Codes and Standards Enhancement (CASE) Initiative

2028 California Energy Code

# Nonresidential Water Heating

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# Executive Summary

This proposal presents updates to nonresidential service hot water requirements for consideration in the 2028 California Energy Code (Title 24, Part 6 or Energy Code). The Statewide Codes and Standards Enhancement (CASE) Team developed the proposal to improve installed system performance, reduce service hot water energy use, strengthen compliance through targeted form updates and self-attestation, and support California’s long-term energy efficiency and greenhouse gas (GHG) reduction goals. The CASE Report evaluates three measures applicable to nonresidential buildings:

1. Circulator pump controls,
2. Return to Primary configuration for split heat pump water heater systems, and
3. Requirements for unitary heat pump / electric resistance hybrid heat pump water heaters (HP/ER HPWHs).

The Statewide CASE Team developed these proposed measures for submission to the California Energy Commission (CEC) for potential inclusion in the 2028 update to Title 24, Part 6. To be adopted, each measure must be technically feasible and cost effective. The proposed measures focus on improving service hot water recirculation pump controls, establishing a Return to Primary pathway for split heat pump water heater systems with recirculation, and ensuring unitary heat pump/electric resistance hybrid water heaters are designed and installed to minimize electric resistance operation.

Stakeholder feedback informed the proposed code changes, associated analyses and assumptions, and compliance and enforcement approach. The Statewide CASE Team worked with manufacturers, designers, water heating subject matter experts, equipment distributors, companies with nonresidential water heater specification experience, professionals with field performance evaluation experience, and a plumbing and HVAC contractor for cost information. The team presented the proposed measures during two state utility meetings on October 23, 2025 and March 10, 2026, and incorporated feedback into code language, definitions, documentation requirements, cost estimates, and measure scope.

The Statewide CASE Team recognizes ongoing systemic inequities in environmental and social justice (ESJ) communities and is developing code change proposals with careful consideration of potential unintended impacts. An initial assessment indicates that the proposed measures would have neutral to positive impacts, depending on the specific measure.

## Circulator Pump Controls

### Proposed Code Change

This proposed code change would add a prescriptive requirement for additional controls for circulator pumps in service hot water systems in nonresidential buildings. Acceptable control types would vary by hot water loop system type and whether the system has risers, and would include internal or external controls that reduce energy use at the pump and/or water heater.

The proposed measure would apply to new construction, alterations, and additions, and would apply only to recirculation systems with dedicated hot water return piping. Proposed continuous and non-continuous pump control methods include pressure-based variable speed control with thermal balancing valves, constant return temperature control, demand flow-based control, and digital timeclock.

### Benefits of Proposed Change

The proposed change would reduce energy use from both the water heater and circulator pump by reducing recirculation system pipe heat losses and tank destratification. Reduced tank destratification would increase the viability and efficiency of heat pump water heaters.

Studies cited indicate that advanced circulator pump controls can substantially reduce pump runtime and improve water heater energy performance in nonresidential applications. The proposed controls are typically easier to set up and more persistent than basic controls.

### Compliance and Enforcement

Compliance would rely on updates to existing Nonresidential Certificate of Compliance (NRCC) and Nonresidential Certificate of Installation (NRCI) forms and would not introduce any new forms, compliance pathways, or documentation systems. The measure would add minor documentation and installation responsibilities, primarily requiring designers to specify pumps with required controls and contractors to install those controls. Designers and contractors would certify compliance through the existing declaration process, with building departments reviewing updated fields during plan check and inspection.

The proposal does not introduce diagnostic testing, field verification, or performance testing requirements, and would not require third-party verification.

## Market Assessment

The market includes established manufacturers and distributors supplying digitally controlled variable-speed pumps. These products are more commonly used in space heating systems and have seen less application in service hot water systems.

Manufacturers already support the control strategies and distributors supply the necessary hardware. The Statewide CASE Team does not anticipate any adverse effects on business competitiveness and the measure would not create new or eliminate existing jobs in California's economy. This was a result of stakeholder feedback and market assessments.

## Cost Effectiveness

The proposed code change is cost effective across all applicable California climate zones. Benefit-to-cost ratios[1] range from 1.03 to 10.5, depending on climate zone and building type.

The three pump sizes the Statewide CASE Team used in the analysis were 1/12, 1/6 and 1/2 horsepower. The incremental cost increases for these pumps were $1,026, $820, and $885 respectively. The Statewide Case Team obtained these results in consultation with a plumbing contractor in February 2026.

## First-Year Statewide Impacts

**Table 1: Summary of Statewide Impacts — Circulator Pump Controls**

| Metric[a] | Total Statewide Impacts |
|---|---|
| **Annual Electricity Savings (GWh)** | 6.8 |
| **Peak Demand Reduction (MW)** | 0.7 |
| **Annual Natural Gas Savings (Million Therms)** | 0.04 |
| **Annual Source Energy Savings (Million kBtu)** | 12.6 |
| **30-Year Long-term System Cost Savings (Million 2029 PV$)** | $63.15 |
| **Annual Avoided GHG (Metric Tons CO2e/yr)** | 785.13 |

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

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

# Return to Primary

## Proposed Code Change

This proposed measure would create a prescriptive pathway requiring Return to Primary configuration for split heat pump water heater systems with recirculation in nonresidential buildings. The proposal would also include an alternative pathway for products on the Northwest Energy Efficiency Alliance Tier 3 qualified product list, including standardized configurations and manufacturer requirements.

The proposed measure would update Joint Appendix JA14 — Qualification Requirements for Hot Water Systems — to include new requirements for design, installation, equipment, and control start-up. This measure would not require installation of heat pump water heaters.

## Benefits of Proposed Change

Return to Primary configuration would eliminate electric resistance in Temperature Maintenance Heater in Series (TMHS) configuration, reducing electricity capacity requirements, peak demand, and grid impact while improving grid reliability. Return to Primary configuration would generally reduce installation costs, space requirements, and installation/start-up complexity compared with base TMHS systems.

Return to Primary and alternative prescriptive pathways both have a higher system coefficient of performance than baseline TMHS systems, which would achieve operational savings. Additionally, proposed start-up requirements would ensure long-term savings for central HPWH systems.

## Compliance and Enforcement

Key compliance considerations include that the market is less familiar with heat pump water heaters generally, and that Return to Primary configuration is currently less common than TMHS. The Statewide CASE Team expects a small, time-limited impact on designers, installers, and building departments.

The Statewide CASE Team recommends training and best-practice guide development to support designers, installers, and building departments as they learn the Return to Primary configuration. The measure would not require third-party verification.

## Market Assessment

The current market share of Return to Primary systems is small but growing. There is widespread awareness among the portion of the market familiar with heat pump water heaters, as indicated by inclusion of Return to Primary configuration in the Northeast Energy Efficiency Alliance (NEEA) Qualified Product List.

The Statewide CASE Team reviewed 59 heat pump water heater products from 15 manufacturers that can work in central applications from the NEEA Qualified Product List. Seven of the 15 manufacturers have products that can work in Return to Primary configuration, and five explicitly advocated Return to Primary configuration in their product brochures or installation manuals.

The proposed change is expected to have modest employment impacts in California. The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy.

## Cost Effectiveness

The proposed code change is cost effective across all applicable California climate zones. Benefit-to-cost ratios range from 1.34 to infinite, depending on climate zone and prototypical building type.

The cost for Return to Primary is typically, but not always, lower than TMHS because the two configurations handle temperature maintenance load differently. In a Return to Primary setup, the primary heat pump manages this load whereas in a TMHS system, the swing tank takes over. Often, the recirculation load is low enough that the measure case and base cases share the same heat pump selection, however, in certain instances, the measure case requires an additional heat pump to meet the load.

## First-Year Statewide Impacts

**Table 2: Summary of Statewide Impacts — Return to Primary**

| Metric[a] | Total Statewide Impacts |
|---|---|
| **Annual Electricity Savings (GWh)** | 15.25 |
| **Peak Demand Reduction (MW)** | 1.74 |
| **Annual Natural Gas Savings (Million Therms)** | 0.00 |
| **Annual Source Energy Savings (Million kBtu)** | 25.96 |
| **30-Year Long-term System Cost Savings (Million 2029 PV$)** | $179.08 |
| **Annual Avoided GHG (Metric Tons CO2e/yr)** | 1,373.64 |

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

# Requirements for Unitary HP/ER Hybrid Heaters

## Proposed Code Change

This proposal would add mandatory requirements to ensure that commercial unitary heat pump / electric resistance hybrid water heaters (HP/ER HPWHs) are specified and installed in a way that minimizes electric resistance use. It would apply to new construction, alterations, and additions in nonresidential buildings.

The measure would require installation using manufacturer design and installation requirements for ventilation, set minimum compressor cutoff temperatures for heat pump-only and hybrid operating modes, require sizing based on expected operational conditions, and require multiple water heaters that are configured in a parallel arrangement to be installed in a way that balances loads. If outside air is used as the heat source, the equipment would need to be capable of operating in heat pump-only mode under the Heating Design Day 0.6 percent dry bulb temperature.

## Benefits of Proposed Change

The proposed change would decrease energy usage and costs for unitary HP/ER HPWHs in nonresidential buildings by helping ensure the heat pump is the primary means of heating water. User satisfaction could improve by reducing the chance of hot water runouts and reducing the risk of unwanted side effects such as overly cooled mechanical spaces and related condensation issues.

## Compliance and Enforcement

Designers would comply via self-attestation during design, including confirming space availability, proper sizing, the availability of makeup air where needed, compressor cutoff requirements, and plumbing configuration. Plumbing designers would conduct this self-attestation for new construction, additions, and alterations. The proposed measure would build upon commonly used sizing principles presented by manufacturers and industry groups such as ASHRAE by incorporating derating of the water heater's output to account for issues such as defrost cycles, nominal voltage in the building, ambient temperature, and control algorithms.

During installation, plumbers would attest that water heaters are configured properly and set to the same setpoint temperature if the water heating system consists of multiple unitary heat pump water heaters arranged in parallel. No changes to third-party verification or updates to compliance software are proposed. These proposed requirements would build upon guidance available to installers through manufacturers and industry groups.

## Market Assessment

South Coast Air Quality Management District (SCAQMD) and Bay Area Air Quality Management District (BAAQMD) rulings are driving adoption of electric water heaters in nonresidential applications in many parts of the state. For buildings with large water heating loads the operational cost savings associated with heat pump technology compared with electric resistance water heaters suggest that many of these electric water heaters will be HP/ER HPWHs.

Current market share for these units is low but growing with incentives encouraging adoption. The Statewide CASE Team's research indicates that all units currently on the market meet the proposed cutoff temperatures and that manufacturers currently provide necessary information on air volume. The Statewide CASE Team discussed the proposal with manufacturers and practitioners and assessed findings from field studies that implement these water heaters to aid in concluding that the proposed requirements are technically feasible and will address shortcomings in current practice.

## Cost Effectiveness

The proposed code change is cost effective across all applicable California climate zones. Benefit-to-cost ratios range from 2.11 to 6.47, depending on climate zone.

## First-Year Statewide Impacts

All savings would arise from electricity savings because the proposed measure is specific to electric water heating systems.

**Table 3: Summary of Statewide Impacts — Requirements for Unitary HP/ER Hybrid Heaters**

| Metric[a] | Total Statewide Impacts |
|---|---|
| **Annual Electricity Savings (GWh)** | 8.09 |
| **Peak Demand Reduction (MW)** | 0.77 |
| **Annual Natural Gas Savings (Million Therms)** | 0.00 |
| **Annual Source Energy Savings (Million kBtu)** | 10.44 |
| **30-Year Long-term System Cost Savings (Million 2029 PV$)** | $86.27 |
| **Annual Avoided GHG (Metric Tons CO2e/yr)** | 552.4 |

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

# Acronyms

Table 4 presents a list of acronyms used in this report. Title24stakeholders.com also maintains a glossary of terms.

**Table 4: List of Acronyms**

| Acronym | Definition |
|---|---|
| **ACM** | Alternative Calculation Method |
| **ASHRAE** | American Society of Heating, Refrigeration, and Air-Conditioning Engineers |
| **BAAQMD** | Bay Area Air Quality Management District |
| **BCR** | Benefit-to-cost Ratio |
| **Btu** | British Thermal Units |
| **CALGreen** | California Green Building Standards Code |
| **CASE** | Codes and Standards Enhancement |
| **CBECC** | California Building Energy Code Compliance Software |
| **CEC** | California Energy Commission |
| **CHPWH** | Central Heat Pump Water Heaters |
| **$CO_2$** | Carbon Dioxide |
| **$CO_2e$** | Carbon Dioxide Equivalent |
| **CPUC** | California Public Utilities Commission |
| **CSE** | California Simulation Engine |
| **CZ** | Climate Zone |
| **DAC** | Disadvantaged Community |
| **DOE** | Department of Energy |
| **DOSH** | Division of Occupational Safety and Health |
| **ECC** | Energy Code Compliance |
| **ECM** | Electronically Commutated Motors |
| **ER** | Electric Resistance |
| **ESJ** | Environmental and Social Justice |
| **GHG** | Greenhouse Gas |
| **GWh** | Gigawatt-Hour |
| **HP** | Heat Pump |
| **HPWH** | Heat Pump Water Heater |
| **HVAC** | Heating, Ventilation, and Air Conditioning |
| **HP/ER HPWH** | Heat Pump / Electric Resistance Hybrid Water Heater |
| **IECC** | International Energy Conservation Code |
| **IOU** | Investor-Owned Utility |
| **kW** | Kilowatt |

| Acronym | Definition |
|---|---|
| **kWh** | Kilowatt-Hour |
| **kWh/year** | Kilowatt-Hour Per Year |
| **Lbs/yr** | Pounds Per Year |
| **LSC** | Long-term System Cost |
| **NEEA** | Northwest Energy Efficiency Alliance |
| **NPDI** | Net Private Domestic Investment |
| **NRCC** | Nonresidential Certificate of Compliance |
| **NRCI** | Nonresidential Certificate of Installation |
| **NREL** | National Renewable Energy Laboratory |
| **PADS** | Product Assessment Datasheet |
| **PG&E** | Pacific Gas & Electric |
| **PID** | Proportional Integral Derivative |
| **PV** | Present Value |
| **QPL** | Qualified Product List |
| **SCAQMD** | South Coast Air Quality Management District |
| **SHW** | Service Hot Water |
| **TMHS** | Temperature Maintenance Heater in Series |
| **UL** | Underwriters Laboratories |
| **W** | Watt |

# 1. Introduction

## 1.1 Report Context

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

## 1.2 Proposal Sponsors

Three California Investor-Owned Utilities (IOUs)—Pacific Gas & Electric Company, San Diego Gas & Electric, and Southern California Edison jointly sponsored this effort. Where the term "Statewide CASE Team" is used in this report, it refers to the authors and State Building Codes Advocacy activities supported through the Codes and Standards program.

## 1.3 Stakeholder Engagement to Inform Proposal

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with many industry stakeholders. The proposal incorporates feedback received during 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.

## 1.4 Addressing Energy Equity and Environmental Justice

The Statewide CASE Team recognizes, acknowledges, and accounts for a history of prejudice and inequality in environmental and social justice (ESJ) communities.[2]

These issues persist today. To minimize the risk of perpetuating inequity, code change proposals are being developed with intentional consideration of the unintended consequences on ESJ communities.

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

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

[2] 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 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).

# 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 additional 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. Specifically, this proposed change would only apply to recirculation systems with dedicated hot water return piping.

Table 5 summarizes the scope of the proposed code change.

**Table 5: Scope of Proposed Code Change**

A ☑ indicates the proposed code change is relevant.

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

| Application Climate Zones (CZs) | Energy Code Sections | Compliance Forms | Sections of ACM Reference Manuals |
|---|---|---|---|
| CZs 1-16 | • Part 6, Sections:<br>• 501.3.4 [140.5(d)]<br>• 501.5.2.2.1 [141.0(b)2.N] | NRCC-PLB & NRCI-PLB | Section 5.9.3 Recirculation Systems |

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

### 2.1.2 Benefits of Proposed Change

The proposed code change would reduce 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 have evaluated a combined measure that included advanced pump controls and electronically commutated motors (ECM).

Based on a Northwest Energy Efficiency Alliance (NEEA) study that 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, & 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 was conducted on four water heating systems (Conservation Applied Research and Development (CARD) 2018). The 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 that constant return temperature controls resulted in 41 percent daily pump energy savings and roughly 20 percent savings from reduced distribution losses. The study also showed that proportional pressure controls achieved pump energy savings between 19–91 percent and 17–34 percent savings from reduced 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 a plans review, the Statewide CASE Team determined that an analog time clock 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. The following sections define basic and advanced controls.

#### *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, time clocks, 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. They include electronic options such as integrated variable speed pump controls designed in circulator pumps for SWH systems, constant return temperature for one loop distribution systems, and 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 like a lockout option, ability to retain control settings during power outages, and remote monitoring and alerts capability via Wi-Fi.

### 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*

**501.3 [SECTION 140.5] – PRESCRIPTIVE REQUIREMENTS (Newly Constructed)**

501.3.4 [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.

**501.5.2.2 [Section 141.0]: Prescriptive requirements (Alterations).**

501.5.2.2.1 [Section 141.0(b)2.N.]:The code language for alterations in section 501.5.2.2.1 [141.0(b)2.N.] need to be edited to add a reference to the proposed code language in 501.3.4 [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 advanced 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 (Nonresidential Certificate of Compliance – Plumbing) would add a statement and a single check box to Table H.

Form NRCI-PLB (Nonresidential Certificate of Installation – Plumbing) would add a single line item to Table F.

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 advanced 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 relevant 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 and NRCI forms.[3] Designers and contractors update compliance forms and will streamline the building department inspection process.

The proposal introduces a minor increase in documentation and installation responsibilities for designers and contractors because each must confirm a new compliance element on the existing forms, and contractors must install the controls. 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 and applying the new design requirements and documenting those on the updated NRCC-PLB. For contractors, the added burden is confirming the installed system meets the updated requirement on the NRCI-PLB. For building departments, the measure introduces only a minor change to current practice by adding review of the updated form entries during plan checking, reviewing the pump specifications in the equipment schedule, and reviewing the pump controls narrative in the control notes, to make sure that the pump controls meet the proposed requirements. The review process, structure, and format remain the same, resulting in a minimal increase in effort.

[3] Nonresidential (NR) and Low-Rise Multifamily Residential (LM) Certificate of Compliance (CC) and Certificate of Installation (CI) forms

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 6 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 6: Impacts on Market Actors and Suggested Training and Education Opportunities**

| Market Actor | Impact(s) | Suggested Outreach and Education |
|---|---|---|
| **Owner/Developer** [a] | None. | None. |
| **Design Professional** [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 Department** [d] | Reviewing plans and compliance forms. | Education on how to review proposed pump controls in design plans. |
| **Verification Tester** [e] | N/A. | N/A. |
| **Manufacturers and Distributors** | Increased demand for pumps focused on applications in service hot water systems. | Educate manufacturers on the importance of designing pump controls focused on applications in service hot water systems. |

a. Owner/Developer is funding the project and is the primary decision maker.
b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California Building Code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on designers, construction team/installers, building departments, and manufacturer and distributors since these market actors are expected to experience the most direct impacts from the requirement to add circulator pump controls that meet the criteria proposed in the code language. 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 7 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

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

**Table 7: 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 de-rating factor if the proposed control does not meet the prescriptive requirements. The proposed standard design piping heat loss methodology is described in Appendix H; the de-rating factor would be 3 percent. 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.

Plan review function would consist of reviewing NRCC-PLB and NRCI-PLB and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

## 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 the equipment availability of specified products. The SHW pump market includes two dominant product types: pumps with fixed discrete speeds and advanced controlled variable speed pumps using pressure, temperature, or time-based control logic. The recent Department of Energy (DOE) ruling requires contractors to install ECM pumps starting in 2028 (DOE, 2024). 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 the 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 advanced 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 design systems and controls to operate pumps continuously in critical facilities, with time clocks or manual switches used for control in other applications. 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 advanced 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 circulator pumps with advanced controls 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 their solutions. These challenges include design familiarity, control configuration uncertainty, distribution practices, and concern over temperature stability. Designers often associate variable-speed pumps with hydronic heating controls rather than with SHW. The second concern is that installers may lack familiarity with selecting and configuring control modes during the system setup. The distribution practices concerns are due to some wholesalers stocking circulator pumps with advanced controls 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

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

The Statewide CASE Team does expect impacts on cost from the proposed code change. However, the incremental upfront costs are expected to be modest and outweighed by the benefits. Specifically, operational energy costs would decrease, which would result in lower utility bills for ESJ communities.

The proposed service hot water recirculation pump controls measure is not expected to create significant ESJ impacts because it does not materially affect indoor air quality, thermal conditions, or building envelope performance. Any health and resilience effects would be indirect and limited to small upstream emissions reductions from reduced energy use. Incremental first costs are expected to be low relative to overall system costs, and operational savings are modest but generally beneficial, resulting in no disproportionate cost burden. Comfort impacts are negligible since the measure only affects hot water distribution timing rather than occupied space conditions.

The Statewide CASE Team does not expect any impact on the health and safety of ESJ communities, or on their disaster preparedness. The comfort of ESJ communities is unlikely to be impacted by the proposed code changes.

### 2.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 8 and Table 9 outline the statewide implications for these job categories. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

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

**Table 8: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| Direct Effects (Additional spending by Commercial Builders) | 11.6 | $910,570 | $1,209,264 | $2,370,568 |
| Indirect Effect (Additional spending by firms supporting Commercial Builders) | 4.7 | $385,119 | $642,586 | $1,142,932 |
| **Total Economic Impacts** | **16.3** | **$1,295,690** | **$1,851,851** | **$3,513,501** |

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[4]

**Table 9: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| Direct Effects (Additional spending by building inspectors) | 1.2 | $132,206 | $156,781 | $190,520 |
| Indirect Effect (Additional spending by firms supporting building inspectors) | 0.1 | $12,244 | $19,070 | $33,213 |
| **Total Economic Impacts** | **1.3** | **$144,450** | **$175,851** | **$223,733** |

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

The proposed change represents a modest adjustment, which is not expected to excessively burden or competitively disadvantage California businesses, nor is it expected to lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[5]

Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have an advantageous or an adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity

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

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

associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling resulted in an estimated $9,121,578 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.[6]

The Statewide CASE Team analyzed national data on corporate profits and capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[7] As Table 31 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

**Table 10: Net Domestic Private Investment and Corporate Profits, U.S.**

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates

[6] It was assumed that 26 percent of proprietor income is to be allocated to net business investment; see Table 15.

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

the proposed code change would result in a $2,141,190 increase in net private investment by California businesses.

### 2.3.5 Economic and Fiscal Impacts

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

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

#### *2.3.5.1 Effects on the State General Fund, State Special Funds, and Local Governments*

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

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

**Cost to Local Governments:** All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 2.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

#### *2.3.5.2 Mandates on Local Agencies or School Districts*

There are no relevant mandates to local agencies or school districts because the requirements would be specified at the statewide level through Title 24, Part 6.

#### *2.3.5.3 Costs to Local Agencies or School Districts*

This measure would not cost local agencies or school districts any additional cost over that of the standard construction incremental costs mentioned in Section 2.4.3

#### *2.3.5.4 Costs or Savings to Any State Agency*

There are no costs or savings to any state agencies because they would not be involved in the enforcement of this measure.

#### *2.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies*

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

#### *2.3.5.6 Costs or Savings in Federal Funding to the State*

There are no costs or savings to federal funding to the state. The proposed measure is a relatively small cost which the market would bear. The state would not require federal funding to implement the proposed measure.

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

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

### 2.4.2 Energy and Energy Cost Savings Results

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 11 through Table 13. 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 0.01 – 2.92 kilowatt-hour (kWh) per square foot, depending on climate zone, and the gas savings range from 0.00 – 3.50 kBtu per square foot, depending on the climate zone. The peak demand reduction ranges from 0.00 – 5.69 kilowatt (kW) per square foot, depending on climate zone.

Table 14 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 11: 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 | 0.00 | 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 |
| 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 |
| Large Office | 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 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 | 0.00 | 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 |
| Medium Office | 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 |
| 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 | 0.04 | 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 |
| 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 | 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 |
| Small Office | 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 |
| Small School | 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 |
| Strip Mall | 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 |
| Controlled-environment Horticulture | 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 |
| Laboratory | 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 |
| Refrigerated Warehouse | 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 |
| Vehicle Service | 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 |
| Manufacturing | 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 |

**Table 12: 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 | 0.00 | 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 |
| 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 |
| Large Office | 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 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 | 0.00 | 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 |
| Medium Office | 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 |
| 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 | 0.04 | 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 |
| 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 | 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 |
| Small Office | 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 |
| Small School | 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 |
| Strip Mall | 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 |
| Controlled-environment Horticulture | 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 |
| Laboratory | 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 |
| Refrigerated Warehouse | 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 |
| Vehicle Service | 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 |
| Manufacturing | 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 13: 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 | 0.01 | 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 | (0.02) | (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 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 | 0.02 | 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 | 0.03 | 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 Office | 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 |
| Medium Retail | 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 |
| Mixed-use Retail | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 |
| Non-refrigerated Warehouse | 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 |
| Restaurant | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) | (0.42) |
| Small Office | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 |
| Small School | 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 |
| Strip Mall | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 |
| Controlled-environment Horticulture | 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 |
| Laboratory | 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 |
| Refrigerated Warehouse | 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 |
| Vehicle Service | 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 |
| Manufacturing | 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 14: 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** | 0.05 | 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 |
| **Grocery** | 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 |
| **Large 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 |
| **Large Retail** | 0.15 | 0.15 | 0.14 | 0.14 | 0.15 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | 0.15 |
| **Large School** | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| **Medium Office** | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 |
| **Medium Retail** | 1.42 | 1.42 | 1.42 | 1.41 | 1.43 | 1.40 | 1.42 | 1.44 | 1.43 | 1.44 | 1.42 | 1.43 | 1.42 | 1.42 | 1.40 | 1.45 |
| **Mixed-use Retail** | 3.67 | 3.66 | 3.65 | 3.64 | 3.69 | 3.61 | 3.66 | 3.70 | 3.69 | 3.72 | 3.67 | 3.67 | 3.65 | 3.65 | 3.61 | 3.74 |
| **Non-refrigerated Warehouse** | 0.66 | 0.66 | 0.66 | 0.65 | 0.66 | 0.65 | 0.66 | 0.67 | 0.67 | 0.67 | 0.66 | 0.66 | 0.66 | 0.66 | 0.65 | 0.67 |
| **Restaurant** | 3.97 | 3.97 | 3.98 | 3.97 | 3.96 | 3.99 | 3.96 | 3.98 | 3.98 | 3.98 | 3.97 | 3.97 | 3.97 | 3.99 | 3.98 | 3.98 |
| **Small Office** | 6.25 | 6.24 | 6.21 | 6.19 | 6.29 | 6.16 | 6.24 | 6.30 | 6.29 | 6.34 | 6.25 | 6.26 | 6.22 | 6.22 | 6.15 | 6.37 |
| **Small School** | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.69 | 0.69 | 0.69 | 0.68 | 0.68 | 0.68 | 0.69 | 0.68 | 0.69 |
| **Strip Mall** | 3.67 | 3.66 | 3.65 | 3.64 | 3.69 | 3.61 | 3.66 | 3.70 | 3.69 | 3.72 | 3.67 | 3.67 | 3.65 | 3.65 | 3.61 | 3.74 |
| **Controlled-environment Horticulture** | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.34 | 0.34 | 0.35 | 0.35 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 |
| **Laboratory** | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| **Refrigerated Warehouse** | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.34 | 0.34 | 0.35 | 0.35 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 |
| **Vehicle Service** | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.34 | 0.34 | 0.35 | 0.35 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 |
| **Manufacturing** | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.34 | 0.34 | 0.35 | 0.35 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 |

### 2.4.3 Incremental First Cost

The incremental first cost will increase slightly. This is because all modern systems installed follow Section 500.3 [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 advanced controls (MAGNA1) and compared it to the line with variable speed reaction to advanced controls (MAGNA3). The three pump sizes the Statewide CASE Team used in the analysis were 1/12, 1/6 and 1/2 horsepower. These incremental cost increases for these pumps were $1,026, $820, and $885, respectively. Table 15 shows the break-out below. The Statewide Case Team obtained these results consultation with a plumbing contractor on 2/2026.

**Table 15: Incremental cost break-out table**

| Pump size | Incremental Labor Increase | Incremental Materials Increase | Incremental Total Increase |
|---|---|---|---|
| **1/12** | $250.00 | $812.00 | $1,062.00 |
| **1/6** | $62.50 | $758.00 | $820.50 |
| **1/2** | $62.50 | $822.52 | $885.02 |

### 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, which was obtained in consultation with a plumbing contractor on 2/2026. 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.

Results of the per-unit cost-effectiveness analyses are presented in Table 16 and Table 17 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 the 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.

The Statewide Case Team conducted BCR analysis 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. The proposed requirement excludes systems below this threshold because 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 16: 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 | 0.69 | 0.43 | 1.60 |
| 2 | 0.52 | 0.37 | 1.41 |
| 3 | 0.37 | 0.25 | 1.48 |
| 4 | 0.37 | 0.24 | 1.51 |
| 5 | 0.53 | 0.36 | 1.46 |
| 6 | 0.40 | 0.30 | 1.32 |
| 7 | 0.41 | 0.30 | 1.37 |
| 8 | 0.33 | 0.22 | 1.48 |
| 9 | 0.40 | 0.30 | 1.30 |
| 10 | 0.52 | 0.41 | 1.25 |
| 11 | 0.54 | 0.38 | 1.41 |
| 12 | 0.46 | 0.32 | 1.42 |
| 13 | 0.56 | 0.40 | 1.41 |
| 14 | 0.49 | 0.40 | 1.25 |
| 15 | 0.55 | 0.41 | 1.32 |
| 16 | 0.52 | 0.39 | 1.34 |

Table 17: 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 | 0.59 | 0.29 | 2.00 |
| 2 | 0.45 | 0.25 | 1.75 |
| 3 | 0.31 | 0.17 | 1.90 |
| 4 | 0.31 | 0.16 | 1.93 |
| 5 | 0.46 | 0.25 | 1.84 |
| 6 | 0.33 | 0.19 | 1.72 |
| 7 | 0.34 | 0.19 | 1.78 |
| 8 | 0.28 | 0.15 | 1.87 |
| 9 | 0.32 | 0.19 | 1.70 |
| 10 | 0.42 | 0.26 | 1.61 |
| 11 | 0.46 | 0.27 | 1.70 |
| 12 | 0.40 | 0.23 | 1.78 |
| 13 | 0.48 | 0.28 | 1.70 |
| 14 | 0.40 | 0.25 | 1.58 |
| 15 | 0.45 | 0.28 | 1.64 |
| 16 | 0.43 | 0.26 | 1.65 |

## 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 (Commision, 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 18) and alterations (Table 19) by CZ. Table 20 presents first-year statewide savings from new construction, additions, and alterations.

Table 18: 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 | 417,265 | 0.01 | 0.00 | 0.00 | 0.02 | $0.07 |
| 2 | 2,597,750 | 0.04 | 0.00 | 0.00 | 0.08 | $0.36 |
| 3 | 12,905,800 | 0.15 | 0.02 | 0.00 | 0.30 | $1.36 |
| 4 | 7,306,265 | 0.12 | 0.01 | 0.00 | 0.22 | $1.08 |
| 5 | 1,255,128 | 0.02 | 0.00 | 0.00 | 0.05 | $0.20 |
| 6 | 8,201,570 | 0.12 | 0.01 | 0.00 | 0.19 | $1.01 |
| 7 | 5,853,330 | 0.05 | 0.00 | 0.00 | 0.13 | $0.45 |
| 8 | 11,759,140 | 0.18 | 0.02 | - | 0.25 | $1.51 |
| 9 | 18,961,400 | 0.27 | 0.03 | 0.00 | 0.38 | $2.27 |
| 10 | 11,094,870 | 0.18 | 0.02 | 0.00 | 0.28 | $1.54 |
| 11 | 2,243,155 | 0.03 | 0.00 | 0.00 | 0.07 | $0.24 |
| 12 | 12,806,060 | 0.15 | 0.02 | 0.00 | 0.40 | $1.47 |
| 13 | 4,457,185 | 0.08 | 0.01 | 0.00 | 0.21 | $0.75 |
| 14 | 2,561,493 | 0.05 | 0.00 | 0.00 | 0.10 | $0.42 |
| 15 | 1,499,336 | 0.03 | 0.00 | 0.00 | 0.04 | $0.21 |
| 16 | 823,425 | 0.01 | 0.00 | 0.00 | 0.03 | $0.13 |
| **Total** | **104,743,171** | **1.47** | **0.16** | **0.01** | **2.74** | **$13.06** |

Table 19: 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 | 1,527,584 | 0.04 | 0.00 | 0.00 | 0.09 | $0.36 |
| 2 | 8,922,728 | 0.17 | 0.02 | 0.00 | 0.30 | $1.47 |
| 3 | 42,231,665 | 0.51 | 0.05 | 0.00 | 0.97 | $4.56 |
| 4 | 24,087,206 | 0.29 | 0.03 | 0.00 | 0.52 | $2.55 |
| 5 | 4,200,828 | 0.08 | 0.01 | 0.00 | 0.18 | $0.72 |
| 6 | 33,573,787 | 0.45 | 0.05 | 0.00 | 0.72 | $3.89 |
| 7 | 23,124,302 | 0.26 | 0.03 | 0.00 | 0.71 | $2.54 |
| 8 | 49,055,890 | 0.64 | 0.07 | - | 0.87 | $5.58 |
| 9 | 76,888,916 | 0.98 | 0.10 | 0.00 | 1.38 | $8.28 |
| 10 | 44,772,053 | 0.74 | 0.08 | 0.00 | 1.17 | $6.70 |
| 11 | 8,439,268 | 0.15 | 0.02 | 0.00 | 0.36 | $1.36 |
| 12 | 44,446,195 | 0.67 | 0.07 | 0.01 | 1.52 | $6.29 |
| 13 | 16,882,529 | 0.29 | 0.03 | 0.00 | 0.74 | $2.83 |
| 14 | 10,401,418 | 0.14 | 0.02 | 0.00 | 0.35 | $1.40 |
| 15 | 6,172,025 | 0.12 | 0.01 | 0.00 | 0.17 | $1.04 |
| 16 | 3,381,924 | 0.05 | 0.01 | 0.00 | 0.11 | $0.51 |
| **Total** | **398,108,317** | **5.59** | **0.59** | **0.03** | **10.14** | **$50.10** |

**Table 20: 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** | 1.47 | 0.16 | 0.01 | 2.74 | 13.06 |
| **Alterations** | 5.4 | 0.6 | 0.0 | 9.8 | 50.1 |
| **Total** | **6.8** | **0.7** | **0.04** | **12.6** | **63.16** |

### 2.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 21 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 ($CO_2e$) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

**Table 21: First-Year Statewide GHG Emissions Impacts**

| Construction Type | Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e) | Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e) | Total Reduced GHG Emissions (Metric Ton CO2e) | Total Monetary Value of Reduced GHG Emissions ($) |
|---|---|---|---|---|
| **New Construction & Additions** | 371.37 | 32.12 | 403.49 | 62,873.99 |
| **Alterations** | 413.76 | 125.62 | 539.38 | 79,608.48 |
| **Total** | **785.13** | **157.74** | **942.88** | **142,482.47** |

### 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 lead, copper, steel, insulation, plastic, and glass.

**Table 22: Annual Statewide Impacts on Material Use**

| Material | Impact (I, D, of NC) [a] | First Year [b] Statewide Impacts (pounds) | Embodied GHG Emissions Saved (MT CO2e) |
|---|---|---|---|
| **Lead** | I | 63,252 | -37 |
| **Copper** | I | 316,258 | -402 |
| **Steel** | I | 316,258 | -174 |
| **Insulation** | I | 63,252 | -70 |
| **Plastic** | I | 316,258 | -266 |
| **Glass** | I | 63,252 | -41 |
| **Total** | **-** | **-** | **-990** |

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

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

### 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 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). New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics.*

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

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

### 2.6.2 Administrative Code (Title 24, Part 1)

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

### 2.6.3 Energy Code (Title 24, Part 6)

**SUBCHAPTER 5 PLUMBING**

**501.3** *[Section 140.5]* **Prescriptive requirements (Newly Constructed).**

**501.3.1** *[Section 140.5(a)]* **Nonresidential occupancies.**

Service water-heating systems in nonresidential buildings shall meet the requirements of Sections 501.3.1.1 or 501.3.1.2, or meet the performance compliance requirements of Section 501.4 *[Section 140.1].*

**501.3.1.1** *[Section 140.5(a)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 101.3 *[Section 110.1]*, 500.3 *[Section 110.3]* and 501.2.1 *[Section 120.3]*.

**Exception to Section 501.3.1.1:** A water-heating system serving an individual *bathroom* space may be an instantaneous electric *water heater*.

**501.3.1.2** *[Section 140.5(a)2]* **All other occupancies.**

A *service water-heating* system that meets the applicable requirements of Sections 101.3 *[Section 110.1]*, 500.3 *[Section 110.3],* 501.2.1 *[Section 120.3]*, ~~and~~ Section 501.3.3 *[Section 140.5(c)]* and Section 501.3.4 *[Section 140.5(d)].*

**501.3.4** *[New section]* **Circulator pump controls.**

Pumps serving recirculation systems with dedicated hot water return piping shall meet the requirements of Section 501.3.4.1 or 501.3.4.2, and Section 501.3.4.3.

**Exception to Section 501.3.4:** Recirculation systems in *hotel/motel* buildings and *nonresidential* buildings with Group R occupancies.

**501.3.4.1 Pump controls option 1**

Pump controls that adjust the speed shall either maintain a constant return temperature setpoint, not to exceed 125 °F, or

The water heating system shall include a thermal balancing valve installed in the return piping. The pump shall maintain a differential pressure with a thermal balancing valve temperature setpoint that shall not exceed 125 °F .

**Exception to Section 501.3.4.1:** For commercial kitchens, the pump or thermal balancing valve setpoint temperature shall not exceed 135 °F.

**501.3.4.2 Pump controls option 2**

Pump controls that activate the pump in response to an associated control signal shall meet one of two configurations depending on system type. Single-loop or single-riser recirculation systems shall include a hot water flow sensor or a temperature sensor capable of detecting hot water draws, used in combination with a recirculation return temperature sensor. The return temperature setpoint shall not exceed 125 °F. In addition, a priming timer shall periodically activate the pump at set intervals to reheat the recirculation system.

For multi-loop or multi-riser distribution systems, pump control shall periodically activate the pump at set intervals to reheat the recirculation system.

**Exception to Section 501.3.4.2:** For commercial kitchens, the pump or thermal balancing valve setpoint temperature shall not exceed 135 °F.

**501.3.4.3 Pump controls for all systems**

Pump controls shall store user-defined temperature, pressure, or timer conditions and operational parameters during loss of power and shall return to normal operation upon return of power without requiring manual input.

Fault indication must be provided by audio, visual alarm, or electronic notifications.

**501.5.2.2** *[Section 141.0(b)2]* **Prescriptive requirements (Alterations).**

**501.5.2.2.1** *[Section 141.0(b)2N]* **Service water-heating systems.** *Service* *water-heating systems* shall meet the requirements of Section 501.3.1.2 *[Section 140.5(a)2]*, ~~and~~ Section 501.3.2 *[Section 140.5(b)]*~~,~~ and Section 501.3.4 *[New Section]* except for the solar water heating requirements.

### 2.6.4 Reference Appendices

There are no proposed changes to the Reference Appendices

### 2.6.5 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 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. The Statewide CASE Team will provide an example based on the prototype analysis.

### 2.6.6 ACM Reference Manual

The Statewide CASE Team proposes the following changes to the 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 5.9.3 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 Standard Design, the circulator pump controls shall meet the prescriptive requirements specified in Section 501.3.4 [140.5].
*Proposed Design:* For the proposed design, 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).

### 2.6.7 Compliance Forms

As discussed in Section 2.1.4.5, the Statewide Case Team would update the NRCC-PLB and NRCI-PLB compliance forms to reflect the proposed change. For CBECC, software updates may be required to support NRCC-PRF-E (Nonresidential Certificate of Compliance-Process Systems) 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 startup.

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

Table 23 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 23: Scope of Proposed Code Change

| Building Type(s) | Construction Type(s) | Type of Change |
|---|---|---|
| ☐ Single Family | ☑ New Construction | ☐ Mandatory |
| ☐ Multifamily | ☑ Additions | ☑ Prescriptive |
| ☑ Nonresidential | ☑ Alterations | ☑ Performance |

| Application Climate Zones | Energy Code Sections | Compliance Forms | Sections of ACM Reference Manuals |
|---|---|---|---|
| Climate Zones 1-16 | • Part 6, Section 201 [Section 100.1]<br>• Part 6, Section 501.3.1 [Section 140.5(a)]<br>• Part 6, Section 501.5.2.2 [Section 141.0(b)]<br>• Joint Reference Appendix JA1 and JA14 | NRCC-PLB-E,<br>NRCI-PLB-E,<br>LMCC-PLB-01-E,<br>LMCI-PLB-E,<br>NRCC-PRF-E,<br>LMCC-PRF-E | Section 5.9.1 Service Water Heating System Loads and Configuration |

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

### 3.1.2 Benefits of Proposed Change

By eliminating the electric resistance (ER) in the Temperature Maintenance Heater in Series (TMHS) configuration, 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 the swing tank configuration, with single- and multi-pass heat pump (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 meet the recirculation loop load, allowing the primary storage tank to meet 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 backup 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, 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.

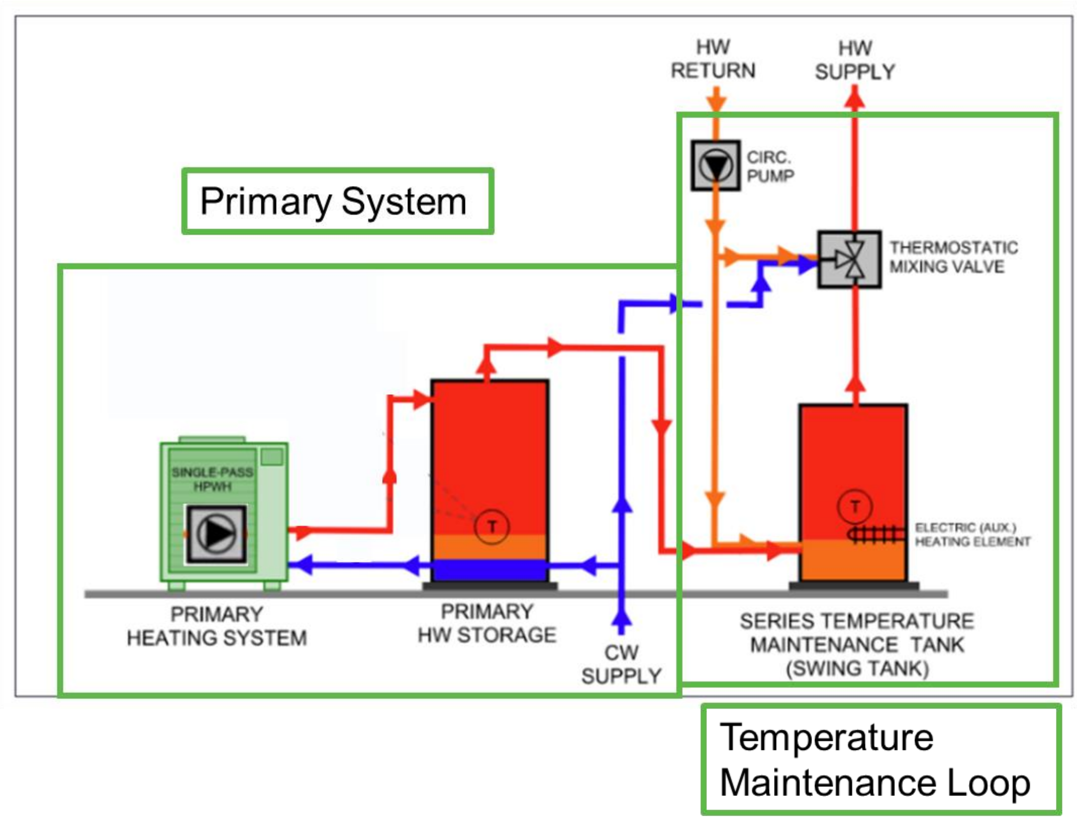


**Figure 1: Diagram of the TMHS configuration.**

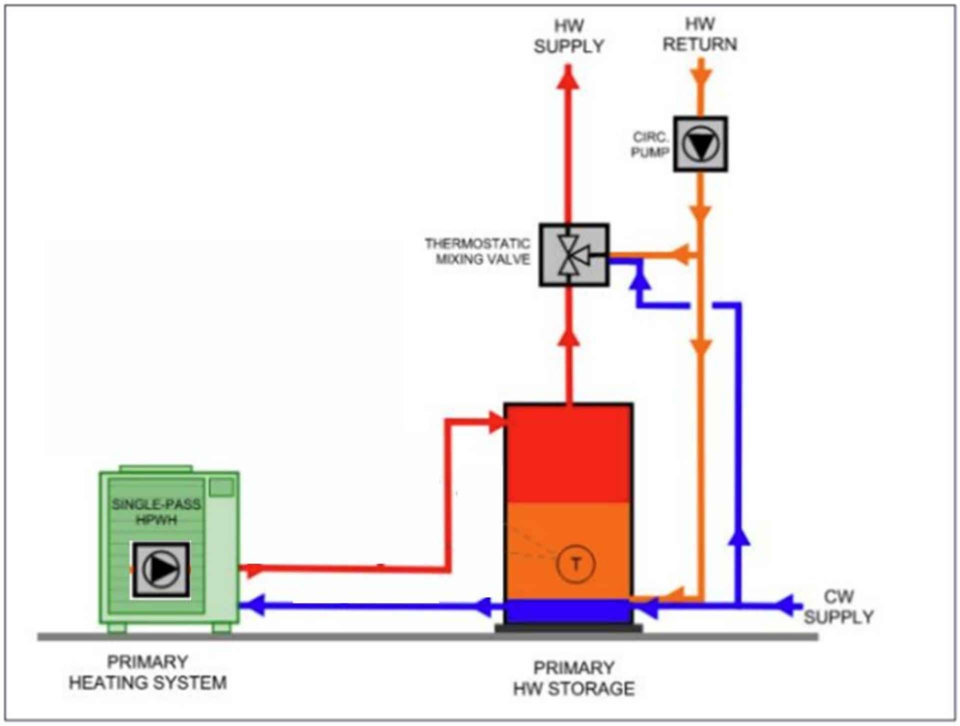


**Figure 2: Diagram of the return to primary configuration.**

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 meets 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 Pacific Gas & Electric (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 carbon dioxide ($CO_2$) systems (Brooks, Neal, & 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 conducted a series of demonstration studies for $CO_2$ HPWHs with recirculation for a Code Readiness project funded by SCE. These tests show that the Return to Primary configuration can maintain sufficient hot water delivery performance with higher return temperatures, which further supports this measure.

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 startup 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 & Ben Larson, 2024) (Brooks, Neal, & 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.

### 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 201 [SECTION 100.1] DEFINITIONS**

The proposed measure adds definitions for Split Heat Pump Water Heater, Appurtenances, Temperature Maintenance Heater in Parallel configuration, and Temperature Maintenance Heater in Series Configuration.

**SECTION 501.3 [SECTION 140.5] PRESCRIPTIVE REQUIREMENTS (Newly Constructed)**

**Subsection 501.3.1 [Section 140.5(a)]:** The proposed measure would redefine the hot water systems in nonresidential buildings 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 with recirculation.

**SECTION 501.5.2.2 [SECTION 141.0(b)2] Prescriptive requirements (Alterations)**

**Subsection 501.5.2.2.1 [Section 141.0(b)2N]:** The proposed measure would add requirements for projects whose scope includes alterations that replace existing service water heater(s) with split HPWH(s) with recirculation.

#### *3.1.4.2 Reference Appendices Change Summary*

**Joint Appendix (JA) 1 – Definitions:**

The proposed measure adds definitions for Heat Pump Water Heater COP, Primary Heat Pump Storage Tank, and Return to Primary Configuration.

**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.

The proposed measure would expand JA14 to add new subsections JA14.5 to add HPWH requirements on design, installation and startup documentation for designers and installers.

#### *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 with recirculation.

#### *3.1.4.5 Compliance Forms Change Summary*

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

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

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

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

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

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

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 startup 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 design, and verify that the design meets either prescriptive or alternative pathway requirements.

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

During the inspection phase, plumbing installers 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, startup, and performance requirements for central HPWH in reference appendices to help streamline the compliance process.

### 3.2.2 Impact on Market Actors

Table 24 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 24: Impacts on Market Actors and Suggested Training and Education Opportunities

| Market Actor | Impact(s) | Suggested Outreach and Education |
|---|---|---|
| **Owner/Developer** [a] | None | None |
| **Design Professional** [b] | Limited awareness of HP products in Return to Primary configuration.<br><br>Limited experience with HPWH designs and applicability. | Training and best practice for designers.<br><br>Develop case studies and provide instructional webinars.<br><br>Provide supplemental guidance and recommendations and context in the compliance manual. |
| **Construction Team**[c] | Limited installation experience with the HPWH systems<br>Added time and coordination to install and startup HPWH systems | Training and best practice for installers.<br><br>Provide instructional webinars and in-person training. |
| **Building Department** [d] | Limited experience with HPWH systems. | Add new plan check and building inspector activities related to compliance with this measure.<br><br>Provide training to plan checkers and building inspectors related to the proposed changes mandated in each code cycle. |
| **Verification Tester** [e] | N/A | N/A |
| **Manufacturer and Distributor** | Lack of sizing or performance data. | Encourage manufacturers to provide readily available product specifications.<br><br>Add a performance data reporting requirement in the reference appendices (COP, defrost derate, input power, output capacity, refrigerant type, etc.). |

a. Owner/Developer is funding the project and is the primary decision maker.

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

c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.

d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.

e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on Design Professionals, Building Departments, Builders, Building Occupants, and Manufacturers, since these market actors are expected to experience the most direct impacts from the prescriptive requirement of Return to Primary configuration. 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 promoting Return to Primary configuration, the Statewide CASE Team expects the primary training need would be education from HPWH manufacturers via lunch and learn sessions and specification support, in addition to the suggestions in Table 24.

**Building Departments.** Building department staff would need education regarding Return to Primary configuration. The suggestions in Table 24 intend to address the marginal impact of the measure. The Statewide CASE Team expects that the more significant training need would be education on HPWHs 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 25 shows the commercial building subsectors that the Statewide CASE Team expects to be impacted by the changes proposed in this report.

**Building occupants (owners and tenants).** The proposed code change would increase incremental costs in some cases and would reduce building owners' utility bills throughout the measure lifetime. Even with increased costs in some cases, this measure is cost effective for all prototypes and climate zones. See the 2028 CASE Methodology Report for a description of how LSC savings relate to occupant utility bill savings.

**Table 25: 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. 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 implementation with different compressor cut-off temperatures for ambient temperature to better reflect the capabilities of different HPWH products with different refrigerants.

The proposed measure would require an update to the software if the proposed control does not meet the prescriptive requirements. In that case, all the pipe heat losses will be met with electric resistance in the swing tank rather than with the primary heat pump. The proposed standard design piping heat loss methodology is described in Appendix H.

CBECC will need to update software 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.

Plan review function would consist of reviewing NRCC-PLB-E, LMCC-PLB-01-E, NRCC-PRF-E, and LMCC-PRF-E, and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing NRCI-PLB-E and LMCI-PLB-E and ensuring that the information on the forms is consistent with the approved NRCC-PLB-E and LMCC-PLB-01-E forms and with what is actually installed.

## 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 climate zones. 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.

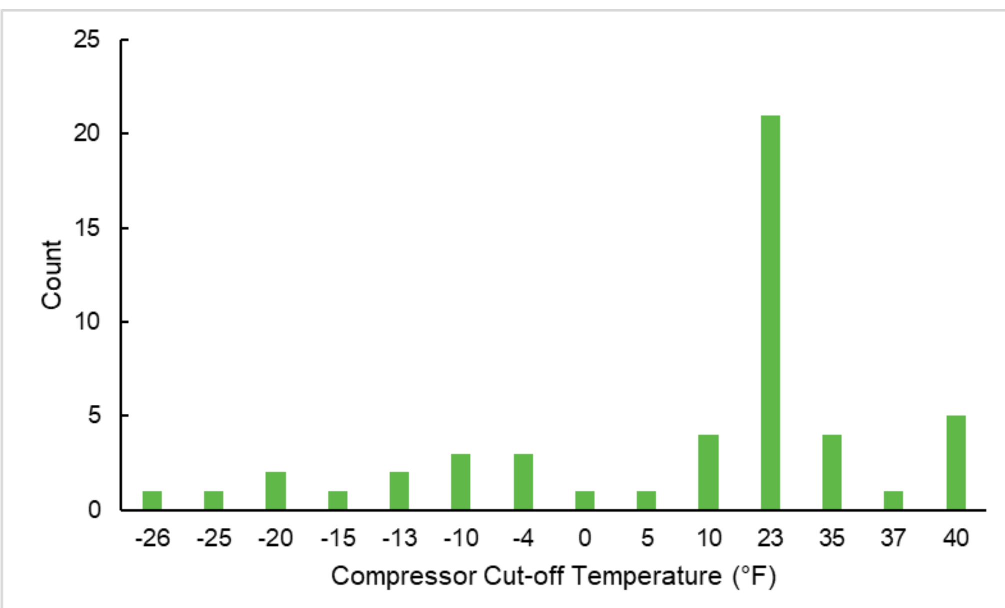


**Figure 3: HP compressor cut-off temperature.**

Product research and lab tests (Evan Green & 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 $CO_2$ 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, installers, 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 & 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. $CO_2$ 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.

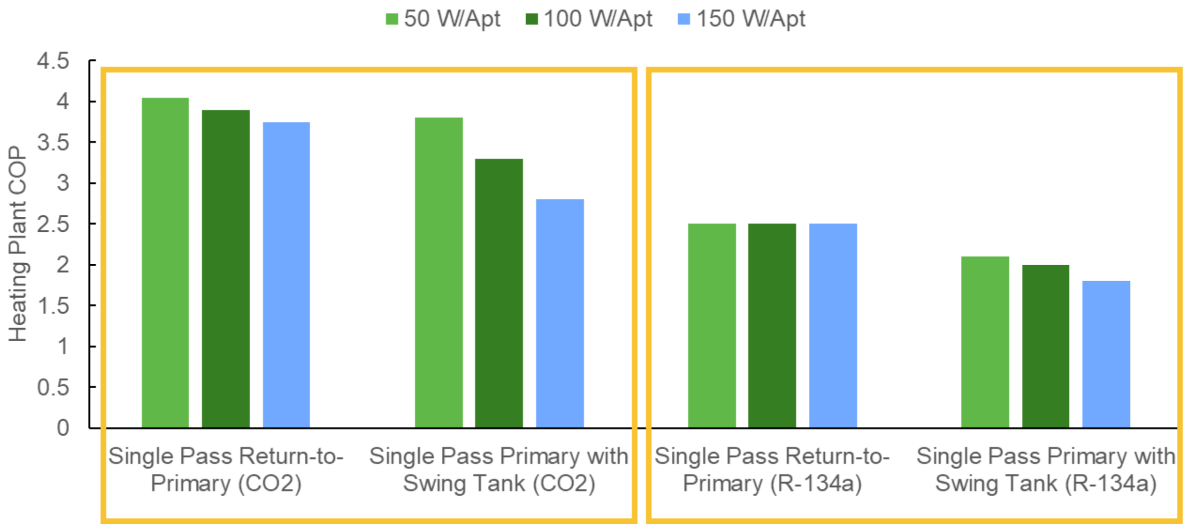


**Figure 4: Heating plant COP from lab tests.**

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 $CO_2$ systems. Table 26 shows the heating plant COP at various return water temperatures and other key parameters, including the number of apartments, distribution heat loss, and return water temperature. 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 an extremely small distribution heat loss (30W/apt).

Table 26: 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 shows that a small CO2 HPWH in Return to Primary configuration has a higher heating plant COP compared to TMHS configuration for small central HPWH applications. Table 27 shows the heating plant COP and key parameters for the two comparable sites.

Table 27: 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<br>(2) 83-gallon storage tanks | 8 | 26 | 172 | 2.37 |
| **Site 2 – Continuous Recirculation** | (4) SanCO2 HPWHs<br>(1) 200-gallon storage tank<br>(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, installers, 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 24 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

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

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 proposal is unlikely to have significant negative or positive impacts on ESJ communities. The Statewide CASE Team does expect impacts on cost from the proposed code change. However, the costs are expected to be modest and outweighed by the benefits. Specifically, energy costs would decrease, which would result in lower utility bills for ESJ communities. The Statewide CASE Team does not expect any impact on the health and safety of ESJ communities, or on their disaster preparedness. The comfort of ESJ communities is unlikely to be impacted by the proposed code changes.

### 3.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 28, Table 29, and Table 30 outline the statewide implications for these job categories. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

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

**Table 28: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| **Direct Effects (Additional spending by Commercial Builders)** | 35.0 | $2,756,641 | $3,758,836 | $7,537,456 |
| **Indirect Effect (Additional spending by firms supporting Commercial Builders)** | 15.5 | $1,251,444 | $2,103,462 | $3,726,029 |
| **Total Economic Impacts** | **50.5** | **$4,008,085** | **$5,862,298** | **$11,263,485** |

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

**Table 29: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| **Direct Effects (Additional spending by building designers and energy consultants)** | 0.6 | $65,222 | $64,569 | $102,057 |
| **Indirect Effect (Additional spending by firms supporting building designers and energy consultants)** | 0.2 | $19,420 | $26,990 | $43,448 |
| **Total Economic Impacts** | **0.8** | **$84,641** | **$91,558** | **$145,505** |

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

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

**Table 30: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| **Direct Effects (Additional spending by building inspectors)** | 0.311 | $35,415 | $41,998 | $51,036 |
| **Indirect Effect (Additional spending by firms supporting building inspectors)** | 0.040 | $3,280 | $5,108 | $8,897 |
| **Total Economic Impacts** | **0.35** | **$38,695** | **$47,107** | **$59,933** |

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

The proposed change represents a modest adjustment, which is not expected to excessively burden or competitively disadvantage California businesses, nor is it expected to lead to a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[9] Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have an advantageous or an adverse effect on the competitiveness of California businesses. The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The Statewide CASE Team's IMPLAN modeling resulted in an estimated $213,347 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.[10]

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[11] As Table 31 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in

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

[10] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

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

2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2022, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

**Table 31: Net Domestic Private Investment and Corporate Profits, U.S.**

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a $908,870 value increase in net private investment by California businesses.

### 3.3.5 Economic and Fiscal Impacts

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

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

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

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

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

**Cost to Local Governments:** All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 3.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

#### 3.3.5.2 Mandates on Local Agencies or School Districts

Title 24, Part 6 specifies the requirements at the statewide level, so local agencies or school districts are not mandated to take action.

#### 3.3.5.3 Costs to Local Agencies or School Districts

Depending on the energy code compliance path used, this measure may impose additional costs on local agencies or school districts undertaking new construction or water heater replacement projects.

#### 3.3.5.4 Costs or Savings to Any State Agency

There are no costs or savings to state agencies because they would not be involved in enforcement of this measure.

#### *3.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies*

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

#### *3.3.5.6 Costs or Savings in Federal Funding to the State*

There are no costs or savings to federal funding to the state. The proposed measure is a relatively small cost which the market would bear. The state would not require federal funding to implement the proposed measure.

## 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 32 through Table 35. Per-unit electricity savings for the first year are expected to range from 0.001 to 1.63 kWh/ft2-yr, depending upon climate zone and prototype. Demand reductions are expected to range between 0.0001 kW/ft2 and 0.1862 kW/ft2, depending on climate zone 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 37 through Table 40. Per-unit electricity savings for the first year are expected to range from 0.001 to 1.69 kWh/ft2-yr, depending upon climate zone and prototype. Demand reductions are expected to range between 0.0001 kW/ft2 and 0.193 kW/ft2, depending on climate zone and prototype. Because the proposed measure is specific to electric heat pump systems, there are no natural gas peak demand reductions.

Table 36 and Table 41 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 than recirculation heat losses, which triggers less electric resistance usage of the series temperature maintenance tank and results in lower 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 32: 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 | 0.55 | 0.55 | 0.56 | 0.52 | 0.56 | 0.55 | 0.54 | 0.53 | 0.52 | 0.53 | 0.50 | 0.52 | 0.51 | 0.51 | 0.42 | 0.55 |

**Table 33: 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 |
| **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** | 0.0630 | 0.0629 | 0.0641 | 0.0593 | 0.0637 | 0.0631 | 0.0622 | 0.0599 | 0.0594 | 0.0601 | 0.0575 | 0.0596 | 0.0578 | 0.0579 | 0.0474 | 0.0625 |

Table 34: 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | 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 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

Table 35: 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 | 0.94 | 0.94 | 0.96 | 0.88 | 0.95 | 0.94 | 0.93 | 0.89 | 0.89 | 0.90 | 0.86 | 0.89 | 0.86 | 0.86 | 0.71 | 0.93 |

Table 36: 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 |
| 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 | 4.82 | 4.81 | 4.90 | 4.53 | 4.86 | 4.85 | 4.75 | 4.57 | 4.52 | 4.58 | 4.39 | 4.55 | 4.41 | 4.42 | 3.63 | 4.76 |

Table 37: 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 | 0.58 | 0.55 | 0.57 | 0.55 | 0.59 | 0.58 | 0.55 | 0.55 | 0.55 | 0.53 | 0.53 | 0.55 | 0.54 | 0.54 | 0.42 | 0.56 |

Table 38: 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 | 0.066 | 0.063 | 0.065 | 0.063 | 0.067 | 0.067 | 0.063 | 0.063 | 0.063 | 0.061 | 0.061 | 0.063 | 0.061 | 0.061 | 0.048 | 0.064 |

Table 39: First Year Natural Gas Savings (kBtu) 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 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Grocery | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large Office | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large Retail | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large School | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Medium Office | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Medium Retail | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Restaurant | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Small School | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Laboratory | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

### Table 40: First Year Source Energy Savings (kBtu) 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** | 0.16 | 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 |
| **Grocery** | 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 School** | 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 |
| **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** | 2.84 | 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 School** | 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 |
| **Laboratory** | 0.99 | 0.93 | 0.97 | 0.93 | 1.00 | 0.99 | 0.94 | 0.94 | 0.93 | 0.91 | 0.91 | 0.94 | 0.91 | 0.91 | 0.71 | 0.96 |

### Table 41: 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** | 5.08 | 4.78 | 4.96 | 4.78 | 5.13 | 5.11 | 4.81 | 4.82 | 4.78 | 4.65 | 4.64 | 4.80 | 4.66 | 4.68 | 3.65 | 4.91 |

### 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 climate zone 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 42 tabulates the design data for entering cold water temperature and design outside air temperature for all 16 California climate zones.

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 backup electric resistance for each climate zone. Lochinvar VAHP060 can work at 25°F ambient temperature and above, which are appropriate for climate zones with design temperature above 25°F. Colmac CxV-7 with R-454B refrigerant can work down to 10°F, which are used for climate zones with a design temperature below 25°F. For CZ5 and CZ10, and Restaurant and Grocery prototypes in CZ3, 8, 9, and 12, the Statewide CASE Team switched from Lochivar to Colmac due to cost-effective consideration.

**Table 42: Design temperature for 16 climate zones**

| 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 |
| **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 installer, including cost of primary HP, primary storage tank, series temperature maintenance tank, piping, and startup. The base case assumed standard startup, while the measure case assumed the proposed startup requirements. Standard split heat pump system startup is focused on ensuring the heat pump and primary storage tank is operating. The proposed startup ensures the heat pump and primary storage, the temperature maintenance tank, and any electric resistance backup are started up to ensure overall efficient operation that avoids unnecessary electric resistance while also improving reliability. For all other components, the Statewide CASE Team assumed the same inputs for base case and measure case, such as pumps, expansion tanks, master mixing valves, miscellaneous supplies, electrical supplies, controls, etc., so the Statewide CASE Team did not determine costs for these components. The Statewide CASE Team worked with a plumbing installer in 2/2026 to receive equipment, installation and startup costs for the components that varied between base and measure case.

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

Table 43 and Table 44 summarize the equipment cost of analyzed prototypes and all climate zones, which is the same for new construction, and additions, and alterations. Table 45 and Table 46 summarize the labor cost. Table 47 summarizes the incremental cost including both equipment cost and labor cost.

### Table 43: 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** | $179,770 | $313,710 | $179,770 | $310,573 | $313,710 | $176,210 | $179,770 | $176,210 | $174,430 | $307,436 | $326,258 | $177,990 | $316,847 | $304,299 | $174,430 | $323,121 |
| **Medium Office** | $54,008 | $98,713 | $54,008 | $97,726 | $98,713 | $52,938 | $54,008 | $52,938 | $52,404 | $96,739 | $102,662 | $53,473 | $99,700 | $95,752 | $52,404 | $101,674 |
| **Laboratory** | $323,523 | $637,000 | $323,523 | $630,630 | $637,000 | $317,117 | $323,523 | $317,117 | $313,914 | $624,260 | $662,480 | $320,320 | $643,370 | $617,890 | $313,914 | $656,110 |
| **Restaurant** | $125,669 | $260,145 | $125,669 | $257,544 | $260,145 | $123,181 | $125,669 | $123,181 | $121,937 | $254,942 | $270,551 | $124,425 | $262,746 | $252,341 | $121,937 | $267,949 |
| **Small School** | $221,069 | $273,884 | $221,069 | $351,054 | $273,884 | $181,570 | $185,238 | $216,691 | $214,502 | $268,406 | $284,839 | $218,880 | $276,623 | $343,962 | $179,736 | $365,238 |
| **Large School** | $585,538 | $906,185 | $549,708 | $977,032 | $906,185 | $503,701 | $513,877 | $538,822 | $533,380 | $888,061 | $942,432 | $544,265 | $915,247 | $957,294 | $498,613 | $1,016,508 |
| **Assembly** | $221,069 | $273,884 | $221,069 | $351,054 | $273,884 | $181,570 | $185,238 | $216,691 | $214,502 | $268,406 | $284,839 | $218,880 | $276,623 | $343,962 | $179,736 | $365,238 |
| ***Retail Large*** | $265,987 | $489,553 | $265,987 | $484,657 | $489,553 | $260,719 | $265,987 | $260,719 | $258,086 | $479,762 | $509,135 | $263,353 | $494,449 | $474,866 | $258,086 | $504,240 |
| **Retail Medium** | $54,008 | $98,713 | $54,008 | $97,726 | $98,713 | $52,938 | $54,008 | $52,938 | $52,404 | $96,739 | $102,662 | $53,473 | $99,700 | $95,752 | $52,404 | $101,674 |
| **Grocery** | $125,669 | $260,145 | $125,669 | $257,544 | $260,145 | $123,181 | $125,669 | $123,181 | $121,937 | $254,942 | $270,551 | $124,425 | $262,746 | $252,341 | $121,937 | $267,949 |

### Table 44: 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 | $194,454 | $292,773 | $158,624 | $369,754 | $292,773 | $155,482 | $158,624 | $155,482 | $153,912 | $286,918 | $304,484 | $157,053 | $295,701 | $362,284 | $153,912 | $301,556 |
| Medium Office | $48,985 | $93,740 | $48,985 | $92,803 | $93,740 | $48,015 | $48,985 | $48,015 | $47,530 | $91,865 | $97,490 | $48,500 | $94,677 | $90,928 | $47,530 | $96,552 |
| Laboratory | $303,432 | $617,108 | $303,432 | $610,937 | $617,108 | $297,424 | $303,432 | $297,424 | $294,419 | $604,766 | $641,792 | $300,428 | $623,279 | $598,595 | $294,419 | $635,621 |
| Restaurant | $120,647 | $255,172 | $120,647 | $252,620 | $255,172 | $118,257 | $120,647 | $118,257 | $117,063 | $250,069 | $265,379 | $119,452 | $257,724 | $247,517 | $117,063 | $262,827 |
| Small School | $199,529 | $333,273 | $199,529 | $329,940 | $333,273 | $195,577 | $199,529 | $195,577 | $193,602 | $326,608 | $346,604 | $197,553 | $336,606 | $323,275 | $158,835 | $343,271 |
| Large School | $596,493 | $881,555 | $560,662 | $1,032,557 | $881,555 | $514,439 | $524,831 | $549,560 | $544,009 | $863,924 | $916,817 | $555,111 | $890,371 | $1,011,697 | $474,476 | $1,074,277 |
| Assembly | $199,529 | $333,273 | $199,529 | $329,940 | $333,273 | $195,577 | $199,529 | $195,577 | $193,602 | $326,608 | $346,604 | $197,553 | $336,606 | $323,275 | $158,835 | $343,271 |
| Retail Large | $296,795 | $484,580 | $260,964 | $559,643 | $484,580 | $255,796 | $260,964 | $255,796 | $253,212 | $474,888 | $503,963 | $258,380 | $489,426 | $548,337 | $253,212 | $499,117 |
| Retail Medium | $48,985 | $93,740 | $48,985 | $92,803 | $93,740 | $48,015 | $48,985 | $48,015 | $47,530 | $91,865 | $97,490 | $48,500 | $94,677 | $90,928 | $47,530 | $96,552 |
| Grocery | $120,647 | $255,172 | $120,647 | $252,620 | $255,172 | $118,257 | $120,647 | $118,257 | $117,063 | $250,069 | $265,379 | $119,452 | $257,724 | $247,517 | $117,063 | $262,827 |

## Table 45: 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 | $22,750 | $25,025 | $24,798 | $25,935 | $20,930 | $21,158 | $20,475 | $21,385 | $21,613 | $21,158 | $22,523 | $22,750 | $21,613 | $20,930 | $21,158 | $22,295 |
| Medium Office | $10,750 | $11,825 | $11,718 | $12,255 | $9,890 | $9,998 | $9,675 | $10,105 | $10,213 | $9,998 | $10,643 | $10,750 | $10,213 | $9,890 | $9,998 | $10,535 |
| Laboratory | $51,250 | $56,375 | $55,863 | $58,425 | $47,150 | $47,663 | $46,125 | $48,175 | $48,688 | $47,663 | $50,738 | $51,250 | $48,688 | $47,150 | $47,663 | $50,225 |
| Restaurant | $16,250 | $17,875 | $17,713 | $18,525 | $14,950 | $15,113 | $14,625 | $15,275 | $15,438 | $15,113 | $16,088 | $16,250 | $15,438 | $14,950 | $15,113 | $15,925 |
| Small School | $30,750 | $30,800 | $33,518 | $35,055 | $25,760 | $26,040 | $25,200 | $28,905 | $29,213 | $26,040 | $27,720 | $30,750 | $26,600 | $28,290 | $26,040 | $30,135 |
| Large School | $53,250 | $55,550 | $55,045 | $60,705 | $46,460 | $44,408 | $42,975 | $47,470 | $47,975 | $46,965 | $49,995 | $50,500 | $47,975 | $48,990 | $44,408 | $52,185 |
| Assembly | $30,750 | $30,800 | $33,518 | $35,055 | $25,760 | $26,040 | $25,200 | $28,905 | $29,213 | $26,040 | $27,720 | $30,750 | $26,600 | $28,290 | $26,040 | $30,135 |
| Retail Large | $34,750 | $38,225 | $37,878 | $39,615 | $31,970 | $32,318 | $31,275 | $32,665 | $33,013 | $32,318 | $34,403 | $34,750 | $33,013 | $31,970 | $32,318 | $34,055 |
| Retail Medium | $10,750 | $11,825 | $11,718 | $12,255 | $9,890 | $9,998 | $9,675 | $10,105 | $10,213 | $9,998 | $10,643 | $10,750 | $10,213 | $9,890 | $9,998 | $10,535 |
| Grocery | $16,250 | $17,875 | $17,713 | $18,525 | $14,950 | $15,113 | $14,625 | $15,275 | $15,438 | $15,113 | $16,088 | $16,250 | $15,438 | $14,950 | $15,113 | $15,925 |

## Table 46: 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 | *$23,500* | $22,825 | $22,618 | $26,790 | $19,090 | $19,298 | $18,675 | $19,505 | $19,713 | $19,298 | $20,543 | $20,750 | $19,713 | $21,620 | $19,298 | $20,335 |
| Medium Office | $8,750 | $9,625 | $9,538 | $9,975 | $8,050 | $8,138 | $7,875 | $8,225 | $8,313 | $8,138 | $8,663 | $8,750 | $8,313 | $8,050 | $8,138 | $8,575 |
| Laboratory | $43,250 | $47,575 | $47,143 | $49,305 | $39,790 | $40,223 | $38,925 | $40,655 | $41,088 | $40,223 | $42,818 | $43,250 | $41,088 | $39,790 | $40,223 | $42,385 |
| Restaurant | $14,250 | $15,675 | $15,533 | $16,245 | $13,110 | $13,253 | $12,825 | $13,395 | $13,538 | $13,253 | $14,108 | $14,250 | $13,538 | $13,110 | $13,253 | $13,965 |
| Small School | $28,750 | $31,625 | $31,338 | $32,775 | $26,450 | $26,738 | $25,875 | $27,025 | $27,313 | $26,738 | $28,463 | $28,750 | $27,313 | $26,450 | $24,180 | $28,175 |
| Large School | $54,000 | $53,350 | $55,863 | $61,560 | $44,620 | $45,105 | $43,650 | $48,175 | $48,688 | $45,105 | $48,015 | $51,250 | $46,075 | $49,680 | $42,548 | $52,920 |
| Assembly | $28,750 | $31,625 | $31,338 | $32,775 | $26,450 | $26,738 | $25,875 | $27,025 | $27,313 | $26,738 | $28,463 | $28,750 | $27,313 | $26,450 | $24,180 | $28,175 |
| Retail Large | $35,500 | $36,025 | $35,698 | $40,470 | $30,130 | $30,458 | $29,475 | $30,785 | $31,113 | $30,458 | $32,423 | $32,750 | $31,113 | $32,660 | $30,458 | $32,095 |
| Retail Medium | $8,750 | $9,625 | $9,538 | $9,975 | $8,050 | $8,138 | $7,875 | $8,225 | $8,313 | $8,138 | $8,663 | $8,750 | $8,313 | $8,050 | $8,138 | $8,575 |
| Grocery | $14,250 | $15,675 | $15,533 | $16,245 | $13,110 | $13,253 | $12,825 | $13,395 | $13,538 | $13,253 | $14,108 | $14,250 | $13,538 | $13,110 | $13,253 | $13,965 |

### Table 47: 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 | $15,434 | -$23,137 | -$23,326 | $60,036 | -$22,777 | -$22,588 | -$22,946 | -$22,608 | -$22,418 | -$22,378 | -$23,754 | -$22,937 | -$23,046 | $58,676 | -$22,378 | -$23,525 |
| Medium Office | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Laboratory | -$28,091 | -$28,692 | -$28,811 | -$28,813 | -$27,252 | -$27,133 | -$27,291 | -$27,213 | -$27,094 | -$26,934 | -$28,608 | -$27,892 | -$27,691 | -$26,655 | -$26,934 | -$28,329 |
| Restaurant | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Small School | -$23,540 | $60,214 | -$23,720 | -$23,394 | $60,079 | $14,705 | $14,965 | -$22,994 | -$22,800 | $58,899 | $62,507 | -$23,327 | $60,695 | -$22,527 | -$22,760 | -$23,927 |
| Large School | $11,704 | -$26,830 | $11,772 | $56,380 | -$26,470 | $11,435 | $11,629 | $11,443 | $11,342 | -$25,997 | -$27,595 | $11,596 | -$26,776 | $55,093 | -$25,997 | $58,504 |
| Assembly | -$23,540 | $60,214 | -$23,720 | -$23,394 | $60,079 | $14,705 | $14,965 | -$22,994 | -$22,800 | $58,899 | $62,507 | -$23,327 | $60,695 | -$22,527 | -$22,760 | -$23,927 |
| Retail Large | $31,558 | -$7,173 | -$7,203 | $75,841 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | $74,161 | -$6,734 | -$7,082 |
| Retail Medium | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Grocery | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |

### 3.4.4 Incremental Maintenance and Replacement Costs

The Statewide CASE Team worked with a plumbing installer in 2/2026 to receive maintenance and replacement costs for the components that varied between base and measure case.

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 48 summarizes the replacement cost during the 30-year period of analysis.

### Table 48: 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 | $15,434 | -$23,137 | -$23,326 | $60,036 | -$22,777 | -$22,588 | -$22,946 | -$22,608 | -$22,418 | -$22,378 | -$23,754 | -$22,937 | -$23,046 | $58,676 | -$22,378 | -$23,525 |
| Medium Office | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Laboratory | -$28,091 | -$28,692 | -$28,811 | -$28,813 | -$27,252 | -$27,133 | -$27,291 | -$27,213 | -$27,094 | -$26,934 | -$28,608 | -$27,892 | -$27,691 | -$26,655 | -$26,934 | -$28,329 |
| Restaurant | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Small School | -$23,540 | $60,214 | -$23,720 | -$23,394 | $60,079 | $14,705 | $14,965 | -$22,994 | -$22,800 | $58,899 | $62,507 | -$23,327 | $60,695 | -$22,527 | -$22,760 | -$23,927 |
| Large School | $11,704 | -$26,830 | $11,772 | $56,380 | -$26,470 | $11,435 | $11,629 | $11,443 | $11,342 | -$25,997 | -$27,595 | $11,596 | -$26,776 | $55,093 | -$25,997 | $58,504 |
| Assembly | -$23,540 | $60,214 | -$23,720 | -$23,394 | $60,079 | $14,705 | $14,965 | -$22,994 | -$22,800 | $58,899 | $62,507 | -$23,327 | $60,695 | -$22,527 | -$22,760 | -$23,927 |
| Retail Large | $31,558 | -$7,173 | -$7,203 | $75,841 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | $74,161 | -$6,734 | -$7,082 |
| Retail Medium | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |
| Grocery | -$7,023 | -$7,173 | -$7,203 | -$7,203 | -$6,813 | -$6,783 | -$6,823 | -$6,803 | -$6,774 | -$6,734 | -$7,152 | -$6,973 | -$6,923 | -$6,664 | -$6,734 | -$7,082 |

### 3.4.5 Cost Effectiveness

Table 49 presents the results of the per-unit cost-effectiveness analyses for new construction/additions by climate zone, and Table 50 presents results for alterations, respectively. Table 51 presents the results of the per-unit cost-effectiveness analysis for new construction/additions per prototype and Table 52 represents results for alterations. 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 climate zone 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 49: 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** | 1.95 | -0.43 | infinite |
| **CZ02** | 2.89 | 0.77 | 3.76 |
| **CZ03** | 2.31 | -0.57 | infinite |
| **CZ04** | 2.23 | -0.47 | infinite |
| **CZ05** | 3.02 | 1.11 | 2.72 |
| **CZ06** | 2.52 | -0.24 | infinite |
| **CZ07** | 2.38 | -0.13 | infinite |
| **CZ08** | 2.36 | -0.64 | infinite |
| **CZ09** | 2.44 | -0.69 | infinite |
| **CZ10** | 3.16 | 0.60 | 5.28 |
| **CZ11** | 2.87 | 1.32 | 2.17 |
| **CZ12** | 2.70 | -0.80 | infinite |
| **CZ13** | 4.01 | 1.60 | 2.50 |
| **CZ14** | 3.42 | -0.94 | infinite |
| **CZ15** | 2.53 | -0.98 | infinite |
| **CZ16** | 3.36 | -1.04 | infinite |

### Table 50: 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** | 2.50 | -0.66 | infinite |
| **CZ02** | 3.02 | 1.84 | 1.63 |
| **CZ03** | 2.13 | -0.59 | infinite |
| **CZ04** | 2.32 | -0.49 | infinite |
| **CZ05** | 2.59 | 1.28 | 2.02 |
| **CZ06** | 2.24 | 0.08 | 28.89 |
| **CZ07** | 2.62 | 0.17 | 14.97 |
| **CZ08** | 2.47 | -0.77 | infinite |
| **CZ09** | 2.31 | -0.73 | infinite |
| **CZ10** | 3.21 | 1.71 | 1.87 |
| **CZ11** | 3.13 | 2.33 | 1.34 |
| **CZ12** | 2.52 | -0.83 | infinite |
| **CZ13** | 3.48 | 2.56 | 1.36 |
| **CZ14** | 2.94 | -0.92 | infinite |
| **CZ15** | 2.71 | -1.16 | infinite |
| **CZ16** | 3.12 | -1.07 | infinite |

### Table 51: 30-Year Cost-Effectiveness Summary Per Square Foot – New Construction & Additions

| Prototype | Benefits LSC Savings + Other PV Savings (2029 PV$) | Costs Total Incremental PV Costs (2029 PV$) | Benefit-to-Cost Ratio |
|---|---|---|---|
| **Assembly** | 0.79 | -0.03 | infinite |
| **Grocery** | 0.66 | -0.23 | infinite |
| **OfficeLarge** | 0.37 | -0.05 | infinite |
| **RetailLarge** | 0.02 | -0.02 | infinite |
| **SchoolLarge** | 1.25 | 0.09 | 14.00 |
| **OfficeMedium** | 0.14 | -0.21 | infinite |
| **RetailMedium** | 0.39 | -0.46 | infinite |
| **RestaurantFastFood** | 13.34 | -4.50 | infinite |
| **SchoolSmall** | 5.23 | -0.26 | infinite |
| **OfficeMediumLab** | 4.76 | -0.86 | infinite |

Table 52: 30-Year Cost-Effectiveness Summary Per Square Foot – Alterations

| Prototype | Benefits LSC Savings + Other PV Savings (2029 PV$) | Costs Total Incremental PV Costs (2029 PV$) | Benefit-to-Cost Ratio |
|---|---|---|---|
| **Assembly** | 0.84 | -0.03 | infinite |
| **Grocery** | 0.69 | -0.28 | infinite |
| **OfficeLarge** | 0.39 | -0.07 | infinite |
| **RetailLarge** | 0.02 | 0.00 | 3.91 |
| **SchoolLarge** | 1.32 | 0.12 | 10.99 |
| **OfficeMedium** | 0.15 | -0.26 | infinite |
| **RetailMedium** | 0.39 | -0.57 | infinite |
| **RestaurantFastFood** | 13.71 | -5.62 | infinite |
| **SchoolSmall** | 5.56 | -0.20 | infinite |
| **OfficeMediumLab** | 4.84 | -1.08 | infinite |

## 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 53) and alterations (Table 54) by climate zone. Table 55 presents first-year statewide savings from new construction, additions, and alterations.

Table 53: 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 | 203 | 0.00 | 0.00 | - | 0.00 | $0.00 |
| 2 | 66,371 | 0.00 | 0.00 | - | 0.00 | $1.63 |
| 3 | 502,236 | 0.22 | 0.02 | - | 0.37 | $8.04 |
| 4 | 144,858 | 0.03 | 0.00 | - | 0.04 | $3.62 |
| 5 | 3,211 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 6 | 1,842,881 | 0.53 | 0.06 | - | 0.90 | $4.65 |
| 7 | 21,479 | 0.01 | 0.00 | - | 0.01 | $0.05 |
| 8 | 3,409,890 | 0.92 | 0.11 | - | 1.57 | $8.04 |
| 9 | 5,626,558 | 1.58 | 0.18 | - | 2.68 | $13.72 |
| 10 | 2,170,325 | 0.79 | 0.09 | - | 1.34 | $6.85 |
| 11 | 7,062 | 0.00 | 0.00 | - | 0.00 | $0.02 |
| 12 | 54,834 | 0.02 | 0.00 | - | 0.04 | $2.93 |
| 13 | 11,225 | 0.01 | 0.00 | - | 0.01 | $0.05 |
| 14 | 79,710 | 0.03 | 0.00 | - | 0.05 | $0.27 |
| 15 | 349,640 | 0.10 | 0.01 | - | 0.17 | $0.88 |
| 16 | 79,804 | 0.03 | 0.00 | - | 0.05 | $0.27 |
| **Total** | **14,370,286** | **4.26** | **0.49** | **-** | **7.26** | **$51.03** |

**Table 54: 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 | 399 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 2 | 173,916 | 0.02 | 0.00 | - | 0.04 | $4.10 |
| 3 | 687,653 | 0.20 | 0.02 | - | 0.35 | $16.21 |
| 4 | 522,046 | 0.18 | 0.02 | - | 0.30 | $9.57 |
| 5 | 6,958 | 0.00 | 0.00 | - | 0.00 | $0.02 |
| 6 | 5,010,289 | 1.28 | 0.15 | - | 2.18 | $11.22 |
| 7 | 48,669 | 0.01 | 0.00 | - | 0.02 | $0.13 |
| 8 | 9,469,288 | 2.68 | 0.31 | - | 4.57 | $23.37 |
| 9 | 14,017,751 | 3.72 | 0.42 | - | 6.34 | $32.37 |
| 10 | 6,411,199 | 2.37 | 0.27 | - | 4.03 | $20.58 |
| 11 | 15,497 | 0.01 | 0.00 | - | 0.01 | $0.05 |
| 12 | 198,437 | 0.03 | 0.00 | - | 0.04 | $6.18 |
| 13 | 32,504 | 0.01 | 0.00 | - | 0.02 | $0.11 |
| 14 | 279,936 | 0.09 | 0.01 | - | 0.16 | $0.82 |
| 15 | 965,782 | 0.30 | 0.03 | - | 0.51 | $2.62 |
| 16 | 225,244 | 0.08 | 0.01 | - | 0.14 | $0.70 |
| **Total** | **38,065,566** | **10.99** | **1.25** | **-** | **18.71** | **$128.05** |

**Table 55: 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** | 4.26 | 0.49 | - | 7.26 | 51.03 |
| **Alterations** | 11.0 | 1.3 | - | 18.7 | 128.1 |
| **Total** | **15.3** | **1.7** | **-** | **26.0** | **179** |

### 3.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 56 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 1,374 metric tons of carbon dioxide equivalent ($CO_2e$) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the [2028 CASE Methodology Report] for additional information.

**Table 56: First-Year Statewide GHG Emissions Impacts**

| Construction Type | Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e) | Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e) | Total Reduced GHG Emissions (Metric Ton CO2e) | Total Monetary Value of Reduced GHG Emissions ($) |
|---|---|---|---|---|
| **New Construction & Additions** | 339 | 0 | 384 | 62,373 |
| **Alterations** | 831 | 0 | 990 | 160,788 |
| **Total** | **1,170** | **0** | **1,374** | **223,161** |

### 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 a swing tank but would add extra HP in some cases. The Statewide CASE Team calculated the per square foot incremental material impacts for each prototype and climate zone, including the HP and swing tank. The Statewide CASE Team applied the statewide square footage impacted by the proposed measure to obtain the total statewide material impacts (Table 57).

Table 57 Annual Statewide Impacts on Material Use

| Material | Impact (I, D, of NC)[a] | First Year[b] Statewide Impacts (pounds) | Embodied GHG Emissions Saved (MT CO2e) |
|---|---|---|---|
| **Copper** | I | 26,548 | -34 |
| **Steel** | D | 362,988 | 200 |
| **Insulation** | I | 1,033 | 1 |
| **Plastic** | I | 6,637 | -6 |
| **Refrigerants** | I | 2,557 | -1,869 |
| **Glass** | D | 30,735 | 20 |
| **Total** | - | - | **-1,688** |

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). New to the 2028 energy code is to *italicize defined terms* when the terms are being used in its defined context. In-line comments that are not part of the proposed code language but are used to help describe the purpose of what is proposed are included *with greyed highlight and italics.*

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

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

### 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)

**SUBCHAPTER 2 DEFINITIONS**

**SECTION 201** [SECTION 100.1]

**DEFINITIONS**

**WATER HEATER** definitions include the following:

1. **CONSUMER WATER HEATER** is a water heater that meets the definition of a consumer product under USDOE 10 CFR 430.
2. **HEAT PUMP WATER HEATER (HPWH)** is a water heater that transfers thermal energy from one temperature level to another temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

   2.1 **INTEGRATED HEAT PUMP WATER HEATER** is a HPWH which has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.

   2.2 **SPLIT HEAT PUMP WATER HEATING SYSTEMS** are water heating systems where the HPWH is configured in one of the following arrangements:

   **SPLIT-REFRIGERANT HEAT PUMP WATER HEATER** is a HPWH which has a single outdoor section and one or more indoor sections connected to the outdoor section via a refrigerant circuit.

   **SPLIT-HYDRONIC HEAT PUMP WATER HEATER** is a HPWH that consists of multiple separate sections. One section houses all the refrigerant components, while one or more additional sections are designated for water storage. These sections are interconnected through a hydronic circuit.

3. **MULTI-PASS WATER HEATER** is a water heater which the cold water passes through multiple times. The water temperature increases with each pass, until the storage tank reaches the intended storage temperature.
4. **SINGLE-PASS WATER HEATER** is a water heater which the cold water passes through once and is heated to the intended use temperature.

**APPURTENANCES** are all elements that are in series in a service or domestic water heating system, including fittings (elbows, tees, flanges, etc.), pumps, valves (isolation, mixing, balancing, check, etc.), strainers, hose bibs, coil u-bends, meters, sensors, heat exchangers and air separators.

**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).

**TEMPERATURE MAINTENANCE HEATER IN PARALLEL CONFIGURATION** is a configuration where a secondary water heater is in parallel with the primary heat pump generation and storage system. The role of this secondary heater is to meet the temperature maintenance load.

**TEMPERATURE MAINTENANCE HEATER IN SERIES CONFIGURATION** is a configuration where a secondary water heater 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.

**501.3.1** [Section 140.5(a)] **Nonresidential occupancies.**

Service water-heating systems in *nonresidential buildings* shall meet the requirements of Sections 501.3.1.1, or 501.3.1.2 and 501.3.1.3 below, or meet the performance compliance requirements of Section 501.4 [Section 140.1].

**501.3.1.1** [Section 140.5(a)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 101.3 [Section 110.1], 500.3 [Section 110.3] and 501.2.1 [Section 120.3].

**Exception to Section 501.3.1.1:** A water-heating system serving an individual *bathroom* space may be an instantaneous electric *water heater*.

**501.3.1.2** [Section 140.5(a)2] **All other occupancies.**

A service water-heating system that meets the applicable requirements of Sections 101.3 [Section 110.1], 500.3 [Section 110.3], 501.2.1 [Section 120.3] and Section 501.3.3 [Section 140.5(c)].

**501.3.1.3** [New section] ***Split heat pump water heating systems.***

Where a *split heat pump water heating system is used,* it shall meet the requirements of 501.3.1.3.1 or 501.3.1.3.2 or 501.3.1.3.3 below:

**Exception to Section 501.3.1.3:** Hotel/motel buildings and nonresidential buildings with Group R occupancies.

**501.3.1.3.1 *Return to Primary Configuration***

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

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

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

3. 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.

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

**501.3.1.3.2 *Temperature maintenance heater in series configuration***

Installation shall follow NEEA Advanced Water Heater Specification for commercial *heat pump water heater* Tier 3 or higher, and the system shall satisfy the additional requirements:

1. The *primary heat pump storage tank* temperature setpoint shall be at least 135°F.

2. The temperature maintenance tank temperature setpoint shall be at least 10°F lower than the *primary heat pump storage tank* temperature setpoint.

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

**501.3.1.3.3 *Temperature maintenance heater in parallel configuration***

Installation shall follow NEEA Advanced Water Heater Specification for commercial heat pump water heater Tier 3 or higher, where electric *heat pump water heater* shall be the heat source.

**501.5.2.2** [Section 141.0(b)2] **Prescriptive requirements (Alterations).**

**501.5.2.2.1** [Section 141.0(b)2N] **Service water-heating systems.**

Service water-heating systems shall meet the requirements of Section 501.3.1.2 [Section 140.5(a)2] and Section 501.3.2 [Section 140.5(b)], except for the solar water heating requirements. Additionally, where a split *heat pump water heater* with recirculation is used, it shall meet the requirements in Section 501.3.1.3 [Section 140.5(a)3].

**Exception 1 to Section 501.5.2.2.1:** Split Heat pump outlet water temperature can reach 175°F or greater.

**Exception 2 to Section 501.5.2.2.1:** Multi pass heat pumps shall meet NEEA commercial heat pump water heater Tier 2 or higher.

### 3.6.4 Reference Appendices

**JA1 – Definitions**

**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 Advanced Water Heater Specification:

a) Water heater input power;
b) Water heater output capacity; and
c) Water heater COP

The performance data shall be provided at the following conditions:

d) 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.

**JA 14 – SECTION JA14.5 Design, installation and start up documentation requirements for nonresidential buildings**

**JA 14.5.1 Design Documentation Requirements for Designers**

Designers shall provide construction documentation to include the following information for *heat pump water heaters*:

1. System piping diagram, including side view of heating plant schematic, and details for all check valves, balancing valves, mixing valves, isolation valves, and service water heating system appurtenances
2. Mixing valve outlet temperature and return water temperature
3. Heat pump ON temperature setpoint
4. Heat pump OFF temperature setpoint
5. Series temperature maintenance tank temperature setpoint
6. Sequence of staging of temperature maintenance heater if there are multiple temperature maintenance heaters
7. Back up water heater temperature setpoint
8. Back up water heater staging
9. Sequence of operation if there are multiple HPWHs
10. Defrost derate factors for calculating output capacity on design day

### JA 14.5.2 Installation and Start Up Documentation Requirements for Installers

Installers 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. 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 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 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, 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.

**Section 5.9.2. Water Heaters**

**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.

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

**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 ft$^2$).

### 3.6.7 Compliance Forms

As discussed in Section 3.1.4.5, the NRCC-PLB-E, NRCI-PLB-E, LMCC-PLB-01-E, LMCI-PLB-E, NRCC-PRF-E and 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 mandatory requirements to Title 24, Part 6 to ensure that commercial 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 the installation of commercial unitary HP/ER HPWHs using 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 the 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 as noted in Table 2.3 of Joint Appendix 2 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 58 summarizes the scope of the proposed code change.

**Table 58: Scope of Proposed Code Change**

A ☑ indicates the proposed code change is relevant.

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

| Application Climate Zones | Energy Code Sections | Compliance Forms | Sections of ACM Reference Manuals |
|---|---|---|---|
| Climate Zones 1-16 | Part 6, Section 500.3 [110.3]<br>Joint Appendix Section 14 | LMCC-PLB-01<br>LMCI-PLB-E<br>NRCI-PLB-E<br>NRCC-PLB-E | N/A |

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

### 4.1.2 Benefits of Proposed Change

Installing unitary HP/ER HPWHs in nonresidential buildings would decrease energy usage and costs under the proposed change. 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, Delagah, Stevens, & Hacking, 2024; Staller, Chu, Delagah, & Adler, 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 the use of the product's ER heater is not as efficient as the 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 the delivered hot water is 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 by requiring 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 this type of heating system, they are capable of adding thermal energy beyond 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 a coefficient of performance (i.e., efficiency) greater than one. For example, a 120-gallon commercially available HPWH designed for commercial buildings has a rated COP of 4.3, meaning that it only uses 23 percent of the energy required by an electric resistance water heater to deliver the same amount of hot water in the same application. In addition to energy savings, a heat pump can generate the same amount of hot water as an 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 when it is running out of hot water and needs a shorter recovery time. This configuration is known as “hybrid” mode, where the tank can run the heat pump for high efficiency but also use 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 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 affects 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 HPWH's capacity and efficiency decrease. To account for this relationship, manufacturers 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 during 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 also 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, as 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 so that the heat pump does not overly cool the space, to the point that it 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, Delagah, Stevens, & Hacking, 2024). The CalNEXT team monitored a water heating system comprised of two hybrid HPWHs 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; combined with the continuous recirculation, this 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 due to 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 to evaluate the resulting 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 several factors. First, ambient temperatures in the spaces surrounding the unitary HP/ER water heaters are low, with preliminary results indicating that the ambient temperatures can drop below 50°F. Another factor is that high setpoint temperatures may lead to increased ER use, and these installed systems had a range of setpoints. Staller et al (2026) found ambient temperatures 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, supported by 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, Delagah, Stevens, & Hacking, 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 for 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 500.3 [110.3] – MANDATORY REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT**

The proposed measure adds requirements for unitary commercial heat pump/electric resistance hybrid water heaters to be specified and installed in nonresidential buildings 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 commercial 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 the compliance software to account for the proposed mandatory measure.

#### *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-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

### 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 59 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 59: Impacts on Market Actors and Suggested Training and Education Opportunities**

| Market Actor | Impact(s) | Suggested Outreach and Education |
|---|---|---|
| **Owner/Developer [a]** | Possible impacts due to requiring more space to meet the ventilation space requirements. | Train the design professionals who consult for owners and developers on selection of proper system type (e.g., split systems where meeting ventilation space requirements is challenging). |
| **Design Professional [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 Department [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 Tester [e]** | None | N/A |
| **Manufacturers and Distributors** | Increased data reporting burden | Educate manufacturers on the need for equipment performance data to allow designers to properly size systems |

a. Owner/Developer is funding the project and is the primary decision maker.
b. Design professionals include architects, engineers (mechanical, electrical, plumbing, structural), specification writers, cost estimators, commissioning agents, lighting designers, and energy consultants.
c. Construction team includes general contractors, design-build contractors, installation contractors (e.g., HVAC, plumbing, electrical), commissioning agents, and tradespeople.
d. Building departments include plans reviewers, building inspectors, specialty inspectors, permit counter technicians and third-party plan review and inspection.
e. Verification testers include commissioning agents, ECC Raters, and Acceptance Test Technicians.

The 2028 CASE Methodology Report presents a quantitative assessment of how changes to the California building code impact builders, building designers and energy consultants, and building owners and occupants. While the analysis in the methodology report is not specific to the code change(s) presented in this report, this measure focuses on owners/developers, design professionals, the construction team, and manufacturers, since these market actors are expected to experience the most direct impacts from the proposed requirements on design and installation of unitary HP/ER water heaters. 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 60 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.

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

**Table 60: 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.)

*An establishment is single economic unit, typically at one physical location, that engages in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Many businesses are composed of multiple establishments. U.S. Bureau of Labor Statistics, Handbook of Methods. **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 not require changes to the compliance software.

### 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.

Plan review function would consist of reviewing LMCC-PLB-01 and NRCC-PLB-E and ensuring that it meets the new code requirement and is consistent with the drawings and specifications.

Inspection review would consist of reviewing LMCI-PLB-E and NRCI-PLB-E and ensuring that the information on the forms is consistent with the approved LMCC-PLB-01 and NRCC-PLB-E forms and with what is actually installed.

## 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, supported by utility incentive programs (Statewide Midstream Water Heating Program, 2025). The current market share of these units is 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 has found 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 can be addressed by relatively simple requirements (Garcia, Delagah, Stevens, & Hacking, 2024). The Statewide CASE Team notes a lack of awareness and attention to these problems in 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 the requirements for achieving an energy-efficient installation. Given the growing adoption of these systems, the current system inefficiencies will persist unless the Energy Code mandates 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 redesign of their products and improved reporting of those cutoff values for use by designers and code officials.

The Statewide CASE Team has determined that the current unitary commercial-grade heat pump water heater can meet the proposed requirements and will not require redesign. The manufacturers will also need to provide clear requirements for the air volume in the space where the unitary HP/ER water heaters are installed, so that the water heaters can operate without overly cooling the surrounding space.

The Statewide CASE Team has found that manufacturers already provide such information (A.O. Smith, 2025). The Statewide CASE Team is aware of one model of unitary heat pump water heater for central recirculation systems that the proposed measure would impact (manufactured by A.O. Smith), but it may also impact other manufacturers of 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 it provides information on the required air volume surrounding the water heaters. The Statewide CASE Team determined that manufacturers do not currently report compressor cutoff temperatures and would need to adjust their 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 their ability to operate at the specified local design temperatures.

The proposed measure applies to situations in which the 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, the designer can opt for other types of water heaters to meet the building's demand.

#### *4.3.1.2 Market Challenges and Solutions*

A key market challenge for the measure is the small number of unitary commercial HPWH's currently on the market. As of April 2026, there is only a single model of unitary commercial-grade HPWH on the market compared to over 200 entries each for electric resistance and natural gas storage water heaters in the AHRI Certification Directory (AHRI, 2026). 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 unclear how many units designers and installers specify and install outside these programs. Educational materials for the design and contracting community will increase market uptake of the technology and ensure that the proposed measure results in unitary HP/ER water heater systems that meet their intended performance.

Section 4.2 describes workforce trainings 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 practices 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 altering the surrounding infrastructure. The Statewide CASE Team found 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.

#### *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, improving the water heater's ability 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*

Several 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 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 serve nonresidential applications. The Statewide CASE Team identified at least ten manufacturers that make unitary heat pump water heaters with rated storage volume of 80 gallons or greater for potential use in nonresidential applications. Additionally, the goal of operating the systems primarily in heat pump mode, as a designer and installer would expect, depends on water heater control algorithms that are outside of the designer's purview. 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 them. 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 to characterize compressor cutoffs.

Another design and construction challenge concerns 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 59 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

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

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

The proposed measure would provide benefits to ESJ communities related to health and safety, resilience, cost, and comfort. The proposed measure should reduce the risk of water-borne pathogens by creating installation conditions for unitary HP/ER water heaters that allow them to operate at their rated heating capacity, thereby reducing the risk that the water heaters would not maintain adequate temperature in the systems. This benefit is relatively small in nonresidential buildings but could have applicability in nonresidential buildings with showers or other end uses that create aerosolized water droplets.

The Statewide CASE Team expects marginal benefits related to resilience because the proposed measure would size systems correctly to maintain a larger capacity of stored hot water that would be available to end uses during power outages. The proposed measure would increase first costs, but operating costs would be lower. The proposed measure would also enhance occupant comfort by reducing the chance of hot water runouts.

### 4.3.4 Impacts on Jobs and Businesses

The Statewide CASE Team does not anticipate significant employment or financial impacts on any particular sector of the California economy. However, the proposed change may have modest impacts on employment in California. The Statewide CASE Team estimates the proposed change would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, energy consultants, and building inspectors. Table 61, Table 62, and Table 63 outline the statewide implications for these job categories. For more information on the Statewide CASE Team's economic impacts methodology, see the 2028 CASE Methodology Report.

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

**Table 61: Estimated Impact that Adoption of the Proposed Measure would have on the California Nonresidential Construction Sector**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| Direct Effects (Additional spending by Commercial Builders) | 34.0 | $2,675,612 | $3,593,399 | $7,113,433 |
| Indirect Effect (Additional spending by firms supporting Commercial Builders) | 14.4 | $1,166,663 | $1,952,920 | $3,467,292 |
| **Total Economic Impacts** | **48.4** | **$3,842,274** | **$5,546,319** | **$10,580,726** |

Source: Statewide CASE Team analysis of data from the IMPLAN modeling software.[12]

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

**Table 62: Estimated Impact that Adoption of the Proposed Measure would have on the California Building Designers and Energy Consultant Sectors**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| **Direct Effects (Additional spending by building designers and energy consultants)** | 0.4 | $40,423 | $40,018 | $63,252 |
| **Indirect Effect (Additional spending by firms supporting building designers and energy consultants)** | 0.1 | $12,036 | $16,727 | $26,928 |
| **Total Economic Impacts** | **0.5** | **$52,458** | **$56,745** | **$90,180** |

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

**Table 63: Estimated Impact that Adoption of the Proposed Measure would have on California Building Inspectors**

| Type of Economic Impact | Employment (Jobs) | Labor Income | Total Value Added | Output |
|---|---|---|---|---|
| **Direct Effects (Additional spending by building inspectors)** | 0.1 | $10,975 | $13,015 | $15,815 |
| **Indirect Effect (Additional spending by firms supporting building inspectors)** | 0.0 | $1,016 | $1,583 | $2,757 |
| **Total Economic Impacts** | **0.1** | **$11,991** | **$14,958** | **$18,572** |

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

The proposed change represents a modest adjustment that is not expected to excessively burden or competitively disadvantage California businesses, nor to confer a competitive advantage for California businesses. Therefore, the Statewide CASE Team does not expect the proposed code changes to result in the creation of new businesses or the elimination of existing ones.

The proposed code changes would apply to all businesses operating in California, regardless of whether the business is incorporated inside or outside of the state.[13]

Therefore, the Statewide CASE Team does not anticipate that the proposed changes would have an advantageous or an adverse effect on the competitiveness of California businesses.

The Statewide CASE Team derived a reasonable estimate of the change in investment by California businesses based on the estimated change in economic activity associated with the proposed measure and its expected effect on business income. The

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

Statewide CASE Team's IMPLAN modeling resulted in an estimated $868,684 increase in California business income due to the proposed code change. The Statewide CASE Team assumed that net business investment is positively correlated with business income and that a portion of business income will be allocated to net business investment.[14]

To estimate the portion of business income that would be allocated to net investment, the Statewide CASE Team analyzed national data on corporate profits and net capital investment by businesses that expand a firm's capital stock (referred to as net private domestic investment, or NPDI).[15] As Table 64 shows, between 2020 and 2024, NPDI as a percentage of corporate profits ranged from a low of 18 percent in 2020 due to the worldwide economic slowdowns associated with the COVID 19 pandemic to a high of 28 percent in 2011, with an average of 23 percent. While only an approximation of the proportion of business income used for net capital investment, it provides a reasonable estimate of the proportion of proprietor income that business owners would reinvest into expanding their capital stock.

**Table 64: Net Domestic Private Investment and Corporate Profits, U.S.**

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

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

Given the estimated total increase in California business income and net business investment ratio described above, the Statewide CASE Team estimates the proposed code change would result in a $203,914 increase in net private investment by California businesses.

[14] 26 percent of proprietor income was assumed to be allocated to net business investment; see Table 15.

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

### 4.3.5 Economic and Fiscal Impacts

The Statewide CASE Team does not anticipate that the economic impacts associated with the proposed measure would lead to a significant change (increase or decrease) in investment, directly or indirectly, in any affected sectors of California's economy. The proposed change would not result in economic disruption to any sector of the California economy.

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

#### *4.3.5.1 Effects on the State General Fund, State Special Funds, and Local Governments*

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

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

**Cost to Local Governments:** All proposed code changes to Title 24, Part 6 would result in changes to compliance determinations. Local governments would need to train building department staff on the revised Title 24, Part 6 Standards. While this retraining is an expense to local governments, it is not a new cost associated with the 2025 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training, and resources provided by the IOU Codes and Standards program (such as Energy Code Ace). As noted in Section 4.2.2, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

#### 4.3.5.2 Mandates on Local Agencies or School Districts

There are no mandates to local agencies or school districts because the requirements would be specified at the statewide level through Title 24, Part 6.

#### 4.3.5.3 Costs to Local Agencies or School Districts

This measure may impose additional costs on local agencies or school districts undertaking new construction or water heater replacement projects, depending on the energy code compliance path being used.

#### 4.3.5.4 Costs or Savings to Any State Agency

There are no costs or savings to state agencies because they would not be involved in enforcement of this measure.

#### 4.3.5.5 Other Non-Discretionary Cost or Savings Imposed on Local Agencies

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

#### 4.3.5.6 Costs or Savings in Federal Funding to the State

There are no costs or savings to federal funding to the state. The proposed measure is a relatively small cost that the market would bear. The state would not require federal funding to implement the proposed measure.

## 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 65 through Table 68 and Table 70 through Table 73 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 0.02 to 0.9 (kWh/ft$^2$)/yr, depending upon CZ. Demand reductions are expected to range between 0.0 (kW/ft$^2$)/yr and 0.1 (kW/ft$^2$)/yr, depending on CZ. Because the proposed measure is specific to electric heat pump systems, there are no natural gas savings.

Table 69 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 69 presents a breakdown of total LSC savings from electricity savings for the prototypical buildings. Table 74 presents total per-unit energy cost savings for alterations in terms of LSC savings realized over a 30-year period, in 2029 present value dollars (2029 PV$).

**Table 65: 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 | 0.04 | 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 |
| Grocery | 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 |
| Large Office | 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 |
| Large Retail | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.08 | 0.12 |
| Large School | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.14 | 0.18 |
| 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 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.09 |
| Restaurant | 0.89 | 0.85 | 0.85 | 0.84 | 0.85 | 0.81 | 0.81 | 0.80 | 0.80 | 0.80 | 0.81 | 0.83 | 0.80 | 0.81 | 0.73 | 0.88 |
| Small School | 0.24 | 0.24 | 0.24 | 0.23 | 0.24 | 0.23 | 0.23 | 0.23 | 0.23 | 0.22 | 0.23 | 0.23 | 0.22 | 0.23 | 0.21 | 0.24 |
| Strip Mall | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.15 | 0.19 |
| Laboratory | 0.21 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.20 | 0.19 | 0.19 | 0.18 | 0.21 |

## Table 66: 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** | 0.00 | 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 |
| **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 |
| **Large Office** | 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 Retail** | 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 School** | 0.02 | 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 | 0.02 |
| **Medium Office** | 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 |
| **Medium Retail** | 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** | 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 | 0.08 | 0.10 |
| **Small School** | 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 |
| **Strip Mall** | 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 |
| **Laboratory** | 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 |

**Table 67: 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** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Grocery** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Large Office** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Large Retail** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Large School** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Medium Office** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Medium Retail** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Restaurant** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Small School** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Strip Mall** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Laboratory** | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Table 68: 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 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 |
| Grocery | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.07 |
| Large Office | 0.05 | 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 | 0.05 |
| 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 | 0.19 | 0.19 | 0.19 | 0.18 | 0.19 | 0.18 | 0.18 | 0.17 | 0.18 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.16 | 0.19 |
| 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 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.11 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.11 |
| Restaurant | 1.39 | 1.34 | 1.33 | 1.32 | 1.33 | 1.27 | 1.27 | 1.26 | 1.26 | 1.25 | 1.28 | 1.30 | 1.26 | 1.28 | 1.15 | 1.37 |
| Small School | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.27 | 0.27 | 0.27 | 0.28 | 0.28 | 0.28 | 0.28 | 0.26 | 0.29 |
| Strip Mall | 0.24 | 0.23 | 0.23 | 0.22 | 0.23 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.21 | 0.22 | 0.19 | 0.24 |
| Laboratory | 0.29 | 0.29 | 0.29 | 0.28 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 | 0.28 | 0.28 | 0.27 | 0.29 |

**Table 69: 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 | 0.29 | 0.28 | 0.27 | 0.26 | 0.27 | 0.24 | 0.25 | 0.25 | 0.26 | 0.25 | 0.25 | 0.26 | 0.24 | 0.24 | 0.21 | 0.30 |
| Grocery | 0.38 | 0.37 | 0.36 | 0.36 | 0.36 | 0.35 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.35 | 0.34 | 0.35 | 0.31 | 0.38 |
| Large Office | 0.31 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.26 | 0.25 | 0.26 | 0.25 | 0.26 | 0.27 | 0.26 | 0.26 | 0.22 | 0.30 |
| Large Retail | 0.91 | 0.84 | 0.83 | 0.79 | 0.84 | 0.72 | 0.72 | 0.71 | 0.72 | 0.70 | 0.72 | 0.78 | 0.70 | 0.71 | 0.55 | 0.88 |
| Large School | 1.36 | 1.30 | 1.29 | 1.26 | 1.29 | 1.21 | 1.21 | 1.20 | 1.21 | 1.20 | 1.21 | 1.25 | 1.20 | 1.21 | 1.07 | 1.33 |
| Medium Office | 0.16 | 0.15 | 0.15 | 0.14 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.13 | 0.15 |
| Medium Retail | 0.72 | 0.69 | 0.69 | 0.67 | 0.69 | 0.65 | 0.65 | 0.65 | 0.65 | 0.64 | 0.65 | 0.67 | 0.64 | 0.64 | 0.59 | 0.71 |
| Restaurant | 7.57 | 7.31 | 7.27 | 7.12 | 7.27 | 6.91 | 6.87 | 6.86 | 6.89 | 6.83 | 6.89 | 7.07 | 6.80 | 6.90 | 6.21 | 7.52 |
| Small School | 1.90 | 1.86 | 1.85 | 1.82 | 1.85 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.81 | 1.77 | 1.79 | 1.66 | 1.89 |
| Strip Mall | 1.50 | 1.43 | 1.42 | 1.38 | 1.43 | 1.31 | 1.31 | 1.31 | 1.32 | 1.30 | 1.32 | 1.38 | 1.30 | 1.31 | 1.14 | 1.48 |
| Laboratory | 1.70 | 1.65 | 1.65 | 1.63 | 1.65 | 1.60 | 1.59 | 1.57 | 1.58 | 1.57 | 1.59 | 1.62 | 1.58 | 1.59 | 1.49 | 1.67 |

**Table 70: 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** | 0.04 | 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 | 0.04 |
| **Grocery** | 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 |
| **Large Office** | 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 |
| **Large Retail** | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.08 | 0.12 |
| **Large School** | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.17 | 0.16 | 0.16 | 0.14 | 0.18 |
| **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** | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.08 | 0.08 | 0.08 | 0.09 |
| **Restaurant** | 0.90 | 0.87 | 0.86 | 0.85 | 0.86 | 0.83 | 0.82 | 0.81 | 0.82 | 0.81 | 0.82 | 0.84 | 0.81 | 0.82 | 0.74 | 0.89 |
| **Small School** | 0.25 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.24 | 0.23 | 0.24 | 0.22 | 0.25 |
| **Strip Mall** | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.15 | 0.19 |
| **Laboratory** | 0.21 | 0.21 | 0.21 | 0.20 | 0.21 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.19 | 0.21 |

**Table 71: 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 | 0.00 | 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 |
| 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 |
| Large Office | 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 Retail | 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 School | 0.02 | 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 | 0.02 |
| Medium Office | 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 |
| Medium Retail | 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 | 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 | 0.08 | 0.10 |
| Small School | 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 |
| Strip Mall | 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 |
| Laboratory | 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 |

Table 72: 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 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Grocery | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large Office | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large Retail | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Large School | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Medium Office | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Medium Retail | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Restaurant | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Small School | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Strip Mall | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Laboratory | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

Table 73: 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** | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 |
| **Grocery** | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.07 | 0.06 | 0.07 |
| **Large Office** | 0.05 | 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 | 0.05 |
| **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** | 0.20 | 0.19 | 0.19 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.18 | 0.18 | 0.17 | 0.20 |
| **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** | 0.12 | 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 | 0.10 | 0.12 |
| **Restaurant** | 1.41 | 1.36 | 1.35 | 1.34 | 1.35 | 1.29 | 1.29 | 1.28 | 1.28 | 1.27 | 1.30 | 1.32 | 1.28 | 1.30 | 1.17 | 1.39 |
| **Small School** | 0.30 | 0.30 | 0.30 | 0.29 | 0.30 | 0.29 | 0.29 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.27 | 0.30 |
| **Strip Mall** | 0.24 | 0.23 | 0.23 | 0.22 | 0.23 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.21 | 0.22 | 0.19 | 0.24 |
| **Laboratory** | 0.30 | 0.30 | 0.30 | 0.29 | 0.30 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.28 | 0.30 |

### Table 74: 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** | 0.29 | 0.28 | 0.28 | 0.27 | 0.28 | 0.25 | 0.25 | 0.26 | 0.26 | 0.25 | 0.25 | 0.26 | 0.25 | 0.25 | 0.21 | 0.30 |
| **Grocery** | 0.38 | 0.37 | 0.37 | 0.36 | 0.37 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.36 | 0.35 | 0.35 | 0.32 | 0.38 |
| **Large Office** | 0.31 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.28 | 0.26 | 0.26 | 0.23 | 0.31 |
| **Large Retail** | 0.91 | 0.84 | 0.83 | 0.79 | 0.84 | 0.72 | 0.72 | 0.71 | 0.72 | 0.70 | 0.72 | 0.78 | 0.70 | 0.71 | 0.56 | 0.88 |
| **Large School** | 1.39 | 1.33 | 1.32 | 1.29 | 1.32 | 1.24 | 1.24 | 1.23 | 1.24 | 1.23 | 1.24 | 1.28 | 1.22 | 1.24 | 1.10 | 1.36 |
| **Medium Office** | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.14 | 0.14 | 0.13 | 0.15 |
| **Medium Retail** | 0.73 | 0.71 | 0.70 | 0.69 | 0.71 | 0.66 | 0.66 | 0.66 | 0.67 | 0.66 | 0.66 | 0.68 | 0.66 | 0.66 | 0.60 | 0.72 |
| **Restaurant** | 7.68 | 7.42 | 7.38 | 7.23 | 7.38 | 7.02 | 6.98 | 6.97 | 7.00 | 6.94 | 7.00 | 7.18 | 6.91 | 7.01 | 6.32 | 7.63 |
| **Small School** | 1.97 | 1.92 | 1.92 | 1.89 | 1.91 | 1.85 | 1.84 | 1.85 | 1.85 | 1.84 | 1.85 | 1.88 | 1.83 | 1.86 | 1.72 | 1.95 |
| **Strip Mall** | 1.50 | 1.43 | 1.42 | 1.38 | 1.43 | 1.31 | 1.31 | 1.31 | 1.32 | 1.30 | 1.32 | 1.38 | 1.30 | 1.31 | 1.14 | 1.48 |
| **Laboratory** | 1.74 | 1.69 | 1.69 | 1.67 | 1.69 | 1.64 | 1.63 | 1.61 | 1.62 | 1.61 | 1.63 | 1.66 | 1.62 | 1.62 | 1.53 | 1.71 |

### 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 higher first costs for 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 to estimate the incremental first costs. Other provisions in the proposed changes may allow use of the same water heater, 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 Statewide CASE Team considers 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, with a rated heat pump output of 41,669 Btu/h indicates a required louver area of 4 square feet per unit (A.O. Smith, 2025). 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 used an online sizing calculator (A.O. Smith, 2025) to estimate the number of these unitary HP/ER water heaters 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 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 (Feng, August 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 (as of March 2026). 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 cost of the additional water heater is based on data from a contractor received in 2/2026.

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 in 2/2026. 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 estimates that there will be no incremental maintenance costs associated with this proposed measure. The major change will involve the installation of passive louvers in the space and setup routines, which would not require maintenance. The proposed measure could increase replacement costs if it requires a larger water heater. The analysis assumes that the water heater will be replaced 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 75 and Table 76 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.

### Table 75: 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 | 0.74 | 0.13 | 5.69 |
| 2 | 0.93 | 0.17 | 5.64 |
| 3 | 1.11 | 0.53 | 2.11 |
| 4 | 0.90 | 0.22 | 4.00 |
| 5 | 1.17 | 0.20 | 5.88 |
| 6 | 0.95 | 0.20 | 4.71 |
| 7 | 1.02 | 0.35 | 2.90 |
| 8 | 0.92 | 0.21 | 4.39 |
| 9 | 0.91 | 0.16 | 5.53 |
| 10 | 1.12 | 0.28 | 4.06 |
| 11 | 1.17 | 0.19 | 6.30 |
| 12 | 1.01 | 0.26 | 3.93 |
| 13 | 1.26 | 0.35 | 3.58 |
| 14 | 1.19 | 0.25 | 4.70 |
| 15 | 0.90 | 0.17 | 5.27 |
| 16 | 1.24 | 0.20 | 6.27 |

Table 76: 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 | 1.17 | 0.22 | 5.80 |
| 2 | 1.13 | 0.25 | 5.78 |
| 3 | 0.98 | 0.27 | 2.15 |
| 4 | 1.02 | 0.35 | 4.10 |
| 5 | 1.09 | 0.21 | 6.03 |
| 6 | 0.95 | 0.20 | 4.82 |
| 7 | 1.00 | 0.26 | 2.97 |
| 8 | 0.96 | 0.20 | 4.48 |
| 9 | 0.96 | 0.19 | 5.66 |
| 10 | 1.14 | 0.23 | 4.16 |
| 11 | 1.12 | 0.21 | 6.47 |
| 12 | 1.02 | 0.21 | 4.04 |
| 13 | 1.19 | 0.24 | 3.68 |
| 14 | 1.13 | 0.21 | 4.82 |
| 15 | 0.98 | 0.18 | 5.42 |
| 16 | 1.25 | 0.21 | 6.43 |

## 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 77) and alterations (Table 78) by climate zone. Table 79 presents first-year statewide savings from new construction, additions, and alterations.

**Table 77: Statewide Energy and LSC Impacts – New Construction and Additions**

| Climate Zone | Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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 | 241 | 0.00 | 0.00 | - | 0.00 | $0.00 |
| 2 | 78,598 | 0.00 | 0.00 | - | 0.00 | $0.42 |
| 3 | 605,707 | 0.10 | 0.01 | - | 0.14 | $2.40 |
| 4 | 207,579 | 0.02 | 0.00 | - | 0.03 | $1.05 |
| 5 | 2,173 | 0.00 | 0.00 | - | 0.00 | $0.00 |
| 6 | 1,206,283 | 0.14 | 0.01 | - | 0.19 | $1.14 |
| 7 | 12,932 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 8 | 2,216,086 | 0.25 | 0.02 | - | 0.33 | $2.04 |
| 9 | 3,717,146 | 0.42 | 0.04 | - | 0.54 | $3.37 |
| 10 | 1,576,219 | 0.22 | 0.02 | - | 0.29 | $1.76 |
| 11 | 4,432 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 12 | 68,298 | 0.01 | 0.00 | - | 0.02 | $0.79 |
| 13 | 9,134 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 14 | 60,983 | 0.01 | 0.00 | - | 0.01 | $0.07 |
| 15 | 276,770 | 0.03 | 0.00 | - | 0.04 | $0.25 |
| 16 | 58,234 | 0.01 | 0.00 | - | 0.01 | $0.07 |
| **Total** | **10,100,814** | **1.22** | **0.12** | **-** | **1.60** | **$13.40** |

**Table 78: Statewide Energy and LSC Impacts – Alterations**

| Climate Zone | Statewide New Construction & Additions Impacted by Proposed Change in 2029 (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 | 1,461 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 2 | 409,807 | 0.03 | 0.00 | - | 0.05 | $2.28 |
| 3 | 1,602,859 | 0.20 | 0.02 | - | 0.28 | $10.02 |
| 4 | 1,140,080 | 0.16 | 0.02 | - | 0.22 | $5.82 |
| 5 | 9,752 | 0.00 | 0.00 | - | 0.00 | $0.01 |
| 6 | 6,733,270 | 0.82 | 0.08 | - | 1.04 | $6.41 |
| 7 | 67,672 | 0.01 | 0.00 | - | 0.01 | $0.07 |
| 8 | 13,130,173 | 1.58 | 0.15 | - | 2.03 | $12.62 |
| 9 | 18,876,262 | 2.27 | 0.21 | - | 2.91 | $18.17 |
| 10 | 9,922,828 | 1.41 | 0.13 | - | 1.83 | $11.29 |
| 11 | 23,436 | 0.00 | 0.00 | - | 0.00 | $0.03 |
| 12 | 520,411 | 0.05 | 0.00 | - | 0.06 | $3.61 |
| 13 | 48,845 | 0.01 | 0.00 | - | 0.01 | $0.06 |
| 14 | 423,408 | 0.06 | 0.01 | - | 0.08 | $0.48 |
| 15 | 1,612,989 | 0.20 | 0.02 | - | 0.26 | $1.58 |
| 16 | 332,532 | 0.05 | 0.00 | - | 0.07 | $0.41 |
| **Total** | **54,855,784** | **6.87** | **0.65** | **-** | **8.84** | **$72.87** |

**Table 79: 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** | 1.2 | 0.12 | - | 1.6 | 13 |
| **Alterations** | 6.9 | 0.65 | - | 8.8 | 73 |
| **Total** | **8.1** | **0.8** | **-** | **10.4** | **86** |

### 4.5.2 Statewide Greenhouse Gas Emissions Reductions

Table 80 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 552 metric tons of carbon dioxide equivalent ($CO_2e$) emissions. These reductions, along with their associated monetary value, were calculated using hourly GHG emissions factors published alongside the LSC hourly factors and source energy hourly factors in the research versions of CBECC, as well as data from the CEC's 2028 Metrics Report. See the 2028 CASE Methodology Report for additional information.

**Table 80: First-Year Statewide GHG Emissions Impacts**

| Measure | Reduced GHG Emissions from Electricity Savings (Metric Tons CO2e) | Reduced GHG Emissions from Natural Gas Savings (Metric Tons CO2e) | Total Reduced GHG Emissions (Metric Ton CO2e) | Total Monetary Value of Reduced GHG Emissions ($) |
|---|---|---|---|---|
| **Unitary HP/ER Hybrid Heaters** | 552 | 0 | 552 | 89,749 |
| **Total** | **552** | **0** | **552** | **89,749** |

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

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

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

### 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)

**SUBCHAPTER 2 DEFINITIONS**

**SECTION 201** [Section 100.1]

**DEFINITIONS**

**WATER HEATER** definitions include the following**:**

1. **CONSUMER WATER HEATER** is a water heater that meets the definition of a consumer product under USDOE 10 CFR 430.
2. **HEAT PUMP WATER HEATER (HPWH)** is a water heater that transfers thermal energy from one temperature level to another temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

2.1 **COMMERCIAL HEAT PUMP WATER** HEATER is a water heater that meets the definitions under USDOE 10 CFR 431.102, meaning a water heater (including all ancillary equipment such as fans, blowers, pumps, storage tanks, piping, and controls, as applicable) that uses a refrigeration cycle, such as vapor compression, to transfer heat from a low-temperature source to a higher-temperature sink for the purpose of heating potable water, and operates with a current rating greater than 24 amperes or a voltage greater than 250 volts.

~~2.1~~ 2.2 **INTEGRATED HEAT PUMP WATER HEATER** is a HPWH that has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.

~~2.2~~ 2.3 **SPLIT-REFRIGERANT HEAT PUMP WATER HEATER** is a HPWH which has a single outdoor section and one or more additional sections are designated

~~2.3~~ 2.4 **SPLIT-HYDRONIC HEAT PUMP WATER** is a HPWH that consists of multiple separate sections. One section houses all the refrigerant components, while one or more additional sections are designated for water storage. These sections are interconnected through a hydronic circuit.

3. **MULTI-PASS WATER HEATER** is a water heater that the cold water passes through multiple times. The water temperature increases with each pass until the storage tank reaches the intended storage temperature.
4. **SINGLE-PASS WATER HEATER** is a water heater which the cold water passes through once and is heated to the intended use temperature.
5. **UNITARY WATER HEATER** is a water heater that has the heating source and a storage tank integrated into a single piece of equipment.

**REVERSE RETURN CONFIGURATION** is a plumbing arrangement when multiple hot water storage tanks are used to supply service hot water as part of a recirculation system that means that the water heater with the shortest return piping length from the recirculation loop has the longest supply piping length back to the recirculation loop and that all water heaters in a parallel configuration have the same length of piping from the recirculation return to the supply.

**SUBCHAPTER 5 PLUMBING**

**SECTION 500**

**MANDATORY REQUIREMENTS FOR ALL OCCUPANCIES**

**(NEWLY CONSTRUCTED, ADDITIONS, ALTERATIONS)**

**500.3** [Section 110.3] **Service water-heating systems and equipment.**

**500.3.4 [New section)] Integrated *Unitary Commercial Heat Pump Water Heaters*.**

Integrated *unitary commercial heat pump water heating* systems with integrated electric resistance heating elements serving all nonresidential occupancies shall be sized to meet the requirements of JA14.6.1, shall meet the installation requirements of JA14.6.2, and shall meet the following requirements:

1. The minimum heat pump water heater compressor cut-off temperature shall be reported by manufacturers and shall be equal to or lower than 40°F ambient air temperature in heat pump-only mode and equal to or lower than 47°F in hybrid mode in which the unit operates with both heat pump and electric resistance heating methods.
2. 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.
3. If outside air is used to meet the heat source requirements, the heat pump water heater shall be able to operate in heat pump mode under Heating Design Drybulb (0.6%) conditions as described in Table 2.3 from JA2.

**Exception to Section 500.3.4:** Integrated unitary commercial heat pump water heaters in hotel/motel buildings and nonresidential buildings with Group R occupancies.

### 4.6.4 Reference Appendices

**JA 14.6: Requirements of *Unitary Commercial Heat Pump Water Heaters* with Electric Resistance (HP/ER)**

**JA 14.6.1 Sizing of *Unitary Commercial HP/ER water heaters*.** *Unitary HP/ER water heaters* shall be sized based on manufacturer specifications for Hybrid Mode in which both the heat pump and electric resistance elements can operate to meet the calculated water demand. The designer shall size the Unitary HP/ER water heaters considering the following conditions:

1. Defrost cycles, if applicable,
2. The nominal voltage of the electric supply in the building,
3. Ambient temperature of 47°F, or an ambient temperature that the designer determines to be appropriate, and
4. 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 size the *unitary* HP/ER water heater system by assigning the delivery capacity of a unitary HP/ER water heater to be 20% less than that value reported by the manufacturer.

**JA 14.6.2: Installation and Setup of Unitary Commercial Heat Pump Water Heaters with Electric Resistance (HP/ER) 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:

1. 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
2. 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
3. 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
4. configure the plumbing to and from the recirculation loop in a *reverse return configuration*. Alternatively, the plumbing is configured 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 59 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 proposed measure will not require changes to the ACM Reference Manual.

### 4.6.7 Compliance Forms

As discussed in Section 4.1.4.5, the 2025-LMCC-PLB-01-E, 2025-LMCI-PLB-E, 2025-NRCI-PLB-E, and 2025 NRCC-PLB-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.

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# 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 a thermal modeling with a piping heat loss methodology described further in Appendix G. 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 81 presents the prototype buildings used in the analysis.

**Table 81: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis**

| Prototype Name | Number of Stories | Floor Area (Square Feet) | Description |
|---|---|---|---|
| **Office Large** | 12 | 498,589 | 12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR–40%. |
| **Office Medium** | 3 | 53,628 | 3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%. |
| **Office Medium Lab** | 3 | 53,628 | 3-story office building with 5 zones and a ceiling plenum on each floor. WWR–33%. |
| **Office Small** | 1 | 5,502 | 1-story, 5-zone office building with pitched roof and unconditioned attic. WWR–24%. |
| **Restaurant Fast Food** | 1 | 2,501 | Fast food restaurant with a small kitchen and dining areas. WWR–14%. Pitched roof with an unconditioned attic. |
| **School Small** | 1 | 24,413 | Elementary school with WWR–36%. |
| **School Large** | 2 | 210,866 | High school with WWR–35% and SRR–1.4%. |
| **Retail Large** | 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. |
| **Retail Mixed Use** | 1 | 9,375 | Similar to Office (Small, Medium, or Large). |
| **Retail Medium** | 1 | 24,563 | Similar to Office (small, medium, or large). |
| **Retail Strip Mall** | 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. |
| **Ref Warehouse** | 1 | 100,000 | Similar to Small office. |
| **Horticulture** | 1 | 100,000 | Similar to Small office. |
| **Manufacturing** | 1 | 100,000 | Similar to Small office. |
| **Vehicle Service** | 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 the 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 time clock 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 postprocessing. The Statewide CASE Team used variable speed ECM and constant return temperature as the control strategy for the proposed case.

### Table 82: 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 |
|---|---|---|---|---|---|
| **Office Large** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 10259 (NC), 10763 (AL);<br>56.69 | 9933 (NC), 10436 (AL);<br>24.33 |
| **Office Medium** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 2386 (NC), 2503 (AL);<br>13.18 | 2310 (NC), 2427 (AL);<br>5.66 |
| **Office Medium Lab** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 6028 (NC), 6270 (AL);<br>48.67 (NC),131.2 (AL) | 5866 (NC), 6101 (AL);<br>15.71 (NC),16.12(AL) |
| **Office Small** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 1021;<br>13.18 | 994;<br>5.66 |
| **Restaurant Fast Food** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 2945 (NC),3062 (AL);<br>24.31(NC),165.18(AL) | 2873 (NC),2987 (AL);<br>23.66(NC),24.88(AL) |
| **School Small** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 15827 (NC),16878(AL);<br>11.82 | 15394 (NC),16414(AL);<br>41.02(NC), 43.85(AL) |
| **School Large** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 31653 (NC),33755 (AL);<br>23.64 | 30787 (NC),32827 (AL);<br>82.04(NC),87.7(AL) |
| **Assembly** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 15827 (NC),16878(AL);<br>11.82 | 15394 (NC),16414(AL);<br>41.02(NC),43.85(AL) |
| **Retail Large** | All CZs | Hot water systems | Recirculation heat loss (Btu/h);<br>Pump power (W) | 1021;<br>13.18 | 994;<br>5.66 |

| Prototype ID | Climate Zone | Objects Modified | Parameter Name | Standard Design Parameter Value | Proposed Design Parameter Value |
|---|---|---|---|---|---|
| **Warehouse** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Retail Mixed Use** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Retail Medium** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Retail Strip Mall** | 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) |
| **Ref Warehouse** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Horticulture** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Manufacturin g** | All CZs | Hot water systems | Recirculation heat loss (Btu/h); Pump power (W) | 1021; 13.18 | 994; 5.66 |
| **Vehicle Service** | 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 83 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 $CO_2$, which already meets NEEA Tier 3 requirements; therefore, savings are not considered for these prototypes.

**Table 83: 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. |
| **Retail Large** | 1 | 240,000 | Big-box type retail building with WWR–12% and SRR–0.82%. |
| **Retail Medium** | 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 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 the California Simulation Engine (CSE) (26ht), the backend engine of CBECC to model central HPWH systems for multifamily buildings, to model a 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 84 through Table 87 demonstrate the energy use and savings from CSE modeling and lab and field test results. CSE modeling results show very low savings (less than 1 percent) for Return to Primary compared to TMHS configuration, while lab data shows much large savings (18 percent). For CO2 refrigerants, CSE modeling shows negative savings from TMHS to Return to Primary, however, field data shows 8 percent or ten percent positive savings.

**Table 84: Comparing CSE Results with Lab and Field Data — CBECC Modeling using 36-unit multifamily prototype**

| System Description | SHW Annual Consumption kWh | Savings kWh | Saving % |
|---|---|---|---|
| **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% |

**Table 85: Comparing CSE Results with Lab and Field Data — Lab 44 Apartments Test**

| System Description | SHW Annual Consumption kWh | Savings kWh | Saving % |
|---|---|---|---|
| **Colmac CxA-15 R134a TMHS** | 65,116 | / | / |
| **Colmac CxA-15 R134a Return to Primary** | 53,400 | 11,717 | 18% |

**Table 86: Comparing CSE Results with Lab and Field Data — AEA 81 Apartments Field Test**

| System Description | SHW Annual Consumption kWh | Savings kWh | Saving % |
|---|---|---|---|
| **Mitsubishi Heat2O TMHS** | 121,910 | / | / |
| **Mitsubishi Heat2O Return to Primary** | 112,420 | 9,490 | 8% |

**Table 87: Comparing CSE Results with Lab and Field Data — AEA 53 Apartments Field Test**

| System Description | SHW Annual Consumption kWh | Savings kWh | Saving % |
|---|---|---|---|
| **WaterDrop TMHS** | 25,185 | / | / |
| **WaterDrop Return to Primary** | 22,630 | 2,555 | 10% |

Based on the findings in Table 84 through Table 87, 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 of heat losses for the selected prototype, including Medium Office, Laboratory, Small Office, Restaurant, and Small School. For the remaining prototypes, the Statewide CASE Team estimated the distribution of heat loss based on the calculated data for the selected prototypes. After that, the Statewide CASE Team leveraged the NEEA CHPWH System Performance Calculator and provided weighted average water usage, average hourly distribution heat loss, hot water supply temperature, return temperature, and primary storage tank temperature for each prototype to obtain system COP for both the Standard and Proposed Design. The NEEA calculator references climates by the zones developed by the International Energy Conservation Code (IECC) to represent CZs nationwide. To adapt this for California, the Statewide CASE Team used the custom weather profile feature, incorporating CBECC weather data for each CZ. Therefore, 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.  presents the system COP in the Standard Design and Proposed Design for both new construction/additions, and alterations.

Table 88 presents the system COP in the Standard Design and Proposed Design for both new construction/additions, and alterations.

**Table 88: 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 |
|---|---|---|---|---|---|---|---|
| **Office Large** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **Office Medium** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **Office Medium Lab** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **Restaurant Fast Food** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **School Small** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **School Large** | 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 Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **Retail Large** | All CZs | Split HPWH System with Recirculation | System COP | Vary by CZ | Vary by CZ | Vary by CZ | Vary by CZ |
| **Retail Medium** | 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 systems in the 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, Delagah, Stevens, & Hacking, 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. The Statewide Case Team used a commercially available sizing tool to determine the number of water heaters for the base case, assuming the designer did not plan for degradation of the operation due to low ambient temperatures or excessive electric resistance use. A 20 percent reduction in the capacity of the water heaters was used to size for the measure case, 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 indicated that ambient temperatures around unitary HP/ER water heaters would typically be approximately 50°F if technicians did not install the water heater properly. (Staller, Chu, Delagah, & Adler, 2026). The laboratory tested these HPWH’s at ambient temperatures of 67.5°F and 50°F over a range of daily usage and recirculation rates. Up to three water heaters could run at the same time, depending upon the daily usage. To identify the equipment COPs 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 89 presents the prototype buildings used in the analysis. The proposed measure applies to alterations, and each prototype simulation estimates the savings for alterations.

**Table 89: 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%<br>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. |
| **Retail Large** | 1 | 240,000 | Big-box type retail building with WWR–12% and SRR–0.82%. |
| **Retail Medium** | 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 hot water  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 90 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 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 90: 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 |
|---|---|---|---|---|---|
| **Office Large** | All CZs | Central HPWH System | COP | 1.3 | 1.8 |
| **Office Medium** | All CZs | Central HPWH System | COP | 1.9 | 2.2 |
| **Office Medium Lab** | All CZs | Central HPWH System | COP | 1.8 | 2.3 |
| **Restaurant Fast Food** | All CZs | Central HPWH System | COP | 1.9 | 2.5 |
| **School Small** | All CZs | Central HPWH System | COP | 1.6 | 1.95 |
| **School Large** | 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 advanced controls.

**Necessity:** The necessity for this change is to require advanced controls on pumps in service water heating systems and better define what advanced 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 Split Heat Pump Water Heating Systems, Appurtenances, Temperature Maintenance Heater in Parallel Configuration and TMHS configuration.

**Necessity:** The necessity for this change is to 1) clarify the existing definitions split-refrigerant and split-hydronic are a subset of split heat pump water heaters; 2) update the naming convention of HPWH with swing tank configuration since TMHS configuration is more accurate. .

**Section: 141.0(b)2.N**

**Purpose:** This change would add cross-reference in Section 140.5(a)3 for service water heating systems if its replacement is split HPWH systems with recirculation.

**Necessity:** The necessity for this change is to add additional requirement to alterations for service water heating systems if its replacement is split HPWH systems with recirculation.

### Purpose and Necessity of Changes to the Reference Appendices

Section: JA1

Purpose: Add new definitions including Heat Pump Water Heater System COP, Primary Heat Pump Storage Tank, and Return to Primary Configuration.

**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 a vetted approach.

**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 designers and installers.

**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: 201** [100.1(b)]

**Purpose:** The purpose of this change is to add new definitions to characterize a commercial heat pump water heater, a unitary water heater, and a reverse return plumbing configuration.

**Necessity:** The addition is necessary to provide clear and consistent definitions of commercial unitary heat pump water heaters and plumbing configurations.

**Section: 500** [110]

**Purpose:** The purpose of this change is to improve the efficiency of unitary HP/ER hybrid water heaters by minimizing the electric resistance heating.

**Necessity:** The addition is necessary to ensure that installers 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.

## 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

## 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 91).

**Table 91: Percentage of Nonresidential Square Feet Having SHW with Recirculation**

| Prototype Name | New Construction/Additions | Alteration |
|---|---|---|
| **Office Large** | 95% | 95% |
| **Office Medium** | 95% | 95% |
| **Office Medium Lab** | 95% | 95% |
| **Office Small** | 75% | 75% |
| **Restaurant Fast Food** | 95% | 30% |
| **School Small** | 95% | 95% |
| **School Large** | 95% | 95% |
| **Assembly** | 60% | 50% |
| **Retail Large** | 75% | 75% |
| **Retail Medium** | 75% | 75% |
| **Retail Strip Mall** | 75% | 75% |
| **Warehouse** | 75% | 75% |
| **Grocery** | 75% | 65% |
| **Ref Warehouse** | 75% | 75% |
| **Horticulture** | 75% | 75% |
| **Manufacturing** | 75% | 75% |
| **Vehicle Service** | 75% | 75% |
| **Manufacturing** | 75% | 75% |

For the SHW with recirculation, the Statewide CASE Team then estimated the percentage of nonresidential floorspace that has electric systems based on BAAQMD and SCAQMD rules. To achieve that, the Statewide CASE Team first estimated the percentage of the population impacted by air quality rules for each CZ, and then assumed the same percentage for each prototype under each CZ. For the CZ or prototypes that the air quality rules do not apply, the Statewide CASE Team assumed 1 percent. Table 92 demonstrates the percentage of floorspace impacted by Air Quality Management Rules under each CZ.

**Table 92: Percentage of Square Feet that Will Be Impacted by Air Quality Management District (AQMD) Rules**

| Climate Zone | All Applicable Prototypes |
|---|---|
| 1 | 2% |
| 2 | 84% |
| 3 | 84% |
| 4 | 90% |
| 5 | 1% |
| 6 | 77% |
| 7 | 1% |
| 8 | 100% |
| 9 | 95% |
| 10 | 78% |
| 11 | 1% |
| 12 | 29% |
| 13 | 1% |
| 14 | 15% |
| 15 | 94% |
| 16 | 38% |

The BAAQMD will not impact the water heaters between 75,000 and 2 million BTU/hr until 2031. The Statewide CASE Team excluded the prototypes that have system under that capacity range from the first-year statewide impacts, including Large Office, Restaurant, Small School, Large School, Assembly, Retail Large, Retail Medium, and Grocery. However, all prototypes were included in the 30-year impacts results.

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 resistance systems and percentage with heat pump water heater systems (Table 93).

**Table 93: Percentage of Nonresidential Square Feet Under AQMD Rules Met with Electric Resistance and Heat Pump Water Heater Systems**

| Prototype Name | Electric Resistance | Heat Pump Water Heater |
|---|---|---|
| **Office Large** | 50% | 50% |
| **Office Medium** | 70% | 30% |
| **Office Medium Lab** | 50% | 50% |
| **Office Small** | 90% | 10% |
| **Restaurant Fast Food** | 20% | 80% |
| **School Small** | 0% | 100% |
| **School Large** | 10% | 90% |
| **Assembly** | 10% | 90% |
| **Retail Large** | 10% | 90% |
| **Retail Medium** | 70% | 30% |
| **Retail Strip Mall** | 70% | 30% |
| **Warehouse** | 90% | 10% |
| **Grocery** | 20% | 80% |
| **Ref Warehouse** | 90% | 10% |
| **Horticulture** | 90% | 10% |
| **Vehicle Service** | 80% | 20% |
| **Manufacturing** | 90% | 10% |

For the heat pump water heater systems, the Statewide CASE Team further the percentage of nonresidential floorspace having split heat pump water heaters and unitary heat pump water heaters (Table 94).

**Table 94: New Construction Nonresidential Floorspace Impacted by System Configuration**

| Prototype Name | New Construction & Additions | Alterations | Alterations | Alterations |
|---|---|---|---|---|
| **Technology** | Swing Tank | Unitary Heat Pump | Swing Tank | Unitary Heat Pump |
| **Office Large** | 60% | 40% | 50% | 50% |
| **Office Medium** | 40% | 60% | 30% | 70% |
| **Office Medium Lab** | 40% | 60% | 30% | 70% |
| **Office Small** | 5% | 95% | 0% | 100% |
| **Restaurant Fast Food** | 75% | 25% | 65% | 35% |
| **School Small** | 60% | 40% | 50% | 50% |
| **School Large** | 80% | 20% | 70% | 30% |
| **Assembly** | 60% | 40% | 50% | 50% |
| **Retail Large** | 80% | 20% | 30% | 70% |
| **Retail Medium** | 40% | 60% | 30% | 70% |
| **Retail Strip Mall** | 40% | 60% | 30% | 70% |
| **Warehouse** | 5% | 95% | 30% | 70% |
| **Grocery** | 20% | 80% | 10% | 90% |
| **Ref Warehouse** | 5% | 95% | 60% | 40% |
| **Horticulture** | 5% | 95% | 50% | 50% |
| **Vehicle Service** | 5% | 95% | 50% | 50% |
| **Manufacturing** | 5% | 95% | 0% | 100% |

For the areas where air quality rules do not apply, the Statewide CASE Team estimated the percentage of nonresidential floorspace having gas or electric resistance system (Table 97).

**Table 95: Alteration Nonresidential Floorspace Impacted by System Configuration**

| Prototype Name | Gas | Electric Resistance |
|---|---|---|
| **Office Large** | 50% | 50% |
| **Office Medium** | 30% | 70% |
| **Office Medium Lab** | 50% | 50% |
| **Office Small** | 10% | 90% |
| **Restaurant Fast Food** | 80% | 20% |

| Prototype Name | Gas | Electric Resistance |
| --- | --- | --- |
| **School Small** | 100% | 0% |
| **School Large** | 90% | 10% |
| **Assembly** | 90% | 10% |
| **Retail Large** | 90% | 10% |
| **Retail Medium** | 30% | 70% |
| **Retail Strip Mall** | 30% | 70% |
| **Warehouse** | 10% | 90% |
| **Grocery** | 80% | 20% |
| **Ref Warehouse** | 10% | 90% |
| **Horticulture** | 10% | 90% |
| **Vehicle Service** | 20% | 80% |

## 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 96).

**Table 96: Percentage of Nonresidential Square Feet 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% |
| **Retail Large** | 75% | 75% |
| **Retail Medium** | 75% | 75% |
| **Grocery** | 75% | 65% |

For the SHW with recirculation, the Statewide CASE Team then estimated the percentage of nonresidential floorspace that has heat pump systems based on BAAQMD and SCAQMD rules. To achieve that, the Statewide CASE Team first estimated the percentage of the population that will be impacted by air quality rules for each CZ, and then assumed the same percentage for each prototype under each CZ. For the CZ or prototypes that the air quality rules do not apply, the Statewide CASE Team assumed 1 percent. Table 97 demonstrates the percentage of floorspace impacted by Air Quality Management Rules under each CZ.

**Table 97: Percentage of Square Feet that Will Be Impacted by Air Quality Management District (AQMD) Rules**

| Climate Zone | All Applicable Prototypes |
|---|---|
| 1 | 2% |
| 2 | 84% |
| 3 | 84% |
| 4 | 90% |
| 5 | 1% |
| 6 | 77% |
| 7 | 1% |
| 8 | 100% |
| 9 | 95% |
| 10 | 78% |
| 11 | 1% |
| 12 | 29% |
| 13 | 1% |
| 14 | 15% |
| 15 | 94% |
| 16 | 38% |

The BAAQMD will not impact the water heaters between 75,000 and 2 million BTU/hr until 2031. The Statewide CASE Team excluded the prototypes that have system under that capacity range from the first-year statewide impacts, including Large Office, Restaurant, Small School, Large School, Assembly, Retail Large, Retail Medium, and Grocery. However, all prototypes were included in the 30-year impacts results.

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 98).

**Table 98: Percentage of Nonresidential Square Feet Under AQMD Rules That 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% |
| Retail Large | 90% | 90% |
| Retail Medium | 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 99).

**Table 99: Percentage of Square Feet with 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% |
| Retail Large | 80% | 30% |
| Retail Medium | 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 100) per prototype per CZ and alterations (Table 101) per prototype per CZ.

Table 100: Percentage of Square Feet 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** | 0.6% | 23.9% | 23.9% | 25.7% | 0.3% | 21.9% | 0.3% | 28.5% | 27.1% | 22.2% | 0.3% | 8.3% | 0.3% | 4.3% | 26.8% | 10.8% |
| **Medium Office** | 0.2% | 9.6% | 9.6% | 10.3% | 0.1% | 8.8% | 0.1% | 11.4% | 10.8% | 8.9% | 0.1% | 3.3% | 0.1% | 1.7% | 10.7% | 4.3% |
| **Laboratory** | 0.4% | 16.0% | 16.0% | 17.1% | 0.2% | 14.6% | 0.2% | 19.0% | 18.1% | 14.8% | 0.2% | 5.5% | 0.2% | 2.9% | 17.9% | 7.2% |
| **Restaurant** | 0.0% | 0.3% | 0.3% | 0.3% | 0.0% | 0.3% | 0.0% | 0.4% | 0.4% | 0.3% | 0.0% | 0.1% | 0.0% | 0.1% | 0.4% | 0.1% |
| **Small School** | 1.1% | 47.9% | 47.9% | 51.3% | 0.6% | 43.9% | 0.6% | 57.0% | 54.2% | 44.5% | 0.6% | 16.5% | 0.6% | 8.6% | 53.6% | 21.7% |
| **Large School** | 1.1% | 47.9% | 47.9% | 51.3% | 0.6% | 43.9% | 0.6% | 57.0% | 54.2% | 44.5% | 0.6% | 16.5% | 0.6% | 8.6% | 53.6% | 21.7% |
| **Assembly** | 1.4% | 57.5% | 57.5% | 61.6% | 0.7% | 52.7% | 0.7% | 68.4% | 65.0% | 53.4% | 0.7% | 19.8% | 0.7% | 10.3% | 64.3% | 26.0% |
| **Retail Large** | 0.6% | 27.2% | 27.2% | 29.2% | 0.3% | 24.9% | 0.3% | 32.4% | 30.8% | 25.3% | 0.3% | 9.4% | 0.3% | 4.9% | 30.5% | 12.3% |
| **Retail Medium** | 1.1% | 45.4% | 45.4% | 48.6% | 0.5% | 41.6% | 0.5% | 54.0% | 51.3% | 42.1% | 0.5% | 15.7% | 0.5% | 8.1% | 50.8% | 20.5% |
| **Grocery** | 0.2% | 7.6% | 7.6% | 8.1% | 0.1% | 6.9% | 0.1% | 9.0% | 8.6% | 7.0% | 0.1% | 2.6% | 0.1% | 1.4% | 8.5% | 3.4% |

Table 101: Percentage of Square Feet 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** | 0.03% | 1.33% | 1.33% | 1.43% | 0.02% | 1.22% | 0.02% | 1.58% | 1.50% | 1.24% | 0.02% | 0.46% | 0.02% | 0.24% | 1.49% | 0.60% |
| **Medium Office** | 0.01% | 0.48% | 0.48% | 0.51% | 0.01% | 0.44% | 0.01% | 0.57% | 0.54% | 0.44% | 0.01% | 0.17% | 0.01% | 0.09% | 0.54% | 0.22% |
| **Laboratory** | 0.02% | 0.80% | 0.80% | 0.86% | 0.01% | 0.73% | 0.01% | 0.95% | 0.90% | 0.74% | 0.01% | 0.28% | 0.01% | 0.14% | 0.89% | 0.36% |
| **Restaurant** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **Small School** | 0.02% | 0.87% | 0.87% | 0.94% | 0.01% | 0.80% | 0.01% | 1.04% | 0.99% | 0.81% | 0.01% | 0.30% | 0.01% | 0.16% | 0.98% | 0.40% |
| **Large School** | 0.06% | 2.66% | 2.66% | 2.85% | 0.03% | 2.44% | 0.03% | 3.17% | 3.01% | 2.47% | 0.03% | 0.92% | 0.03% | 0.48% | 2.98% | 1.20% |
| **Assembly** | 0.08% | 3.35% | 3.35% | 3.59% | 0.04% | 3.07% | 0.04% | 3.99% | 3.79% | 3.11% | 0.04% | 1.16% | 0.04% | 0.60% | 3.75% | 1.52% |
| **Retail Large** | 0.03% | 1.26% | 1.26% | 1.35% | 0.02% | 1.16% | 0.02% | 1.50% | 1.43% | 1.17% | 0.02% | 0.44% | 0.02% | 0.23% | 1.41% | 0.57% |
| **Retail Medium** | 0.03% | 1.13% | 1.13% | 1.22% | 0.01% | 1.04% | 0.01% | 1.35% | 1.28% | 1.05% | 0.01% | 0.39% | 0.01% | 0.20% | 1.27% | 0.51% |
| **Grocery** | 0.01% | 0.38% | 0.38% | 0.41% | 0.00% | 0.35% | 0.00% | 0.45% | 0.43% | 0.35% | 0.00% | 0.13% | 0.00% | 0.07% | 0.42% | 0.17% |

Table 102 presents the projected nonresidential new construction that the proposed code change will impact in 2026. Table 103 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2026.

**Table 102: 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** | - | - | 0.64 | 0.34 | - | 0.30 | 0.00 | 0.57 | 1.26 | 0.14 | - | 0.27 | - | 0.01 | 0.01 | 0.00 | 3.54 |
| **Medium Office** | 0.00 | 0.06 | 0.12 | 0.10 | 0.00 | 0.13 | 0.00 | 0.23 | 0.28 | 0.14 | 0.00 | 0.01 | 0.00 | 0.01 | 0.03 | 0.01 | 1.11 |
| **Large Retail** | - | - | 0.80 | 0.17 | 0.00 | 0.36 | 0.01 | 0.64 | 0.97 | 0.40 | 0.00 | 0.13 | - | 0.01 | 0.06 | 0.01 | 3.56 |
| **Medium Retail** | 0.00 | 0.04 | 0.06 | 0.05 | 0.00 | 0.05 | 0.00 | 0.09 | 0.17 | 0.14 | 0.00 | 0.06 | 0.00 | 0.01 | 0.03 | 0.00 | 0.71 |
| **Large School** | 0.00 | 0.13 | 0.66 | 0.28 | 0.00 | 0.32 | 0.00 | 0.71 | 0.76 | 0.22 | 0.00 | 0.07 | 0.00 | 0.01 | 0.01 | 0.01 | 3.18 |
| **Small School** | 0.00 | 0.16 | 0.52 | 0.34 | 0.00 | 0.31 | 0.00 | 0.45 | 1.04 | 0.61 | 0.00 | 0.33 | 0.01 | 0.02 | 0.12 | 0.03 | 3.94 |
| **Assembly** | 0.00 | 0.12 | 0.13 | 0.21 | 0.00 | 0.19 | 0.00 | 0.37 | 0.64 | 0.23 | 0.00 | 0.12 | 0.00 | 0.01 | 0.06 | 0.01 | 2.08 |
| **Laboratory** | 0.00 | 0.00 | 0.38 | 0.05 | 0.00 | 0.03 | 0.00 | 0.06 | 0.04 | 0.07 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 |
| **Restaurant** | 0.00 | 0.04 | 0.15 | 0.08 | 0.00 | 0.15 | 0.00 | 0.29 | 0.45 | 0.22 | 0.00 | 0.06 | 0.00 | 0.01 | 0.03 | 0.01 | 1.48 |
| **Grocery** | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| TOTAL | **0.00** | **0.56** | **3.47** | **1.62** | **0.00** | **1.84** | **0.02** | **3.41** | **5.63** | **2.17** | **0.01** | **1.08** | **0.01** | **0.08** | **0.35** | **0.08** | **20.3** |

Table 103: 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 | 0.04 | 1.76 | 0.94 | 0.00 | 1.29 | 0.01 | 2.70 | 4.54 | 0.77 | 0.00 | 0.40 | 0.00 | 0.05 | 0.06 | 0.03 | 12.60 |
| **Medium Office** | 0.00 | 0.14 | 0.34 | 0.20 | 0.00 | 0.22 | 0.00 | 0.35 | 0.45 | 0.31 | 0.00 | 0.16 | 0.00 | 0.01 | 0.06 | 0.01 | 2.25 |
| **Large Retail** | 0.00 | 0.11 | 0.70 | 0.34 | 0.00 | 0.36 | 0.00 | 0.64 | 0.90 | 0.63 | 0.00 | 0.25 | 0.00 | 0.02 | 0.13 | 0.02 | 4.10 |
| **Medium Retail** | 0.00 | 0.05 | 0.17 | 0.11 | 0.00 | 0.16 | 0.00 | 0.32 | 0.48 | 0.26 | 0.00 | 0.08 | 0.00 | 0.01 | 0.04 | 0.01 | 1.70 |
| **Large School** | 0.00 | 0.22 | 1.86 | 0.78 | 0.00 | 1.10 | 0.01 | 1.23 | 1.95 | 0.53 | 0.00 | 0.41 | 0.00 | 0.02 | 0.04 | 0.02 | 8.18 |
| **Small School** | 0.00 | 0.55 | 1.51 | 1.00 | 0.00 | 1.09 | 0.01 | 2.66 | 3.70 | 2.57 | 0.01 | 0.79 | 0.02 | 0.11 | 0.44 | 0.09 | 14.56 |
| **Assembly** | 0.00 | 0.19 | 0.79 | 0.35 | 0.00 | 0.56 | 0.00 | 1.15 | 1.45 | 0.93 | 0.00 | 0.26 | 0.00 | 0.04 | 0.15 | 0.03 | 5.91 |
| **Laboratory** | 0.00 | 0.03 | 0.35 | 0.32 | 0.00 | 0.08 | 0.00 | 0.15 | 0.15 | 0.13 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 | 1.26 |
| **Restaurant** | 0.00 | 0.03 | 0.13 | 0.07 | 0.00 | 0.14 | 0.00 | 0.26 | 0.39 | 0.27 | 0.00 | 0.05 | 0.00 | 0.01 | 0.03 | 0.01 | 1.39 |
| **Grocery** | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 |
| TOTAL | **0.01** | **1.36** | **7.62** | **4.13** | **0.01** | **5.01** | **0.05** | **9.47** | **14.02** | **6.41** | **0.02** | **2.45** | **0.03** | **0.28** | **0.97** | **0.23** | **52.04** |

## 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 104).

**Table 104: Percentage of Nonresidential Square Feet 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% |
| **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% |
| **Manufacturing** | 0% | 0% |
| **Data Centers** | 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, the Statewide CASE Team first estimated the percentage of the population that will be impacted by air quality rules for each climate zone, and then assumed the same percentage for each prototype under each climate zone. For the climate zone or prototypes that the air quality rules do not apply, the Statewide CASE Team assumed 1 percent. Table 105 demonstrates the percentage of floorspace impacted by Air Quality Management Rules under each climate zone.

**Table 105: Percentage of Square Feet That Will Be Impacted by Air Quality Management District (AQMD) Rules**

| Climate Zone | All Applicable Prototypes |
|---|---|
| 1 | 2% |
| 2 | 84% |
| 3 | 84% |
| 4 | 90% |
| 5 | 1% |
| 6 | 77% |
| 7 | 1% |
| 8 | 100% |
| 9 | 95% |
| 10 | 78% |
| 11 | 1% |
| 12 | 29% |
| 13 | 1% |
| 14 | 15% |
| 15 | 94% |
| 16 | 38% |

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 106).

**Table 106: Percentage of Nonresidential Square Feet 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% |
| Large School | 90% | 90% |
| Assembly | 90% | 90% |
| Large Retail | 90% | 90% |
| 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 107).

**Table 107: Percentage of Square Feet 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% |
| Medium Retail | 60% | 60% |
| Strip Mall | 60% | 60% |
| Grocery | 80% | 80% |

Table 108 presents the projected nonresidential new construction that the proposed code change will impact in 2029. Table 109 shows the projected nonresidential existing statewide building stock that the proposed code change would affect through alterations in 2029.

**Table 108: 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 | 0.45 | 0.24 | 0.00 | 0.21 | 0.00 | 0.40 | 0.88 | 0.10 | 0.00 | 0.19 | 0.00 | 0.01 | 0.01 | 0.00 | 2.48 |
| Medium Office | 0.00 | 0.08 | 0.14 | 0.12 | 0.00 | 0.15 | 0.00 | 0.28 | 0.33 | 0.16 | 0.00 | 0.01 | 0.00 | 0.01 | 0.03 | 0.01 | 1.32 |
| Large Retail | 0.00 | 0.00 | 0.27 | 0.06 | 0.00 | 0.12 | 0.00 | 0.21 | 0.32 | 0.13 | 0.00 | 0.04 | 0.00 | 0.00 | 0.02 | 0.00 | 1.19 |
| Medium Retail | 0.00 | 0.06 | 0.09 | 0.08 | 0.00 | 0.08 | 0.00 | 0.14 | 0.26 | 0.21 | 0.00 | 0.09 | 0.00 | 0.01 | 0.04 | 0.01 | 1.06 |
| Strip Mall | 0.00 | 0.00 | 0.01 | 0.04 | 0.00 | 0.06 | 0.00 | 0.12 | 0.09 | 0.07 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.40 |
| Large School | 0.00 | 0.03 | 0.17 | 0.07 | 0.00 | 0.08 | 0.00 | 0.19 | 0.20 | 0.06 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.84 |
| Small School | 0.00 | 0.11 | 0.35 | 0.23 | 0.00 | 0.21 | 0.00 | 0.30 | 0.70 | 0.41 | 0.00 | 0.22 | 0.00 | 0.02 | 0.08 | 0.02 | 2.63 |
| Assembly | 0.00 | 0.13 | 0.14 | 0.23 | 0.00 | 0.21 | 0.00 | 0.41 | 0.71 | 0.25 | 0.00 | 0.13 | 0.00 | 0.01 | 0.07 | 0.01 | 2.31 |
| Laboratory | 0.00 | 0.00 | 0.45 | 0.05 | 0.00 | 0.03 | 0.00 | 0.07 | 0.05 | 0.09 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 |
| Restaurant | 0.00 | 0.01 | 0.04 | 0.02 | 0.00 | 0.04 | 0.00 | 0.08 | 0.12 | 0.06 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.39 |
| Grocery | 0.00 | 0.03 | 0.04 | 0.04 | 0.00 | 0.02 | 0.00 | 0.03 | 0.06 | 0.04 | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.28 |
| **TOTAL** | **0.0** | **0.5** | **2.2** | **1.2** | **0.0** | **1.2** | **0.0** | **2.2** | **3.7** | **1.6** | **0.0** | **0.8** | **0.0** | **0.1** | **0.3** | **0.1** | **13.7** |

**Table 109: 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 | 0.04 | 1.85 | 0.99 | 0.00 | 1.36 | 0.01 | 2.85 | 4.78 | 0.81 | 0.00 | 0.43 | 0.00 | 0.05 | 0.06 | 0.03 | 13.26 |
| Medium Office | 0.00 | 0.26 | 0.63 | 0.37 | 0.00 | 0.40 | 0.00 | 0.64 | 0.83 | 0.57 | 0.00 | 0.29 | 0.00 | 0.02 | 0.10 | 0.02 | 4.14 |
| Large Retail | 0.00 | 0.33 | 2.17 | 1.06 | 0.00 | 1.13 | 0.01 | 1.99 | 2.80 | 1.95 | 0.01 | 0.77 | 0.01 | 0.08 | 0.42 | 0.06 | 12.77 |
| Medium Retail | 0.00 | 0.12 | 0.41 | 0.25 | 0.00 | 0.38 | 0.00 | 0.75 | 1.11 | 0.60 | 0.00 | 0.19 | 0.00 | 0.03 | 0.10 | 0.02 | 3.96 |
| Strip Mall | 0.00 | 0.09 | 0.34 | 0.18 | 0.00 | 0.35 | 0.00 | 0.63 | 0.86 | 0.59 | 0.00 | 0.15 | 0.00 | 0.03 | 0.09 | 0.02 | 3.34 |
| Large School | 0.00 | 0.10 | 0.84 | 0.35 | 0.00 | 0.50 | 0.00 | 0.56 | 0.88 | 0.24 | 0.00 | 0.18 | 0.00 | 0.01 | 0.02 | 0.01 | 3.69 |
| Small School | 0.00 | 0.55 | 1.51 | 1.00 | 0.00 | 1.09 | 0.01 | 2.66 | 3.70 | 2.57 | 0.01 | 0.79 | 0.02 | 0.11 | 0.44 | 0.09 | 14.56 |
| Assembly | 0.00 | 0.37 | 1.58 | 0.71 | 0.00 | 1.11 | 0.01 | 2.29 | 2.89 | 1.87 | 0.00 | 0.53 | 0.01 | 0.07 | 0.31 | 0.06 | 11.81 |
| Laboratory | 0.00 | 0.06 | 0.64 | 0.59 | 0.00 | 0.15 | 0.00 | 0.28 | 0.27 | 0.23 | 0.00 | 0.08 | 0.00 | 0.01 | 0.01 | 0.00 | 2.32 |
| Restaurant | 0.00 | 0.04 | 0.17 | 0.09 | 0.00 | 0.18 | 0.00 | 0.34 | 0.53 | 0.37 | 0.00 | 0.07 | 0.00 | 0.01 | 0.05 | 0.01 | 1.88 |
| Grocery | 0.00 | 0.05 | 0.15 | 0.12 | 0.00 | 0.08 | 0.00 | 0.15 | 0.23 | 0.12 | 0.00 | 0.04 | 0.00 | 0.01 | 0.02 | 0.01 | 0.99 |
| **TOTAL** | **0.0** | **2.0** | **10.3** | **5.7** | **0.0** | **6.7** | **0.1** | **13.1** | **18.9** | **9.9** | **0.0** | **3.5** | **0.0** | **0.4** | **1.6** | **0.3** | **72.7** |

# 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.

### 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 that 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 advanced controls, preserving flexibility and avoiding 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. The 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 110. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report.

**Table 110: 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 | • Proposal Description<br>• Market and Technical Considerations<br>• Per Unit Energy and Cost Impacts<br>• Compliance and Enforcement |
| **Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting** | Thursday, March 10, 2026 | • 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 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 111.

Table 111: Engaged Stakeholders

| Organization/Individual Name | Market Role | Mentioned in CASE Report Sections |
|---|---|---|
| **Steve Taylor** | Designer | - |
| **Villara** | Contractor | 2.4.3 |
| **Christoph Lohr** | SME | 2.6.2 |

## 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 112. Please see below for dates and links to event pages on 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 112: 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 | • Proposal Description<br>• Market and Technical Considerations<br>• Per Unit Energy and Cost Impacts<br>• Compliance and Enforcement |
| **Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting** | Tuesday, March 10, 2026 | • Proposal Description<br>• Market and Technical Considerations<br>• Per Unit Energy and Cost Impacts<br>• Compliance and Enforcement |

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 held personal communications over email and phone with numerous stakeholders when developing this report, listed in Table 113.

**Table 113: Engaged Stakeholders**

| Organization/Individual Name | Market Role | Mentioned in CASE Report Sections |
|---|---|---|
| **Ben Larson** | Software Developer | - |
| **Neal Kruis** | Software Developer | - |
| **Craig Silvey** | Northern Region Applications Manager | - |
| **Bradford White/Michael Corbett** | State Gov't Affairs & Product Specialist | - |

## 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 2028 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 114. Please see below for dates and links to event pages on [Title24Stakeholders.com](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 114: 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 | • Types of buildings where Unitary HP/ER water heaters are being installed in Central Service Water Heating Systems.<br>• Technical challenges to ensure that the intended operation of Unitary HP/ER water heaters is achieved in the field.<br>• Recommended ventilation requirements<br>• Cost data for installation of central heat pump water heaters |
| **Second Round of NR Water Heating Utility-Sponsored Stakeholder Meeting** | Tuesday, March 10, 2026 | • Prescriptive vs. Mandatory provisions<br>• Technical approaches to minimize risk that water heaters operate predominantly in ER mode<br>• Methods to ensure that there is sufficient thermal energy for the heat pump water heater<br>• Methods to assess energy savings and cost effectiveness of proposed measure<br>• Cost data for installation of central heat pump water heaters |

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 interviewed professionals familiar with unitary HP/ER water heaters to further develop the proposed measure. Table 115 identifies the people that were engaged by the Statewide CASE Team.

**Table 115: 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 |
| **NEEA/Adam Gage** | Energy Efficiency Alliance | n/a |
| **Bradford White/Michael Corbett** | Manufacturer | n/a |

# 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 116 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 following section details the methodology

**Table 116: Prototype Similarity for Analyzed Prototypes**

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

## 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 are 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 (Fast Food): 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 Institute 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 Institute 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 for continuous recirculation.

## F.2 Small Office System Design

Table 117 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 117: 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 |
| 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 118 below shows the total pipe length for each pipe section in the recirculation system.

**Table 118: Small Office Recirculation Pipe Sizing**

| Construction Type | Pipe Size | Pipe Length (ft) |
|---|---|---|
| New Construction and Existing Building | 3/4" HW | 59 |
| New Construction and Existing Building | 1/2" HWR | 10 |

Figure 5, below, illustrates the recirculation system design.

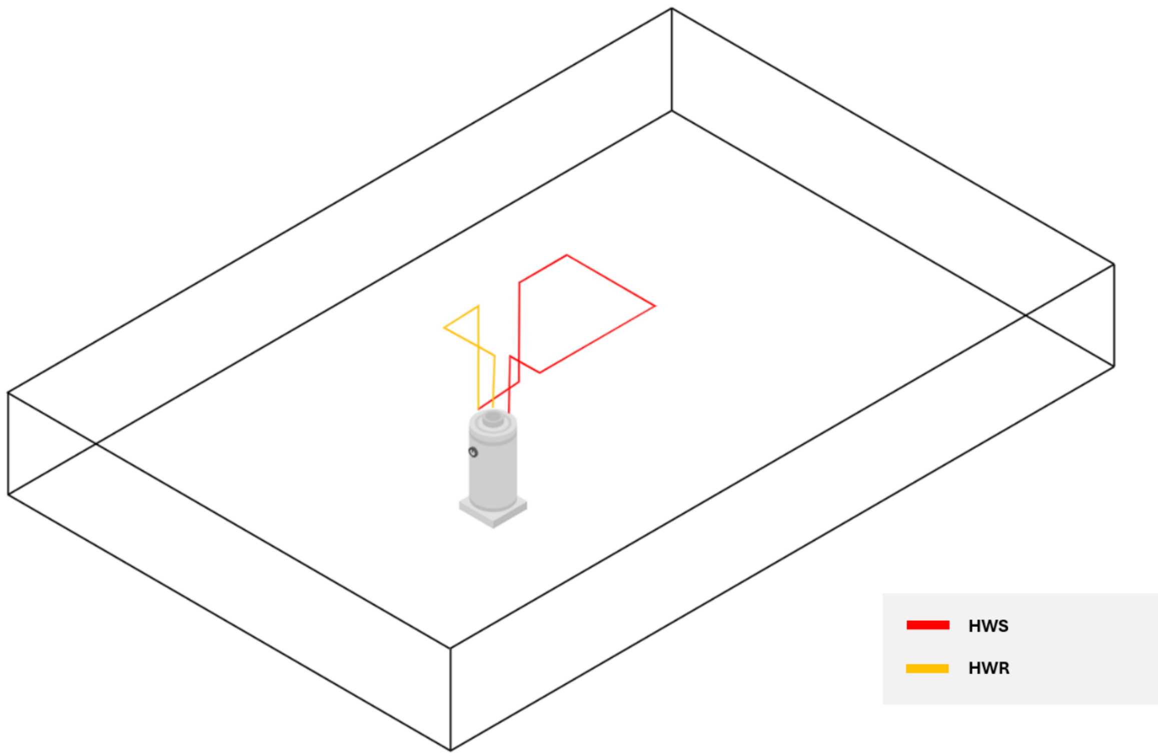


**Figure 5: Small office prototype recirculation system.**

## F.3 Medium Office System Design

Table 119 presents the fixture unit loading for the Medium Office prototype building.

**Table 119: Medium Office Fixture Unit Analysis**

| Fixture Type | 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 Dishwasher** | 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.

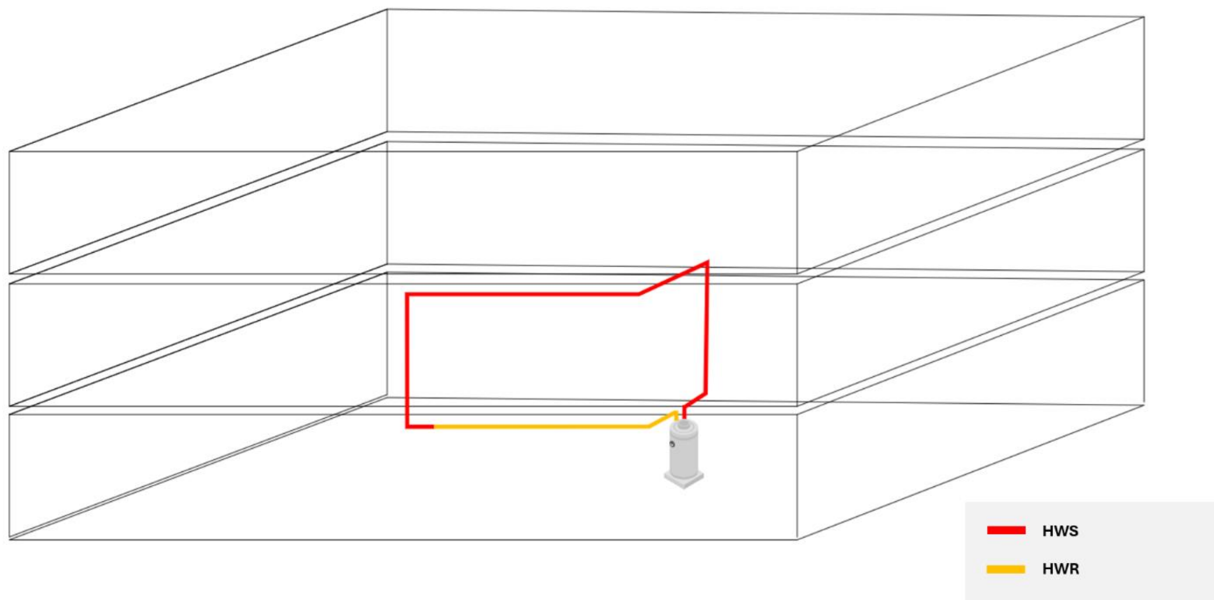


**Figure 6: Medium office prototype recirculation system.**

Table 120 below shows the total pipe length for each pipe section in the recirculation system.

**Table 120: Medium Office Recirculation System Total Pipe Lengths by Pipe Size**

| Building Type | Pipe Size | Pipe Length (ft) |
|---|---|---|
| **New Construction and Existing Building** | 1-1/4" HW | 29 |
| **New Construction and Existing Building** | 1" HW | 9 |
| New Construction and Existing Building | 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-sized 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 (Table 121). 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 121: Laboratory Fixture Unit Analysis**

| Fixture Type | 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.

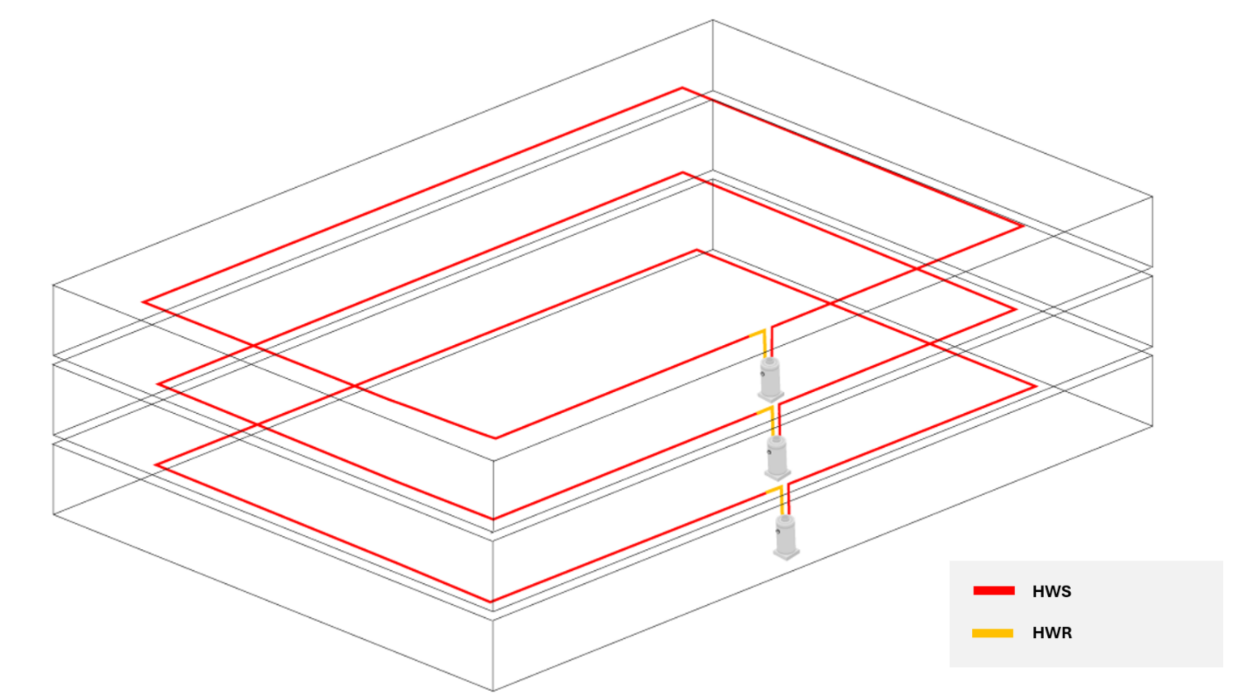


**Figure 7: Medium laboratory prototype process recirculation system.**

Table 122 below shows the total pipe length for each pipe section in the recirculation system.

**Table 122: Laboratory Industrial Hot Water Recirculation System Pipe Sizing**

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

## F.5 Small School System Design

Table 123 presents the fixture unit loading for the Small School prototype building.

**Table 123: Small School Fixture Unit Analysis**

| Fixture Type | 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.

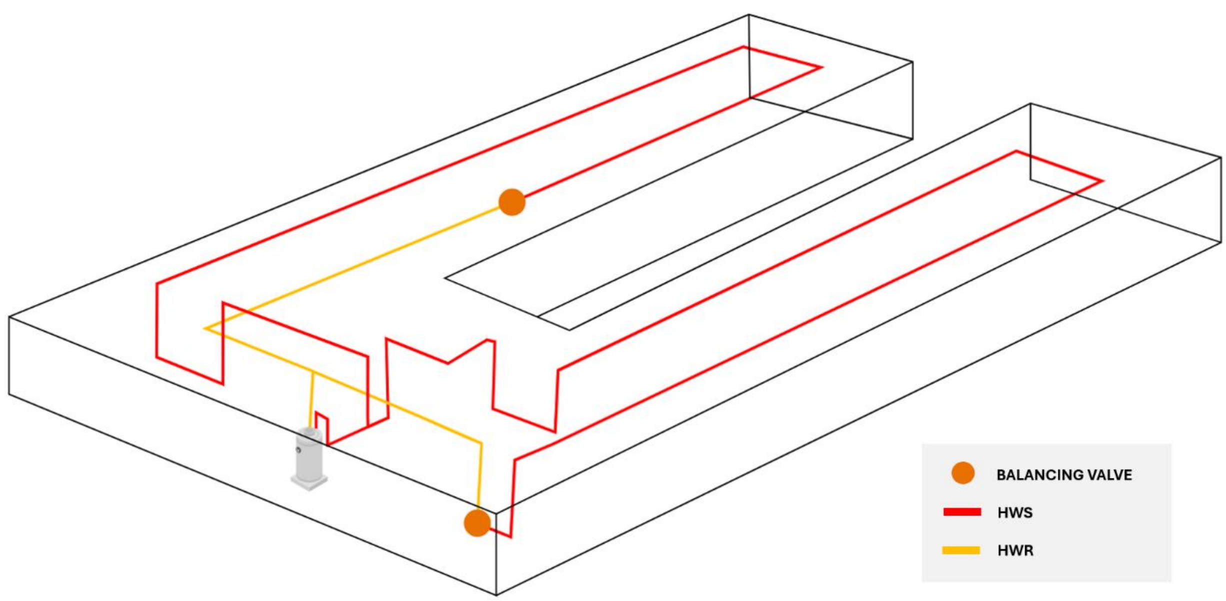


**Figure 8: Small school prototype process recirculation system.**

Table 124 below shows the total pipe length for each pipe section in the recirculation system.

**Table 124: Small School 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 |
| **Loop 1** | 1" HW | 144 |
| **Loop 1** | 3/4" HW | 80 |
| **Loop 1** | 3/4" HWR | 119 |
| **Loop 2** | 1-1/2" HW | 27 |
| **Loop 2** | 1-1/4" HW | 206 |
| **Loop 2** | 1" HW | 80 |
| **Loop 2** | 3/4" HW | 114 |
| **Loop 2** | 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 125, below, shows the pipe sizes for the two restaurants.

**Table 125: Restaurant Pipe Sizing — Restaurant 1**

| Pipe Size | Pipe Length (ft) |
|---|---|
| 1" HW | 34 |
| 3/4" HW | 96 |
| 1/2" HW | 24 |
| 1/2" HWR | 114 |

### Table 126: Restaurant Pipe Sizing — Restaurant 2

| 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 the 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 the 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 the average output water temperature of upstream pipe sections is used 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 2025 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 the pipe cooldown process. The Statewide CASE Team neglected cooldown mode for the energy impact analysis because the base case and proposed case hot water systems 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 the 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 the recirculation supply pipes experience hot water draw flows. The second half of the 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 a standard practice; recirculation flow rates based on system hydraulics and anticipated circulator pump selection informed by a plans review and product review. The 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 percent 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.

# Appendix H: Methodology for Developing Hot Water Distribution Pipe Heat Loss Density

## Hot Water Distribution Pipe Heat Loss Density

The Statewide CASE Team developed ACM modeling rules for calculating recirculation pipe heat loss in nonresidential buildings. Building on the existing framework of nonresidential ACM, the Statewide CASE Team suggested calculating the hourly recirculation pipe heat loss for each space or function type within the building. The total hourly recirculation pipe heat loss for the building would then be determined by adding up the heat loss from all individual space types. Hourly recirculation pipe heat loss of each space type is calculated as the product of floor area (square feet) and hot water distribution hourly heat loss density (HotWtrDistHrlyLossDens) (btu/h per $ft^2$).

The Statewide CASE Team acknowledges that the proposed method of calculating recirculation pipe heat loss using space floor areas has some limitations. In general, pipe heat loss is proportional to the total pipe length, which is usually proportional to the space's floor circumference, not floor area. However, calculations based on floor area provide a simplified compliance process because this method is used for other end uses, like domestic hot water consumption and lighting energy use. Recirculation system designs in real buildings have large variations, so it is impractical to expect that ACM rules can provide an accurate estimation of recirculation heat loss for building designs. The goal of the proposed ACM rules was to provide an average recirculation heat loss in commercial buildings.

## Method of Determining Hot Water Distribution Hourly Heat Loss Density

The Statewide CASE Team determined the hot water distribution hourly heat loss density for a list of building space types, which are defined in nonresidential ACM, based on recirculation heat loss calculated for the nonresidential prototype buildings analyzed by this CASE study.

In the Title 24 ACM Reference Manual, the Hot Water Schedule provides a cross-reference between building occupancy types and space types. For Medium Office and restaurant buildings, lists of space types according to this cross-reference are provided in the following tables. For School, this cross-reference only provides one space type: Classroom, Lecture, Training, Vocational Areas. However, based on prototype school building design, three more space types were added: Office Area (>250 square feet), Kitchen/Food Preparation Area, and All Other. Laboratory – Process Load building prototype has only one space type: Scientific Laboratory.

Ideally, prototype designs would provide floor areas for each space type included in the building design. However, this information was only available for the School prototype. For Medium Office and Restaurant prototypes, the Statewide CASE Team developed assumptions of which space type existed in the prototype building and its floor area as a percent of total building floor area based on professional judgement.

The Statewide Case Team developed a set of hot water distribution hourly heat loss densities so the total recirculation heat loss is the same or similar to the modeling results for the building. This was calculated based on the method described in the first section of this Appendix. To simplify the iteration process and results, the Statewide CASE Team used five levels of hot water distribution hourly heat loss densities: very low, low, medium, high, and very high. These five levels were assigned to each space type according to the likelihood of the presence of recirculation pipes. The iteration results are shown in Table 127, Table 128, Table 129, and Table 130.

**Table 127: Assumptions for Determining HotWtrDistHrlyLossDens for Space Types in Medium Office Buildings**

| Space Type | % of Floor Area | Level of Heat Loss | HotWtrDistHrly-LossDens |
|---|---:|---:|---:|
| Aging Eye/Low-vision (Corridor Area) | na | Very low | 0.042 |
| Aging Eye/Low-vision (Restroom) | na | Very low | 0.042 |
| Aging Eye/Low-vision (Stairwell) | na | Very low | 0.042 |
| Copy Room | na | Very low | 0.042 |
| Corridor Area | 10% | Very low | 0.042 |
| Financial Transaction Area | na | Very low | 0.042 |
| Kitchenette or Residential Kitchen | 3% | Low | 0.084 |
| Library (Reading Area) | na | Very low | 0.042 |
| Library (Stacks Area) | na | Very low | 0.042 |
| Office Area (>250 square feet) | 60% | Very low | 0.042 |
| Office Area (<250 square feet) | 10% | Very low | 0.042 |
| Restrooms | 3% | Low | 0.084 |
| Stairwell | 1% | Very low | 0.042 |
| Unleased Tenant Area | na | Very low | 0.042 |
| Videoconferencing Studio | na | Very low | 0.042 |
| All other | 13% | Very low | 0.042 |

### Table 128: Assumptions for Determining HotWtrDistHrlyLossDens for Space Types in Restaurant Buildings

| Space Type | % of Floor Area | Level of Heat Loss | HotWtrDistHrly-LossDens |
|---|---|---|---|
| Aging Eye/Low-vision (Dining) | na | Medium | 0.196 |
| Dining Area (Bar/Lounge and Fine Dining) | na | Medium | 0.196 |
| Dining Area (Cafeteria/Fast Food) | 60% | Medium | 0.196 |
| Dining Area (Family and Leisure) | na | Medium | 0.196 |
| Kitchen/Food Preparation Area | 40% | Very high | 2.650 |

### Table 129: Assumptions for Determining HotWtrDistHrlyLossDens for Space Types in School Buildings

| Space Type | % of Floor Area | Level of Heat Loss | HotWtrDistHrly-LossDens |
|---|---|---|---|
| **Classroom, Lecture, Training, Vocational Areas** | 51% | Very low | 0.042 |
| **Office Area (>250 square feet)** | 15% | Very low | 0.042 |
| **All other** | 19% | Very low | 0.042 |
| **Kitchen/Food Preparation Area** | 15% | Very high | 2.65 |

### Table 130: Assumptions for Determining HotWtrDistHrlyLossDens for Space Types in SchoolLab – Process Load Buildings

| Space Type | % of Floor Area | Level of Heat Loss | HotWtrDistHrly-LossDens |
|---|---|---|---|
| **Laboratory, Scientific** | 100% | High | 0.368 |

The comparison of hourly recirculation heat loss between simulation results and calculations based on the proposed hot water distribution hourly heat loss densities are presented in Table 131. The proposed hot water distribution hourly heat loss densities resulted in a conservative estimation of recirculation heat loss in Small School prototype.

**Table 131: Comparison of Hourly Recirculation Heat Loss (Btu/hour)**

| Prototype Building | Simulation Results | Based on Proposed HotWtrDistHrlyLossDens | % Difference |
|---|---|---|---|
| **Medium Office** | 2,386 | 2,386 | 0% |
| **Restaurant** | 2,945 | 2,945 | 0% |
| **Small School** | 15,827 | 10,414 | -34% |
| **Lab - Process Load** | 6,028 | 6,028 | 0% |

## Hot Water Distribution Hourly Heat Loss Density for All Nonresidential Space Types

For other space types defined in Title 24 ACM Reference Manual, hot water distribution pipe heat loss density was estimated based on results presented in the prior section. The estimated hot water distribution pipe heat loss density for all space types is shown in Table 132. Please note that some of these space types were assumed not to have any recirculation pipe and the corresponding hot water distribution pipe heat loss density is zero.

**Table 132: Estimated HotWtrDistHrlyLossDens for All Space Types**

| Space Type | HotWtrDistHrly-LossDens |
|---|---|
| Aging Eye/Low-vision (Corridor Area) | 0.042 |
| Aging Eye/Low-vision (Dining) | 0.042 |
| Aging Eye/Low-vision (Lobby, Main Entry) | 0.042 |
| Aging Eye/Low-vision (Lounge/Waiting Area) | 0.042 |
| Aging Eye/Low-vision (Multipurpose Room) | 0.042 |
| Aging Eye/Low-vision (Religious Worship Area) | 0.042 |
| Aging Eye/Low-vision (Restroom) | 0.042 |
| Aging Eye/Low-vision (Stairwell) | 0.042 |
| Audience Seating Area | 0.042 |
| Auditorium Area | 0.042 |
| Auto Repair / Maintenance Area | 0 |
| Barber, Beauty Salon, Spa Area | 0.196 |
| Civic Meeting Place Area | 0.042 |
| Classroom, Lecture, Training, Vocational Areas | 0.042 |
| Computer Room | 0.042 |
| Concourse and Atria Area | 0.042 |
| Convention, Conference, Multipurpose and Meeting Area | 0 |
| Copy Room | 0.042 |
| Corridor Area | 0.042 |

| | |
|---|---|
| Dining Area (Bar/Lounge and Fine Dining) | 0.196 |
| Dining Area (Cafeteria/Fast Food) | 0.196 |
| Dining Area (Family and Leisure) | 0.196 |
| Electrical, Mechanical, Telephone Rooms | 0.042 |
| Exercise/Fitness Center and Gymnasium Areas | 0.042 |
| Financial Transaction Area | 0.042 |
| Healthcare Facility and Hospitals (Exam/Treatment Room) | 0.196 |
| Healthcare Facility and Hospitals (Imaging Room) | 0.042 |
| Healthcare Facility and Hospitals (Medical Supply Room) | 0.042 |
| Healthcare Facility and Hospitals (Nursery) | 0.196 |
| Healthcare Facility and Hospitals (Nurse's Station) | 0.196 |
| Healthcare Facility and Hospitals (Operating Room) | 0.196 |
| Healthcare Facility and Hospitals (Patient Room) | 0.196 |
| Healthcare Facility and Hospitals (Physical Therapy Room) | 0.196 |
| Healthcare Facility and Hospitals (Recovery Room) | 0.196 |
| High-Rise Residential Living Spaces | 0.196 |
| Hotel Function Area | 0.196 |
| Hotel/Motel Guest Room | 0.196 |
| Kitchen/Food Preparation Area | 2.65 |
| Kitchenette or Residential Kitchen | 0.084 |
| Laboratory, Scientific | 0.368 |
| Laundry Area | 0.084 |
| Library (Reading Area) | 0 |
| Library (Stacks Area) | 0 |
| Lobby, Main Entry | 0.042 |
| Locker Room | 0.084 |
| Lounge, Breakroom, or Waiting Area | 0.196 |
| Manufacturing, Commercial & Industrial Work Area (Low Bay) | 0 |
| Manufacturing, Commercial & Industrial Work Area (High Bay) | 0 |
| Manufacturing, Commercial & Industrial Work Area (Precision) | 0 |
| Museum Area (Exhibition/Display) | 0 |
| Museum Area (Restoration Room) | 0.042 |
| Office Area (>250 square feet) | 0.042 |
| Office Area (<250 square feet) | 0.042 |
| Parking Garage Area (Parking Zone and Ramps) | 0 |
| Parking Garage Area (Daylight Adaptation Zones) | 0 |
| Pharmacy Area | 0 |

| | |
|---|---|
| Retail Sales Area (Grocery Sales) | 0.042 |
| Retail Sales Area (Retail Merchandise Sales) | 0 |
| Retail Sales Area (Fitting Room) | 0 |
| Religious Worship Area | 0 |
| Restrooms | 0.084 |
| Stairwell | 0.042 |
| Storage, Commercial/Industrial (Warehouse) | 0 |
| Storage, Commercial/Industrial (Refrigerated) | 0 |
| Storage, Commercial/Industrial (Shipping & Handling) | 0 |
| Storage, General | 0 |
| Sports Arena - Playing Area (> 5,000 Spectators) | 0 |
| Sports Arena - Playing Area (2,000 - 5,000 Spectators) | 0 |
| Sports Arena - Playing Area (< 2,000 Spectators) | 0 |
| Sports Arena - Playing Area (Recreational) | 0 |
| Theater Area (Motion Picture) | 0 |
| Theater Area (Performance) | 0 |
| Transportation Function (Baggage Area) | 0 |
| Transportation Function (Ticketing Area) | 0 |
| Unleased Tenant Area | 0.042 |
| Unoccupied-Exclude from Gross Floor Area | 0 |
| Unoccupied-Include in Gross Floor Area | 0 |
| Videoconferencing Studio | 0 |
| All other | 0.042 |
| Conference, Multipurpose and Meeting Area | 0 |
| Storage | 0 |
| Health Care / Assisted Living (Nurse's Station) | 0.196 |
| Health Care / Assisted Living (Physical Therapy Room) | 0.196 |

# Appendix I: Markup of Code Language (Non-restructured)

The language below reflects markup from the non-restructured 2025 Title 24 Part 6 Code Language.

## I.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 <u>underlining</u> (new language) and ~~strikethroughs~~ (deletions).

## I.2 Circulator Pump Controls - Proposed Language Code

### I.2.1 Administrative Code (Title 24, Part 1)

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

### I.2.2 Energy Code (Title 24, Part 6)

**Section 140.5 – PRESCRIPTIVE REQUIREMENTS FOR SERVICE ~~WATER HEATING~~ <u>HOT WATER</u> SYSTEMS**

**(a) Nonresidential occupancies.** Service water heating 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 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<u>,</u> ~~and~~ 140.5(c)<u>, and 140.5(d).</u>

(d) <u>**Circulator pump controls.** Pumps serving recirculation systems with dedicated hot water return piping shall meet 1, 2 and 3 below:</u>

1. Be equipped with one of the following controls specified in A or B:

   A. <u>Pump controls that adjust pump speed shall meet either i or ii below:</u>

      i. <u>Maintain a constant return temperature setpoint. The return temperature setpoint shall not exceed 125 °F</u>

      ii. <u>The water heating system shall include a thermal balancing valve installed in the return piping. The pump shall maintain</u>

a differential pressure with a thermal balancing valve temperature setpoint that shall not exceed 125 deg F.

**Exception to Section 140.5(d)1.A.: For** Commercial Kitchens, the return temperature setpoint shall not exceed 135 °F

B. Pump controls that activate the pump in response to an associated control signal to must meet one of the configurations specified in i or ii below depending on the system type:

   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 a temperature sensor capable of detecting hot water draws in combination with a recirculation return temperature sensor. The return temperature setpoint must not exceed 125 °F.

      b. Priming timer that automatically activates the pump at set intervals to reheat the recirculation loop.

   ii. Pump control for multi-loop or multi-riser distribution system recirculation systems shall have a priming timer that automatically activates the pump at set intervals to reheat the recirculation loop.

**Exception to Section 140.5(d)1.B.: For** Commercial Kitchens, the return temperature setpoint shall not exceed 135 °F

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.

**Exception to Section 140.5(d):** Recirculation systems in *hotel/motel* buildings and *nonresidential* buildings with Group R occupancies.

**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 water-heating systems shall meet the requirements of 140.5(a)2, ~~and~~ (b), and (d), except for the solar water heating requirements.

## I.3 Require Return to Primary Configuration - Proposed Language Code

### I.3.1 Administrative Code (Title 24, Part 1)

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

### I.3.2 Energy Code (Title 24, Part 6)

**SECTION 100.1 – Definitions and Rules of Construction**

**WATER HEATER** definitions include the following:

**CONSUMER WATER HEATER** is a water heater that meets the definition of a consumer product under USDOE 10 CFR 430.

**HEAT PUMP WATER HEATER (HPWH)** is a water heater that transfers thermal energy from one temperature level to another temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

**INTEGRATED HEAT PUMP WATER HEATER** is a HPWH that has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.

**SPLIT HEAT PUMP WATER HEATING SYSTEMS** are water heating systems where the HPWH is configured in one of the following arrangements

**SPLIT-REFRIGERANT HEAT PUMP WATER HEATER** is a HPWH which has a single outdoor section and one or more indoor sections connected to the outdoor section via a refrigerant circuit.

**SPLIT-HYDRONIC HEAT PUMP WATER HEATER** is a HPWH that consists of multiple separate sections. One section houses all the refrigerant components, while one or more additional sections are designated for water storage. These sections are interconnected through a hydronic circuit.

**MULTI-PASS WATER HEATER** is a water heater that the cold water passes through multiple times. The water temperature increases with each pass, until the storage tank reaches the intended storage temperature.

**SINGLE-PASS WATER HEATER** is a water heater which the cold water passes through once and is heated to the intended use temperature.

**APPURTENANCES** are all elements that are in series in a service or domestic water heating system, including fittings (elbows, tees, flanges, etc.), pumps, valves (isolation, mixing, balancing, check, etc.), strainers, hose bibs, coil u-bends, meters, sensors, heat exchangers and air separators.

**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).

**TEMPERATURE MAINTENANCE HEATER IN PARALLEL CONFIGURATION** is a configuration where a secondary water heater is in parallel with the primary heat pump generation and storage system. The role of this secondary heater is to meet the temperature maintenance load.

**TEMPERATURE MAINTENANCE HEATER IN SERIES CONFIGURATION** is a configuration where a secondary water heater 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 Systems**

Nonresidential occupancies. Service water-heating 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. Where a split heat pump water heating system is used, it shall meet the requirements of A or B, or C below:

   **Exception to SECTION 140.5(a)3:** Hotel/motel buildings and nonresidential buildings with Group R occupancies.

   A. ***Return to Primary Configuration***

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

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

2. 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.

3. 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.

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

Installation shall follow NEEA Advanced Water Heater Specification for commercial heat pump water heater Tier 3 or higher.

B. ***Temperature maintenance heater in series configuration***

Installation shall follow NEEA Advanced Water Heater Specification for commercial *heat pump water heater* Tier 3 or higher, and the system shall satisfy the additional requirements:

1. The *primary heat pump storage tank* temperature setpoint shall be at least 135°F.

2. The temperature maintenance tank temperature setpoint shall be at least 10°F lower than the *primary heat pump storage tank* temperature setpoint.

C. ***Temperature maintenance heater in parallel configuration***

Installation shall follow NEEA Advanced Water Heater Specification for commercial heat pump water heater Tier 3 or higher, where 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, where a split heat pump water heater with recirculation is used, it shall meet the requirements Section 140.5(a)3.

**Exception 1 to Section 141.0(b)2.N:** Split Heat pump outlet water temperature can reach 175°F or greater.

**Exception 2 to Section 141.0(b)2.N:** Multi pass heat pumps shall meet NEEA commercial heat pump water heater Tier 2 or higher.

# I.4 Requirements for Unitary HP/ER Hybrid Heaters - Proposed Language Code

## I.4.1 Administrative Code (Title 24, Part 1)

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

## I.4.2 Energy Code (Title 24, Part 6)

**SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION**
**(b) Definitions.**

**WATER HEATER** definitions include the following**:**

**CONSUMER WATER HEATER** is a water heater that meets the definition of a consumer product under USDOE 10 CFR 430.

**HEAT PUMP WATER HEATER (HPWH)** is a water heater that transfers thermal energy from one temperature level to another temperature level for the purpose of heating water, including all ancillary equipment such as fans, storage tanks, pumps, or controls necessary for the device to perform its function.

**COMMERCIAL HEAT PUMP WATER HEATER** is a water heater that meets the definitions under USDOE 10 CFR 431.102, meaning a water heater (including all ancillary equipment such as fans, blowers, pumps, storage tanks, piping, and controls, as applicable) that uses a refrigeration cycle, such as vapor compression, to transfer heat from a low-temperature source to a higher-temperature sink for the purpose of heating potable water, and operates with a current rating greater than 24 amperes or a voltage greater than 250 volts**.**

**INTEGRATED HEAT PUMP WATER HEATER** is a HPWH that has all components, including fans, storage tanks, pumps, or controls necessary for the device to perform its function contained in a single factory-made assembly.

**SPLIT-REFRIGERANT HEAT PUMP WATER HEATER** is a HPWH which has a single outdoor section and one or more indoor sections connected to the outdoor section via a refrigerant circuit

**SPLIT-HYDRONIC HEAT PUMP WATER** is a HPWH that consists of multiple separate sections. One section houses all the refrigerant components, while one or more additional sections are designated for water storage. These sections are interconnected through a hydronic circuit.

**MULTI-PASS WATER HEATER** is a water heater that the cold water passes through multiple times. The water temperature increases with each pass until the storage tank reaches the intended storage temperature.

**SINGLE-PASS WATER HEATER** is a water heater which the cold water passes through once and is heated to the intended use temperature.

**UNITARY WATER HEATER** is a water heater that has the heating source and a storage tank integrated into a single piece of equipment.

**REVERSE RETURN CONFIGURATION** is a plumbing arrangement when multiple hot water storage tanks are used to supply service hot water as part of a recirculation system that means that the water heater with the shortest return piping length from the recirculation loop has the longest supply piping length back to the recirculation loop and that all water heaters in a parallel configuration have the same length of piping from the recirculation return to the supply.

**Section 110.3 - Mandatory Requirements for Service Water-Heating Systems and Equipment.**

**110.3(d)** [New section] **Integrated Unitary Commercial Heat Pump Water Heaters**.

Integrated unitary commercial heat pump water heating systems with integrated electric resistance heating elements serving all nonresidential occupancies shall be sized to meet the requirements of JA14.6.1, shall meet the installation requirements of JA14.6.2, and shall meet the following requirements:

1. The minimum heat pump water heater compressor cut-off temperature shall be reported by manufacturers and shall be equal to or lower than 40°F ambient air temperature in heat pump-only mode and equal to or lower than 47°F in hybrid mode in which the unit operates with both heat pump and electric resistance heating methods.
2. 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.
3. If outside air is used to meet the heat source requirements, the heat pump water heater shall be able to operate in heat pump mode under Heating Design Drybulb (0.6%) conditions as described in Table 2.3 from JA2.

**Exception to Section 110.3(d):** Integrated unitary commercial heat pump water heaters in hotel/motel buildings and nonresidential buildings with Group R occupancies.