined this measure would not result in indirect adverse environmental impacts.

Mitigation Measures

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

Reasonable Alternatives to Proposal

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

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

Requirements for Unitary HP/ER Hybrid Heaters

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 direct environmental impacts include a positive impact resulting from electrical energy savings and GHG reduction, and a negative impact from increased use of materials and embodied carbon to create the space necessary for the required ventilation air and to add water heaters to meet sizing requirements.

Direct Environmental Benefits

The savings detailed and summarized in Appendix A demonstrate the electrical energy savings for this proposed change, and consequentially the presence of a reduction in GHG.

Direct Adverse Environmental Impacts

This proposal would result in an adverse environmental impact from an increased use of materials to create the air volume needed to supply the unitary HP/ER and to meet sizing requirements and additional water heaters in limited situations to meet sizing requirements, and consequentially an increase in embodied carbon.

Indirect Environmental Impacts

Indirect Environmental Benefits

The Statewide CASE Team determined this measure would not result in indirect environmental benefits.

Indirect Adverse Environmental Impacts

The Statewide CASE Team determined this measure would not result in indirect adverse environmental impacts.

Mitigation Measures

The Statewide CASE Team has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of “specific economic, environmental, legal, social, and technological factors” (California Code of Regulations, Title 14, § 15021). The Statewide CASE Team determined that this measure would not result in significant direct or indirect adverse environmental impacts and, therefore, did not develop any mitigation measures.

Reasonable Alternatives to Proposal

The Statewide CASE Team has considered alternatives to the proposal and determined that no alternative would achieve its purpose with less environmental effect. One alternative includes a mandate to install split heat pump water heaters instead of a unitary, but that approach may require more material and refrigerant which could have more environmental impact. Another alternative is to mandate ducting to and from the outdoors for unitary HP/ER water heaters, but that approach risks decreasing the performance of the water heater and adding environmental impact through the added material required to create the ducting.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use.

Appendix E: Summary of Stakeholder Engagement

Introduction to Stakeholder Engagement

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

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

Circulator Pump Controls

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 analyses
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for Circulator Pump Controls via webinar, as described in Table 89. Please see below for dates and links to event pages on [Title24Stakeholders.com](https://www.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 89: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Thursday, October 23, 2025	<ul style="list-style-type: none"> • Proposal Description • Market and Technical Considerations • Per Unit Energy and Cost Impacts • Compliance and Enforcement
Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Thursday, March 10, 2026	<ul style="list-style-type: none"> • TBD

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.

The second round of utility-sponsored stakeholder meetings occurred in March 2026 and provided updated details on proposed code changes. These of meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

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

The Title 24 Stakeholders listserv is an opt-in service comprising participants from 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 90.

Table 90: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Steve Taylor	Designer	
Villara	Contractor	2.4.3

Engagement with ESJ communities

The Statewide CASE Team will engage with stakeholders that targeting ESJ communities and will update this section to summarize detailed stakeholder engagement activities.

Require Return to Primary Configuration

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 two stakeholder meetings for require return to primary configuration via webinar, as described in Table 91. Please see below for dates

and links to event pages on [Title24Stakeholders.com](https://www.title24stakeholders.com). Materials from each meeting, such as slide presentations (The Statewide CASE Team 2025), proposal summaries with code language (The Statewide CASE Team 2025), and meeting notes (The Statewide CASE Team 2025), are included in the bibliography section of this report.

Table 91: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Thursday, October 23, 2025	<ul style="list-style-type: none"> • Proposal Description • Market and Technical Considerations • Per Unit Energy and Cost Impacts • Compliance and Enforcement
Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Tuesday, March 10, 2026	<ul style="list-style-type: none"> • TBD

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.

The second round of utility-sponsored stakeholder meetings will occur in March 2026 and provide updated details on proposed code changes. These meetings will introduce early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

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

The Title 24 Stakeholders listserv is an opt-in service comprising participants from 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 and will list them in Table 92.

Table 92: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Ben Larson	Software Developer	-
Neal Kruis	Software Developer	-

Engagement with ESJ communities

The Statewide CASE Team will engage with stakeholders that were targeted towards ESJ communities and will update this section to summarize detailed stakeholder engagement activities.

Requirements for Unitary HP/ER Hybrid Heaters

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 analyses
- Data to support assumptions
- Compliance and enforcement
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for Unitary HP/ER Hybrid Heaters via webinar, as described in Table 93. Please see below for dates and links to event pages on [Title24Stakeholders.com](https://www.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 93: Utility-Sponsored Stakeholder Meetings

Meeting Name and Link to Materials	Meeting Date	Summary of Items Discussed
First Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Thursday, October 23, 2025	<ul style="list-style-type: none"> • Types of buildings where Unitary HP/ER water heaters are being installed in Central Service Water Heating Systems. • Technical challenges to ensure that the intended operation of Unitary HP/ER water heaters is achieved in the field. • Recommended ventilation requirements • Cost data for installation of central heat pump water heaters •
Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting	Tuesday, March 10, 2026	

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.

The second round of utility-sponsored stakeholder meetings occurred in March 2026 and provided updated details on proposed code changes. These meetings introduced early results of energy, cost effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com.

One email was sent to the full Title 24 Stakeholders listserv, which includes over 3,000 individuals. A second email targeted specific recipients based on their subscription preferences.

The Title 24 Stakeholders listserv is an opt-in service comprising participants from 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 is planning to interview professionals familiar with unitary HP/ER water heaters to further develop the proposed measure. Table 94 will identify the people that were engaged by the Statewide CASE Team.

Table 94: Engaged Stakeholders

Organization/Individual Name	Market Role	Mentioned in CASE Report Sections
Gary Klein	Codes and Standards	Comparable Model Codes and Standards
Villara	Pricing	Incremental First Cost

Engagement with ESJ communities

The Statewide CASE Team intends to engage with ESJ communities to ensure that the proposed measure meets ESJ community priorities.

Add Headings for Other Outreach Mechanisms

The Statewide CASE Team will continue to engage stakeholders and will report any such interactions in the final report.

Appendix F: Prototype Recirculation System Designs

Current standard practice in nonresidential buildings includes the use of circulator pumps and hot water return piping, collectively known as a recirculation system, in many hot water systems to ensure adequate hot water delivery performance at fixtures that are distant from the water heater. The inclusion of a recirculation system has a significant impact on water heater energy use, yet the existing nonresidential prototype buildings do not include a hot water distribution system, and the existing modeling software does not account for heat loss in the recirculation system.

To improve the accuracy of our energy analysis, the Statewide CASE Team developed basic prototype designs for select nonresidential prototype buildings. The Statewide CASE Team analyzed 17 prototypes to support our code change proposals. The Statewide CASE Team performed the following activities for the analysis:

- Reviewed building plans to better understand current standard practices around recirculation system design for various nonresidential building types.
- Reviewed the prototype building characteristics including size, occupancy, hot water demand profiles, and peak flow.
- Identified prototypes for which there is reasonable similarity in the design of the recirculation system, with special consideration given to how distant the fixtures would be from each other and the plant. The Statewide CASE Team leveraged similarities to group prototypes, select a representative prototype from each group for detailed design, and use the same heat loss values for the representative prototype for each prototype in the group. Table 95 below lists the prototype grouping.
- For the detailed designs, the Statewide CASE Team limited the design activities to the minimum work required to size the recirculation system. This required consideration of minimum required fixtures, additional common fixtures, fixture placement for fixtures served by cold water alone and cold and hot water, water meter and building mains sizing, and sizing of the hot water and hot water return piping. The methodology is detailed in the following section.

Table 95: Prototype Similarity for Analyzed Prototypes

Building Prototype	Number of Stories	Area (sq. ft.)	Proposed Recirculation System Heat Loss
Large office	<i>12 + Basement</i>	<i>498,589</i>	<i>4.3x Heat Loss of Medium Office</i>
Medium Office	<i>3</i>	<i>53,628</i>	<i>Based on detailed design</i>
Small Office	<i>1</i>	<i>5,502</i>	<i>Based on detailed design</i>
Medium Lab	<i>3</i>	<i>53,628</i>	<i>Based on detailed design</i>
Restaurant (FastFood)	<i>1</i>	<i>2,501</i>	<i>Based on detailed design</i>
Small School	<i>1</i>	<i>24,413</i>	<i>Based on detailed design</i>
Large School	<i>2</i>	<i>210,866</i>	<i>2x Heat Loss of Small School</i>
Assembly	<i>1</i>	<i>315,339</i>	<i>Same as Small School</i>
Large Retail	<i>1</i>	<i>240,000</i>	<i>Same as Small Office</i>
Mixed Use Retail	<i>1</i>	<i>9,375</i>	<i>Same as Small Office</i>
Medium Retail	<i>1</i>	<i>24,563</i>	<i>Same as Small Office</i>
Retail Strip Mall	<i>1</i>	<i>9,375</i>	<i>Same as Small Office</i>
Warehouse	<i>1</i>	<i>52,045</i>	<i>Same as Small Office</i>
Grocery	<i>1</i>	<i>50,002</i>	<i>Same as Restaurant (FastFood)</i>
Refrigerated Warehouse	<i>1</i>	<i>100,000</i>	<i>Same as Small Office</i>
Horticulture	<i>1</i>	<i>100,000</i>	<i>Same as Small Office</i>
Vehicle Service	<i>1</i>	<i>100,000</i>	<i>Same as Small Office</i>

F.1 Recirculation System Design Methodology

The Statewide CASE Team developed prototype hot water recirculation system designs for five nonresidential prototype buildings: Small Office, Medium Office, Laboratory, Small School, and Restaurant. The Statewide CASE Team used the prototype building definitions from CBECC including floor plan dimensions, occupancy, peak hot water flow, and hot water draw schedule. The pre-existing prototype buildings do not include fixture count or placement. Fixture placement and hot water system design is variable and highly dependent on the use of the building, therefore representing each building type with one prototypical hot water system design is inherently challenging. For example, some medium office buildings have one tenant whereas others have multiple tenants. The medium office prototype building can be reasonably represented by a design with one water heating system or by a design with multiple smaller water heating systems. The Statewide CASE Team made key decisions to address these challenges; the key decisions regarding fixture placement and hot water system design are documented below:

- Small Office: Water heater and fixtures are co-located in the center of the building. Fixture locations and pipe lengths between fixtures are based on plans review of office projects.
- Medium Office: One central water heater with fixtures co-located in the center of the building. Fixture locations and pipe lengths between fixtures are based on plans review of office projects.
- Medium Lab: Four separate water heaters, one for sanitary facilities and the other three for process loads (one per floor). Process water heaters located on the perimeter. Recirculation system piped near the building perimeter. Process load fixture count is based on plans review of a similar sized building.
- Restaurant (FastFood): The system design is based on a plans review of two comparably sized fast food/quick service restaurants.
- Small School: Based on the design concept for a Primary School prototype in the National Institutes of Standards and Technology (NIST) Standard Building Plumbing System Models Basis of Design Document, which includes the Basis of Design for a Small School (National Institutes of Standard and Technology 2022). The Primary School Prototype Building analyzed in the NIST design has a larger floor plan with one extra classroom wing than the Small School prototype building the Statewide CASE Team used for our analysis, however the floor plan is sufficiently similar that the Statewide CASE Team was able to apply similar design concepts to the Small School prototype.

Once the Statewide CASE Team determined the fixture location and the water heating plant location the Statewide CASE Team calculated the minimum plumbing fixtures required for each prototype building, per the 2025 California Plumbing Code (CPC), based on the building occupancy defined in CBECC. For the medium laboratory prototype, the Statewide CASE Team designed the service hot water system to meet the occupancy of the medium office prototype which has the same floor plan. The Statewide CASE Team determined additional fixtures for each prototype based on plans review and our professional judgement and experience, with input from a plumbing design engineer and a plumbing contractor.

Using the fixture count, fixture location, and water heating plant location, the Statewide CASE Team performed a Water Supply Fixture Units analysis (water calculation) based on CPC Chapter 6 which also references CPC Appendix A. The Statewide CASE Team determined the total water load and the total developed length of the cold and hot water piping system. The Statewide CASE Team sized the water meter and cold water mains per CPC Chapter 6. For all prototypes, the Statewide CASE Team assumed a street mains pressure of 60 PSI.

For the Small Office prototype, the Statewide CASE Team sized the hot water supply piping per CPC Table 610.4. For the other prototypes, the Statewide CASE Team determined the permissible pressure drop per 100 feet of piping based on the street pressure, elevation of the highest fixture, and Total Developed Length (TDL) to the most remote fixture. For all calculations, the Statewide CASE Team used a design multiplier of 1.5 times the geometric length of the piping to account for fittings and appurtenances; this is a common method supported by plans review data. The multiplier varies in practice: some designers use 1.5, others use lower values such as 1.25.

The Statewide CASE Team sized each section of hot water piping based on the permissible pressure drop and the load on the pipe in GPM. The Statewide CASE Team ensured compliance with the maximum pipe velocity of 5 feet per second for hot water in accordance with the CPC. Finally, the Statewide CASE Team determined the size of the hot water return pipe based on a rough calculation of expected flow in the hot water recirculation piping. In general, the Statewide CASE Team understands that most designers do not perform a detailed analysis to determine the hot water return flow rate, however practice varies and the Statewide CASE Team used a rough estimate of heat loss to determine a design estimate for hot water recirculation flow rate. The Statewide CASE Team then sized the hot water return piping, targeting a design velocity of 2 to 4 feet per second in the hot water return piping. The design engineer the Statewide CASE Team worked with agreed with this methodology, however the plumbing contractor told us that 2 feet per second is the best value to design to for continuous recirculation.

F.2 Small Office System Design

Table 96 presents the fixture unit loading for the Small Office prototype building. The load of a fixture on the building mains piping is presented as Water Supply Fixture Units (WSFU), a statistical concept for cold water demand that is defined in the CPC. The load of a fixture on the first hot water supply pipe is presented as a Hot Water Supply Fixture Unit (HW WSFU) and is calculated in accordance with the CPC.

Table 96: Small Office Fixture Unit Analysis

Fixture Type	Fixture Count	WSFU per Fixture	HW WSFU per Fixture	Total HW WSFU	Total WSFU
Lavatories	2	1	0.75	6.375	24
Service Sink	1	3	2.25	6.375	24
Break Sink and Dish Washer	1	3.5	2.625	6.375	24

Fixture Type	Fixture Count	WSFU per Fixture	HW WSFU per Fixture	Total HW WSFU	Total WSFU
Tank Type Water Closets	3	2.5	0	6.375	24
Flush Tank Urinal	1	2	0	6.375	24
First Hose Bibb	1	2.5	0	6.375	24
Additional Hose Bibb	3	1	0	6.375	24
Drinking Faucet	1	0.5	0	6.375	24

Table 97 below shows the total pipe length for each pipe section in the recirculation system.

Table 97: Small Office Recirculation Pipe Sizing

	Pipe Size	Pipe Length (ft)
<u>New Construction and Existing Building</u>	3/4" HW	59
	1/2" HWR	10

Figure 5, below, illustrates the recirculation system design.

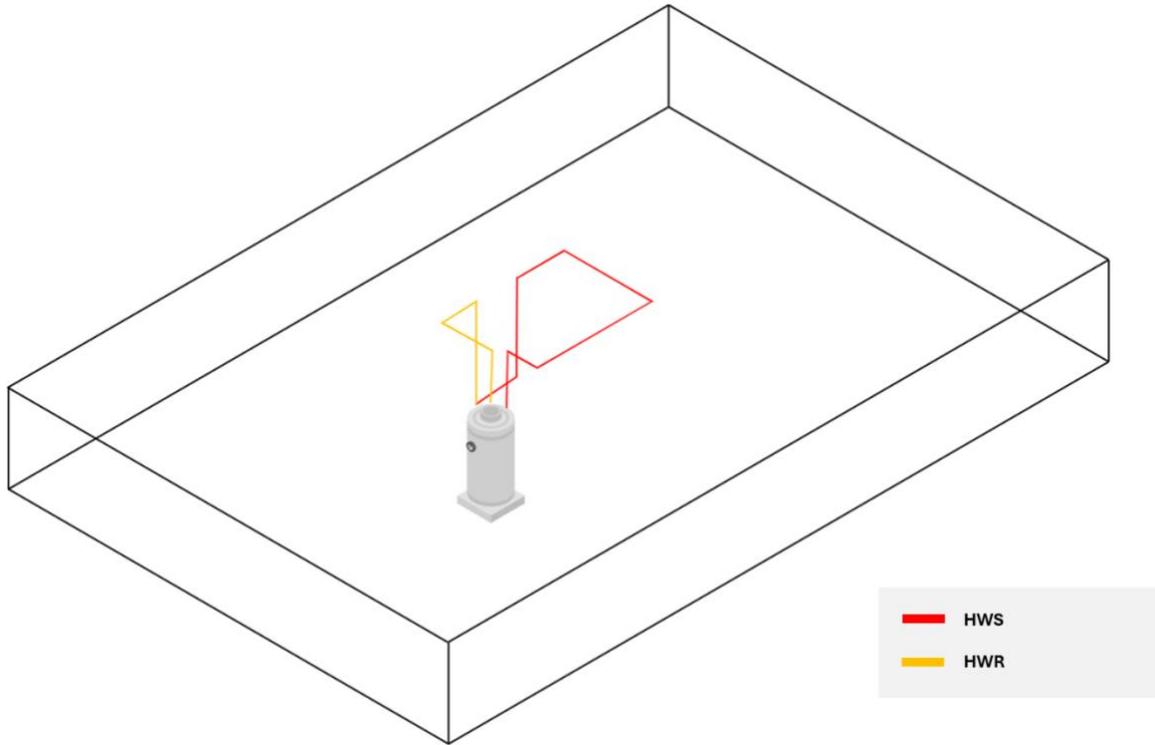


Figure 5: Small Office Prototype Recirculation System

F.3 Medium Office System Design

Table 98 presents the fixture unit loading for the Medium Office prototype building.

Table 98: Medium Office Fixture Unit Analysis

	Total Fixture Count	WSFU per Fixture	HW WSFU per Fixture	Total HW WSFU	Total WSFU
Lavatories	12	1	0.75	23.625	293
Service Sinks	3	3	2.25	23.625	293
Break Sink and Dish Washer	3	3.5	2.625	23.625	293
Flush Valve Water Closets	15	N/A	0	23.625	293
Flush Valve Urinal	3	N/A	0	23.625	293
Drinking Faucet	3	0.5	0	23.625	293

Figure 6, below, illustrates the recirculation system design.

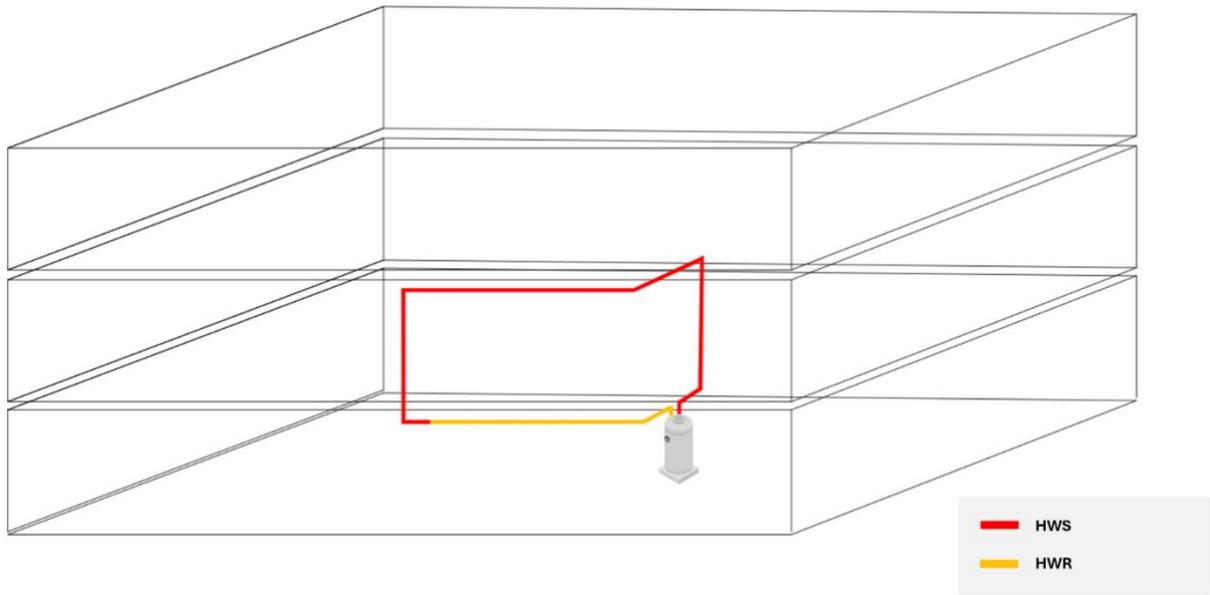


Figure 6: Medium Office Prototype Recirculation System

Table 99 below shows the total pipe length for each pipe section in the recirculation system.

Table 99: Medium Office Recirculation System Total Pipe Lengths by Pipe Size

	Pipe Size	Pipe Length (ft)
New Construction and Existing Building	1-1/4" HW	29
	1" HW	9
	3/4" HW	103
New Construction	1/2" HWR	15
Existing Building	3/4" HWR	15

F.4 Laboratory System Design

The Laboratory building prototype was based on a similar size building to the Medium Office prototype and modified to consider the existence of laboratory spaces. In addition to the fixtures specified in the Medium Office System Design described above, there is one hot water plant and recirculation system per floor serving the process fixtures. The Statewide CASE Team designed the distribution system on the basis that separate

instantaneous hot water systems serve the emergency eye wash and showers to reduce the size of the process load plant.

Table 100: Laboratory Fixture Unit Analysis

	Total Fixture Count per system	WSFU per Fixture	HW WSFU per Fixture	Total HW WSFU	Total WSFU
Laboratory Sink	13	1.5	1.125	19.5	14.625

Figure 7, below, illustrates the recirculation system design.

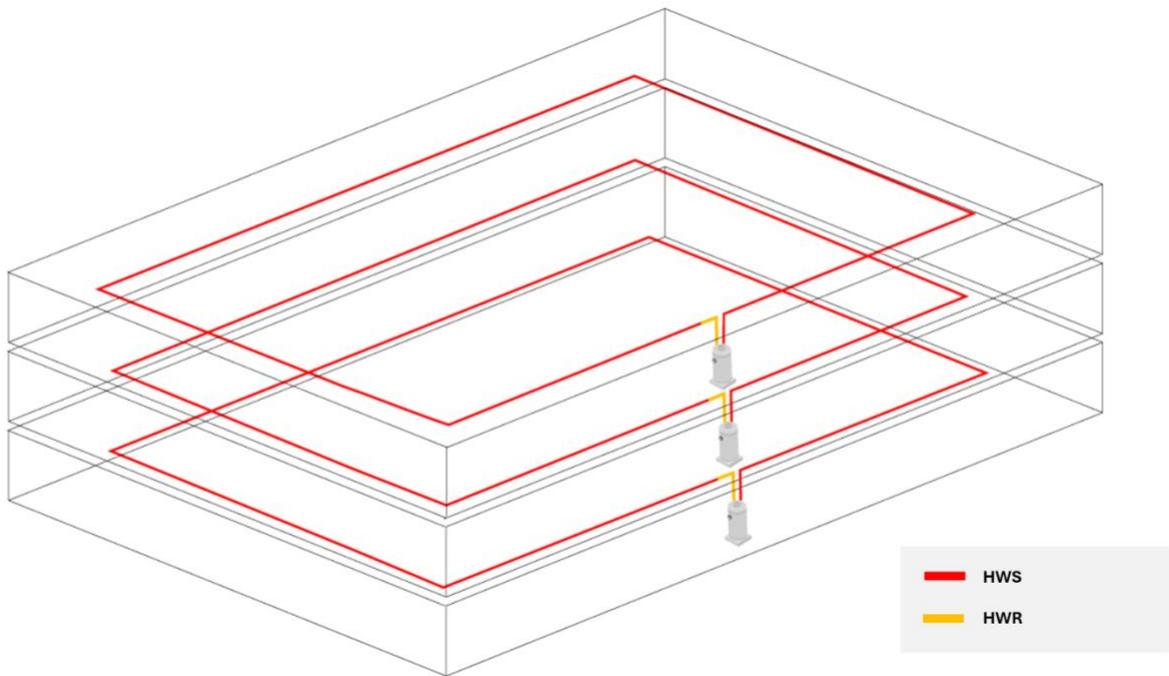


Figure 7: Medium Laboratory Prototype Process Recirculation System

Table 101 below shows the total pipe length for each pipe section in the recirculation system.

Table 101: Laboratory Industrial Hot Water Recirculation System Pipe Sizing

	Pipe Size	Pipe Length (ft)
New Construction and Existing Building	1" HW	143
	3/4" HW	227
	3/4" HWR	10

F.5 Small School System Design

Table 102 presents the fixture unit loading for the Small School prototype building.

Table 102: Small School Fixture Unit Analysis

	Total Fixture Count per system	WSFU per Fixture	HW WSFU per Fixture	Total HW WSFU	Total WSFU
Lavatories	15	1	0.75	54.4	397.3
Service Sink	2	3	2.25	54.4	397.3
Dish Sink and Dish Washer	1	1.5	1.125	54.4	397.3
Hand Sink	20	2	1.5	54.4	397.3
2-Comp Sink	1	3	2.25	54.4	397.3
3-Comp Sink	1	3	2.25	54.4	397.3
Door Type Commercial Dish Washer	1	3	3	54.4	397.3
Water Closets	20	265	0	54.4	397.3
Urinal	5	58	0	54.4	397.3
Drinking Faucet	5	0.5	0	54.4	397.3

Figure 8, below, illustrates the recirculation system design.

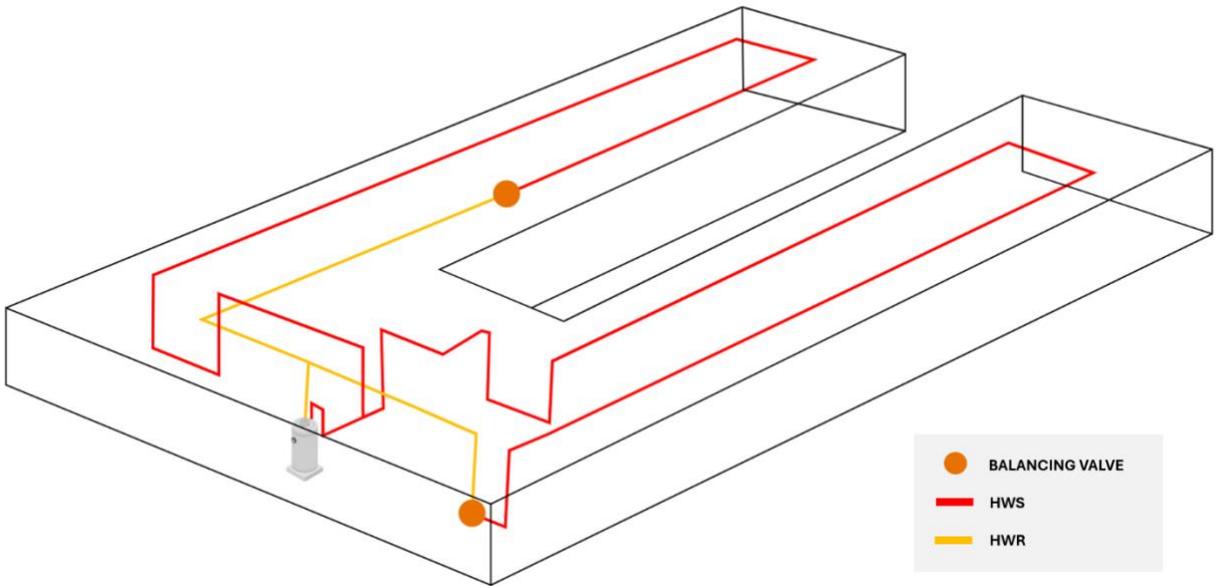


Figure 8: Small School Prototype Process Recirculation System

Table 103 below shows the total pipe length for each pipe section in the recirculation system.

Table 103: Small Schol Pipe Sizing

Pipe Section/Loop (NC & EB)	Pipe Size	Pipe Length (ft)
Plant and before split	2" HW	21
Loop 1	1-1/4" HW	89
	1" HW	144
	3/4" HW	80
	3/4" HWR	119
Loop 2	1-1/2" HW	27
	1-1/4" HW	206
	1" HW	80
	3/4" HW	114
	3/4" HWR	53
HWR after loops	3/4" HWR	6

F.6 Restaurant System Design

The Statewide CASE Team reviewed plans for two fast food restaurants to determine the prototype design for the Restaurant prototype. The Statewide CASE Team chose

this methodology because process drives the system design for restaurants, the prototype is defined specifically as a Fast Food Restaurant which allowed the team to focus on that segment for plans review, and because the Statewide CASE Team had access to multiple plan sets for fast food restaurants that are roughly the same size as the prototype. The Statewide CASE Team measured the hot water recirculation system piping length for each section of pipe for both restaurants, and used the average of the resulting heat loss for the Restaurant prototype hot water recirculation system heat loss. Table 104, below, shows the pipe sizes for the two restaurants.

Table 104: Restaurant Pipe Sizing

<u>Restaurant 1</u>	
Pipe Size	Pipe Length (ft)
1" HW	34
3/4" HW	96
1/2" HW	24
1/2" HWR	114
<u>Restaurant 2</u>	
Pipe Size	Pipe Length (ft)
1-1/4" HW	84
1" HW	4
3/4" HW	14
3/4" HWR	16

Appendix G: Pipe Heat Loss Analysis Methodology Details

Recirculation Heat Loss Spreadsheet Calculator

The Statewide CASE Team used a custom spreadsheet calculator to analyze the energy impacts of the service hot water (SHW) distribution measures. The spreadsheet calculator was developed by the 2022 Title 24 Statewide CASE Team based on a recirculation system model developed by a CEC funded research on multifamily DHW distribution systems (Zhang 2013), pipe heat loss calculation methods defined in the current Title 24 ACM Reference Manual (developed during the 2013 Title 24 Code Cycle), and a 2021 CEC funded research on residential DHW distribution systems (Klein 2021). The Statewide CASE Team made necessary improvements to the spreadsheet calculator to account for nonresidential SWH systems to support energy impact analysis of the proposed 2025 nonresidential code changes. The spreadsheet calculator includes features to handle detailed recirculation designs, insulation conditions, and recirculation flow controls which are not available in the current CBECC software. This spreadsheet calculator enables the Statewide CASE Team to assess the energy impact of energy efficiency measures that have not been incorporated into Title 24 ACM Reference Manual and CBECC. The overall modeling approach, features, and related assumptions of the spreadsheet calculator are described in following sections.

Recirculation Piping Network Configurations

Recirculation-based SHW distribution systems in nonresidential buildings include complicated piping configurations, as shown by recirculation system plumbing designs for prototype buildings in Appendix F. The existing Title 24 ACM Reference Manual and CBECC software use six pipe sections connected in series to model recirculation systems in multifamily buildings. The six-pipe section recirculation model was designed as a practical recirculation performance model to simplify the compliance process by not requiring builders to specify detailed plumbing configurations in the compliance model. However, this modeling approach is not adequate to model complicated recirculation designs in real buildings. The existing Title 24 ACM Reference Manual and CBECC software do not include any modeling methods for recirculation systems in nonresidential buildings. The recirculation heat loss spreadsheet calculator uses detailed and full recirculation piping configurations to assess energy impacts of realistic recirculation designs and, therefore, enables accurate assessment of energy impacts of proposed code change measures.

In the recirculation heat loss spreadsheet calculator, a recirculation system is represented as a collection of pipe sections connected to each other according to actual

designs. The spreadsheet calculator does not limit the number of pipe sections or the flow pathways; both serial and parallel flow paths (e.g., those through vertical risers) are allowed. The Statewide CASE Team developed detailed pipe section configurations to reflect full recirculation piping designs of the five prototype nonresidential buildings. As shown by recirculation system designs presented in Appendix F.

In the spreadsheet calculator, pipe sections and major pipe connectors are identified by unique indices. Specifications of each pipe section include pipe size (diameter), length, insulation thickness, index of the beginning pipe connector, and index of the ending pipe connector. The spreadsheet calculator uses specifications of the beginning and ending pipe connectors of all pipe sections to determine the recirculation network topology. The calculator determines flow rate for each pipe section based on the recirculation network topology, recirculation pump operation status, and hot water draw schedules.

Heat Loss Calculation Steps

For each time step, the calculator starts pipe section analysis from the first pipe section - the supply pipe connected to the central water heater - to obtain pipe heat loss, average output water temperature, and average pipe temperature at the end of the time step. The average output water temperature is then used as the input water temperature for the downstream pipe section(s). For pipe sections with multiple upstream pipe sections, the sum of water flows and average output water temperature of upstream pipe sections the calculator uses as the input condition. A pipe section analysis is performed for each pipe section following recirculation flow paths. Total recirculation system pipe heat loss for each time step is the sum of pipe heat loss from all pipe sections.

According to the 2022 ACM Reference Manual, recirculation pipes can have two modes of heat loss: pipe heat loss with hot water flow in the pipe and heat loss without flow in the pipe. The latter is also called cooldown mode, and it takes place when the recirculation pump is turned off by a control and there is no hot water draw by users. When there is flow in the pipe section, due to recirculation operation and/or hot water draws, pipe heat loss is calculated according to the ACM Reference Manual for pipe heat loss with flows. If there is no flow in the pipe section, pipe heat loss is calculated according to the ACM Reference Manual for pipe cooldown process. The Statewide CASE Team neglected Cooldown mode for the energy impact analysis because for each measure because the base case and proposed case hot water systems that the Statewide CASE Team analyzed would only experience one cooldown event per day, and removing Cooldown mode is a reasonable and conservative simplification of the energy analysis.

Pipe Heat Loss Calculation Assumptions

The calculator determines recirculation pipe heat loss by recirculation pipe designs, pipe ambient temperature, hot water flow rate and pipe insulation conditions. Recirculation pipe design parameters, i.e. pipe diameter and length of each pipe section, are used to set up the detailed recirculation model.

Pipe Ambient Temperatures

Building indoor temperatures represent ambient temperatures of the recirculation systems because most or all recirculation pipes are located in indoor spaces. The Statewide CASE Team assumed that the indoor space temperature remained at 68°F during periods when corresponding nonresidential buildings were in operation and the recirculation pump was on. Because of this assumption of constant ambient temperature, the recirculation pipe heat loss is independent of CZ.

Hot Water Flow Rate

The model determined hot water flow rates in pipe sections based on overall draw flow rate, overall reticulation flow rate, distribution pipe network configurations, and a default assumption that risers/branches are balanced and have equal amount of recirculation flows.

For hot water draw flow rate, the Statewide CASE Team developed building-level hot water draw schedules based on the 2025 Nonresidential and Multifamily ACM Reference Manual and CBECC. These Title 24 sources specify different hot water draw schedules for weekday, Saturday, and Sunday. However, no information is provided regarding locations of hot water draws in the recirculation system. There is also a lack of industry guidelines and field studies on fixture-level hot water draw patterns in nonresidential buildings. For energy impact analysis, The Statewide CASE Team applied a constant draw at the mid-point of the recirculation supply section. Therefore, only the first half of recirculation supply pipes experience hot water draw flows. The second half of recirculation supply pipes and all recirculation return pipes do not carry any hot water draw flows. For each building type, the Statewide CASE Team calculated draw flow rates for weekday, Saturday and Sunday by averaging the corresponding hourly hot water draw flows for hours when the recirculation pump was scheduled to be on, according to specifications provided in the 2025 Nonresidential and Multifamily ACM Reference Manual and CBECC.

Recirculation flows through all pipe sections

The Statewide CASE Team determined standard practice, recirculation flow rates based on system hydraulics and anticipated circulator pump selection informed by a plans review and product review. Standard practice return temperature is calculated by the model based on the input flow rate. For the pump control measure case, the Statewide

CASE Team originally assumed that the Laboratory process systems, Restaurant, and Small Office would have a target return temperature of 130 °F based on the CBECC supply temperature of 135 °F. The Statewide CASE Team assumed that the Medium Office, Laboratory office system, and Small School would have a target return temperature of 125 °F based on the CBECC supply temperature of 135 °F. *The Statewide CASE Team plans to update all prototypes to have 125 °F return temperature depending on stakeholder feedback.* For cases where the Statewide CASE Team specifies the target return temperature, the Statewide CASE Team adjusts the modeled recirculation flow to achieve the target return temperature.

Pipe Insulation Conditions

For the 2022 multifamily DHW distribution CASE study, the Statewide CASE Team investigated distribution pipe insulation conditions in multifamily buildings and found that, on average, approximately 38.5% of the pipes were not insulated. The Statewide CASE Team assumed that the same level of uninsulated pipes existed in nonresidential buildings. For insulated pipes, the recirculation pipe heat loss calculation method defined in the 2025 Title 24 ACM Reference Manual includes an adjustment factor of 2.0 for recirculation systems in multifamily buildings. This adjustment factor, based on a prior CEC field study (Zhang 2013), reflects imperfect pipe insulation for insulated pipes and doubles the pipe heat loss based on perfect pipe insulation. The Statewide CASE Team used a 2.0 adjustment factor for the nonresidential analysis.