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Document Title:	2028 California Energy Code Measure Proposal – Existing Building Alterations Large Single Zone Heat Pump Rooftop Units
Description:	Proposed 2028 Energy Code change which would require alteration projects of large single zone rooftop units to use single zone heat pumps, or to use gas furnace RTUs installed with additional efficiency measures in retail and sit-down restaurants built prior to 1997, with some exceptions.
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2028 California Energy Code

Measure Proposal

Existing Building Alterations:

Large Single Zone Heat Pump Rooftop Units

MEASURE CATEGORY: Nonresidential HVAC

Prepared by: California Energy Commission April 2026

CALIFORNIA ENERGY COMMISSION

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EXECUTIVE SUMMARY

Introduction

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. The energy efficiency measures described in this proposal are for consideration and potential inclusion in California's Energy Code (California Code of Regulations, Title 24, Part 6). The Energy Code sets statewide energy efficiency requirements for newly constructed buildings, and additions and alterations to existing buildings. Measures will be reviewed, may be modified, and may be incorporated into a broader regulatory package proposed and adopted by the CEC. When considering measures to be included in the Energy Code, the CEC evaluates the proposed measures, cost-effectiveness and technical feasibility.

Code Change Description

Commercial single-zone rooftop units serve a large portion of low-rise commercial building space. These units provide heating, cooling and ventilation to a wide range of nonresidential buildings, including retail, warehouse, and sit-down restaurant spaces. In the 2025 Energy Code, a prescriptive requirement for alterations to existing nonresidential buildings was added for installation of new or replacement single zone packaged rooftop units (RTUs) with direct expansion cooling capacity less than 65,000 Btu/h. The 2025 Energy Code also provides a prescriptive option for gas furnaces with direct expansion (DX) cooling units (gas furnace RTUs) installed with additional efficiency measures.

The proposed code change for the 2028 Energy Code extends the prescriptive requirements for alterations for small, single-stage units to larger capacity units, which typically have two or more stages. Specifically, the proposal would require alteration projects of large single zone rooftop units to use single zone heat pumps, or to use gas furnaces with DX cooling units (gas furnace RTUs) installed with additional efficiency measures in retail and sit-down restaurants built prior to 1997, with some exceptions. Warehouses are not included in the proposed code change. Heat pumps can reduce LSC and Source Energy consumption and contribute to environmental impact reduction for these building types.

Scope of Work

The 2025 Energy Code requires that alterations (replacements) of single zone rooftop units use heat pump for replacements, for equipment with a rated

capacity not exceeding 65,000 Btu/h. For the 2028 Energy Code, a proposal to extend this requirement to larger-capacity equipment is evaluated. Heat pump RTU equipment with capacities between 5.4 tons and up to 20 tons (greater than 65,000 Btu/h and up to 240,000 Btu/h) is widely available and is proposed as a requirement for newly constructed buildings. Single zone unitary equipment, also referred to as packaged rooftop units, is commonly used in nonresidential low-rise buildings with large zone sizes. The building types evaluated for this proposal are large retail buildings, sit-down restaurants, and non-refrigerated warehouses. Warehouses are not included in the proposed code change.

Cost-effectiveness in California climate zones was evaluated. Energy savings was determined by applying energy simulation prototype models to estimate energy savings. Measure costs were evaluated by gathering cost data from equipment distributors and from energy service providers. For this proposed prescriptive requirement, a viable option with packaged gas furnace RTUs was demonstrated, by adding efficiency measures for heat recovery and equipment staging.

Table 1: Code Change Scope of Work

Restructured 2025 Energy Code Section(s)	Regulation Type(s): M, Ps, or Pm	Reference Appendices	Modeling Tools	Forms	Other Supporting Documents
Section 401.5.2.2.1.2	Ps, Pm	N/A	CBECC, EnergyPlus, See Appendix E	N/A	N/A

An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.
Note: Section 401.5.2.2.1.2 of the Restructured 2025 Energy Code is equivalent to Section 141.0(b)2C(ii) of the 2025 Energy Code.

Compliance and Enforcement

This measure is an extension of the existing 2025 Energy Code requirement for alterations of air conditioners with capacity of 65,000 Btu/h or less be replaced with heat pumps. The proposal is to extend this requirement to larger-capacity equipment. This type of equipment is commonly used in alterations of nonresidential buildings involving space-conditioning system upgrades and/or replacements, and the measure poses no significant burden on enforcement agencies for alterations projects. One potential obstacle to enforcement of the measure is projects which require emergency replacement of equipment, necessitating expedited permit processing. However, HVAC equipment

suppliers should have sufficient time to plan to comply with the proposed requirements,

Market Assessment

Commercial heat pumps with capacities between 5.4 tons and 20 tons (greater than 65,000 Btu/h and up to 240,000 Btu/h) are available from most major manufacturers. These systems are commonly used in retail buildings, larger sit-down restaurants, and warehouses to heat and cool large spaces. These units have two or more cooling stages and airside economizers as standard efficiency measures. Single zone heat pumps with these capacities are required by the Energy Code for newly constructed buildings. A market characterization study (Sathe 2025) found that 79% of single zone rooftop unit (RTU) installations in California are for alterations (replacement units). Heat pump RTUs with rated capacity between 5.4 tons and 20 tons represent 40% of the commercial single zone RTU market (Sathe 2025).

The market study determined from surveys of contractors that supplemental electric resistance heating is rarely specified with heat pump RTU installations in California (Sathe 2025). Also, most replacements are emergency replacement projects. For best practice, building owners will schedule replacements when equipment is nearing the end of its expected useful life, to ensure that heat pump RTU products are available for alterations.

Cost-effectiveness

Cost effectiveness was evaluated for replacements of existing single zone rooftop units with single zone heat pumps for three building types – large retail buildings, sit-down restaurants and warehouses – and for multiple building vintages. Each building vintage has original building envelope characteristics corresponding to minimum requirements at the time of construction; however, lighting and HVAC systems were modeled as having periodic upgrades based on the expected useful life of these systems. Specifically, lighting was assumed to be upgraded in 2016, and HVAC equipment was assumed to be upgraded every 15 years.

Replacement of existing single zone rooftop units with single zone heat pumps is cost-effective for large retail building spaces in all climate zones except climate zone 15 for all vintages, and except climate zones 7 and 8 for existing buildings built prior to 1978. Heat pump RTU replacements were shown to be cost-effective for sit-down restaurants in all climate zones except as follows:

- Climate zone 7 and 15 for existing buildings newly constructed in 1978 to 1997, and
- Climate zone 15 for existing buildings newly constructed prior to 1978.

In climate zone 15 (Palm Springs), the combination of low heating loads and high cooling loads affected the energy savings of the measure. Since the code-minimum heat pump RTU cooling efficiency is slightly lower than the code-minimum gas furnace with air conditioning rooftop unit cooling efficiency, replacement with a heat pump increased cooling energy, counteracting heating energy savings in the Palm Springs climate. The federal minimum cooling efficiency for heat pumps is slightly lower than the minimum cooling efficiency for rooftop units with air conditioners and gas furnaces.

For warehouses, while replacement of rooftop units with heat pumps was cost-effective, it was not possible to demonstrate that replacement gas-fired units could perform as well as the heat pump-based units even after the addition of efficiency measures to the gas-fired units. Therefore, warehouses were excluded from the proposed code change.

Statewide Energy Impacts

Tables 2 and 3 summarize the estimated statewide energy savings for the first year that the proposed measure is implemented. As shown, the measure is projected to increase statewide electricity use by 11.6 GWh in the first year, while reducing natural gas use by 2.0 million therms. From a cost perspective, the increase in electricity-related LSC of $115.1 million is more than offset by the natural gas LSC savings of $184.8 million, resulting in net LSC savings. Overall, the results show that although the measure increases electricity consumption, it reduces natural gas use, providing statewide energy and economic benefits. In addition, the measure has the co-benefit of reducing GHG emissions by 8,798 MTCO2e per year.

Table 2: Estimated Statewide Energy Savings

	First Year Statewide Electricity Savings (GWh)	First Year Statewide Power Demand Reduction (MW)	First Year Statewide Natural Gas Savings (Million Therms)	First Year Statewide Electricity LSC Savings (PV$)	First Year Statewide Natural Gas LSC Savings (PV$)
Large Retail (Pre-1978)	(2.9)	0.5	0.5	(27.4)	42.8
Large Retail (1978 – 1997)	(4.5)	1.4	0.8	(41.9)	68.0
Sit-Down Restaurant (Pre-1978)	(2.3)	(0.2)	0.4	(24.1)	40.2
Sit-Down Restaurant (1978 – 1997)	(2.0)	(0.2)	0.4	(21.7)	33.8
TOTAL	(11.6)	1.5	2.0	(115.1)	184.8

* These results incorporate the 35% adoption rate.

Table 3: Estimated Statewide Greenhouse Gas Emission Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)
Large Retail (Pre-1978)	2,027.9
Large Retail (1978 – 1997)	3,251.7
Sit-Down Restaurant (Pre-1978)	1,924.7
Sit-Down Restaurant (1978 – 1997)	1,593.6
Total	8,797.9

* These results incorporate the 35% adoption rate.

ACRONYMS

Acronym	Definition
AC	Air Conditioner
ACM	Alternate Calculation Method
BCR	Benefit-Cost Ratio
BCZ	Building Climate Zone
BEM	Building Energy Modeling
BtU	British Thermal Units
CBECC	California Building Energy Code Compliance software
CBECC-Res	California Building Energy Code Compliance software for single-family buildings
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CZ	California Climate Zone
DX	Direct Expansion
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HVAC	Heating, Ventilation and Air Conditioning
IECC	International Energy Conservation Code
KBtU	Thousands of British Thermal Units
kWh	Kilowatt-Hour
LSC	Long-term System Cost (30-year $)
MTCO2e	Metric Tons of Carbon Dioxide Equivalent
MW	Megawatt

PV$	Present Value Dollars
RTU	Rooftop unit. Refers to unitary equipment used for heating, cooling and ventilation.
SZAC existing	Existing single zone air conditioning unit with gas furnace. May include either a constant volume or variable volume fan.
SZAC1	Term used in Table 141.0-E-1 of the 2025 Energy Code (Table 401.5-B of the Restructured 2025 Energy Code) for a single zone air conditioner with furnace + variable speed fan + economizer, or Dual Fuel Heat Pump + Variable Speed Fan + Economizer. Economizer in accordance with Section 140.4(e)
System 7A-SZVAVAC	Single Zone variable air volume unit with gas furnace heating (System 7A in the 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual)
System 7B-SZVAVHP	Single Zone variable air volume unit with heat pump for space heating (System 7B in the 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual)
SZVAVAC 1	Term used in proposed code language for a single zone variable air volume unit with gas furnace and efficiency measures to qualify as a prescriptive gas pathway option
VCA	Virtual Compliance Assistant

0. INTRODUCTION

This proposal describes specific energy efficiency actions that could result in further reductions of wasteful, uneconomic, inefficient, or unnecessary consumption of energy in California. The code change proposal, or "measure," described in this proposal is provided by the California Energy Commission (CEC) for consideration and potential inclusion in the California Energy Code (Title 24, Part 6). The Energy Code sets statewide energy efficiency requirements for newly constructed buildings, and additions and alterations to existing buildings. This measure will be considered and may be modified as part of a comprehensive regulatory package proposed and adopted by the CEC. The Energy Code must be found to be technically feasible and cost-effective as a whole.

Consistent with Public Resources Code 25402(b)(3), an energy standard is cost-effective if the life-cycle value of the energy savings (benefits) exceed the life-cycle costs, when amortized over the economic life of the structure. This corresponds to a Benefit-Cost Ratio (BCR) of 1.0 or greater. BCR is calculated by dividing the total dollar benefit of the measure by the total dollar cost of the measure, over a period of analysis of 30 years.

To calculate benefit, Long-term System Cost (LSC) is used to determine the dollar value of energy efficiency measures in the Energy Code. LSC hourly factors account for long-term benefits associated with policies needed to meet the statewide climate actions goals – such as 100% renewable generation, proliferation of electric transportation, and drastic reductions in fossil fuel combustion occurring in buildings. Today's energy costs do not adequately account for these long-term values to California's energy system. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are more valuable, and times off-peak demand are less valuable. LSC hourly factors are not utility rates or energy rate forecasts. LSC is not a predicted utility bill.

LSC hourly conversion factors are developed and published by the CEC for each code cycle. These LSC hourly factors are used to convert predicted site energy use – an output common to building energy modeling (BEM) software – to 30-year present value to California's energy system.

Energy savings for the proposed measures are estimated using both LSC hourly factors and CEC-established model prototypes. Large sets of survey data are used to create prototypes that act as averaged representations of common building types in California. These prototypes are created for use in BEM software to provide accuracy and consistency amongst energy models that are used to determine energy savings for the state. CEC-developed

prototypes and LSC hourly factors are published by the CEC ahead of each code cycle integral to research versions of CEC's reference Energy Code compliance software (CBECC-Res and CBECC). For this reason, CBECC-Res and CBECC are the CEC-recommended BEM software tools when assessing energy savings of proposed measures.

To calculate cost, first costs and ongoing maintenance costs must be assessed for proposed measures and accounted for over a period of analysis of 30 years. In the BCR, both the benefits and the costs are assessed incrementally, meaning in comparison to the latest adopted version of the Energy Code.

In addition to LSC, the CEC also considers the Source Energy impact of proposed measures. Source energy is defined as the long run hourly marginal source energy of fossil fuels that are combusted as a result of building energy consumption either directly at the building site or caused to be consumed to meet the electrical demand of the building considering the long-term effects of Commission-projected energy resource procurement. For a given hour, the value in that hour for each forecasted year is averaged to establish a lifetime average source energy.

The CEC develops and publishes conversion factors for LSC, Source Energy, and for GHG Emissions for each code cycle. The GHG emissions factors are used to estimate any GHG emissions reduction co-benefits associated with measure proposals. These three sets of hourly factors are published on CEC's website and formatted to be accessible and usable in combination with broadly available BEM tools.

1. MEASURE DESCRIPTION

Section 401.5.2.2 of the Restructured 2025 Energy Code (Section 141.0 of the 2025 Energy Code) defines prescriptive requirements that apply to altered HVAC components of existing buildings. Replacements of existing single-zone HVAC units must meet the prescriptive requirement of Section 401.5.2.2.1.2 of the Restructured 2025 Energy Code (Section 141.0(b)2C of the 2025 Energy Code). The 2025 Energy Code included new requirements that alterations (replacements) of single-zone DX HVAC units (smaller than 65,000 Btu/h) be heat pump RTUs (see Section 401.5.2.2.1.2 of the Restructured 2025 Energy Code, Section 141.0(b)2C(ii) of the 2025 Energy Code). A single-zone AC unit with a gas furnace is allowed as a prescriptive alternative, but that system must provide equivalent performance to the heat pump RTU, according to CEC energy compliance metrics.

This measure proposes extending this 2025 Energy Code single-zone heat pump RTU requirement to larger, multi-stage units. Several manufacturers offer heat pumps in nominal capacity between 5.4 and 20 tons. These systems can be used as a direct alternative to single zone units with gas furnaces. The heat pumps provide good energy performance, while reducing environmental impacts.

Large single zone HVAC units differ from single-zone units of 5 tons or less by including multiple compressors with multiple cooling stages, and variable-speed drives for control of supply air volume. Large single-zone units are staged based on cooling demand and serve larger zones typical of retail spaces, warehouses and sit-down restaurants. In contrast, multizone VAV units, typically control the cooling stages to maintain a supply air temperature, and serve zones in the range of 500 to 1,000 ft^2.

Larger single-zone units are commonly used in standalone retail buildings, conditioned portions of warehouses, and dining areas of sit-down restaurants. While the systems can be used in other applications, such as assembly and common areas of hotels, this proposal focuses on retail, warehouse and sit-down restaurants. Office buildings were not considered because they typically use multizone systems when larger capacities are required.

A recent market study (Sathe 2025) indicated that supplemental heat is usually only specified to improve performance of heat pump RTUs in cold weather. As such, the proposal specifies a dual fuel heat pump in CZ 16, and does not consider supplemental heat in other climate zones. Heat pumps used to meet the proposed regulation are not expected to require supplementary resistance heat, so no changes to the electrical panel or transformer should be required. Alterations that do exceed the existing main service panel or service transformer capacity are excepted from the requirement.

1.1 Measure Modifications to Energy Code Documents

This section provides descriptions of how the proposed measure will affect each Energy Code document. See *Section 6. Proposed Code Language* for detailed revisions to code language.

1.1.1 Energy Code Change Summary

Section 401 Nonresidential and Hotel/Motel Occupancies (Newly constructed, Additions, Alterations)

Subsection 401.5.2 *[Section 141.0(b)]* **Alterations.**

Subsection 401.5.2.2 *[Section 141.0(b)2]* **Prescriptive requirements (Alterations).**

Subsection 401.5.2.2.1 *[Section 141.0(b)2C]* **New or Replacement Space-Conditioning Systems or Components.**

A new table, Table 401.5-C is added to the alterations section of the Energy Code, requiring alterations of equipment with rated capacity of at least 65,000 Btu/h and not exceeding 240,000 Btu/h.

New Code Language:

401.5.2.2.1.2- New or replacement single zone packaged rooftop systems with direct expansion cooling with rated cooling capacity of at least 65,000 Btu/hr but not exceeding 240,000 Btu/hr shall meet the applicable requirements specified in Table 401.5-C [or shall meet the performance compliance requirements of Section 401.5.2.3 [Section 141.0(b)3].

Exception to Section 401.5.2.2.1.2: This requirement is not applicable if the alteration requires both 1) a system that exceeds the rated heating and cooling capacity of the existing replaced unit, and 2) an increase to the existing main service panel or service transformer capacity. An electrical load calculation shall be submitted by a registered professional engineer in accordance with Article 220 of the California Electrical Code, and verification by a licensed engineer is required to confirm that additional heating and cooling capacity is required.

Table 401.5-C New or Replacement Single Zone Air Conditioner or Heat Pump Requirement in Retail or Restaurant Spaces, Newly Constructed on December 31, 1997 or Earlier, Replaced System Capacity between 65,000 and 240,000 Btu/h

For Buildings Newly Constructed Between 1978 and 1997																
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1

For Buildings Newly Constructed Before 1978															
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1

SZVAVAC 1 = Single-zone VAV air conditioner with economizer, heat recovery (ERR = 85%), three-stage DX cooling coil, two-stage gas heating coil, no-load fan speed reduced to 25%, and fan power reduced by 15% in addition to not taking the extra fan power allowance permitted under Table 141.0-D.

1.1.2 Reference Appendices Change Summary

There are no planned changes to the Reference Appendices.

1.1.3 Compliance Manuals Change Summary

The proposed measure will not modify Compliance Manuals. The measure prescriptively requires commercial single-zone heat pumps for alterations. The equipment products have been widely available for many years, and installation follows standard practice.

A note indicating that heat pump RTU replacements should not include electric resistance supplementary heat can be added. Heat pumps are expected to use the reverse cycle for defrost.

1.1.4 ACM Reference Manuals Change Summary

The HVAC System Map for alterations in section 5.1.4 Nonresidential ACM Reference Manual will be revised to include a standard design (baseline) HVAC system type of single zone VAV heat pumps for all units with rated capacity of 20 tons or less for applicable retail and sit-down restaurant buildings.

1.1.5 Compliance Forms Change Summary

Compliance forms should include any exceptions to the proposed alterations requirement.

1.2 Measure Context

1.2.1 Comparable Model Code or Standard

The Energy Code includes prescriptive requirements for heat pumps for alterations of spaces served by single zone unitary equipment with capacity of up to 65,000 Btu/h. The proposed requirement is an extension of this requirement to equipment with larger rated capacities. This measure is not in

the national model codes, ASHRAE Standard 90.1-2022, or the IECC 2024, currently.

1.2.2 Conflicts with Other Regulations or Certifications

The proposed requirement does not conflict with any federal, state, or local regulatory standards. The measure includes a compliance option that allows the use of gas furnace RTUs (referred to as "SZVAVAC 1" in the proposed code language) when the units include efficiency measures to achieve LSC and Source Energy savings equivalent with single zone heat pumps.

Some regional air quality management districts have requirements for the use of ultra-low NOx (less than 14 ng/J emissions rate) furnaces on gas-fueled space heating equipment. The Bay Area Air Quality Management District has added amendments to this rule, which states that only "zero-NOx furnaces" can be sold or installed in the Bay Area beginning in 2029. The San Joaquin Valley Unified Air Pollution Control District has adopted regulations that require ultra-low NOx furnaces for heating capacities not exceeding 175,000 Btu/h when the cooling system has a capacity less than 65,000 Btu/h. Currently, the only equipment available that can meet a zero-NOx emissions requirement are heat pumps and electricity-based heating equipment.

The transition towards ultra-low NOx and zero-NOx heating equipment will increase naturally occurring market adoption of heat pumps, and when the zero-NOx emission takes effect, the local air quality regulation would be more stringent than the proposed code change to the Energy Code, which will not create a conflict.

1.3 Compliance and Enforcement

Enforcement of this measure does not place significant additional burden on compliance officials – rooftop heat pumps are common practice in new construction and have gained increasing market share for replacements of gas furnace RTUs. Commissioning acceptance test procedures for the units should be aligned with heat pump RTU operations.

2. MARKET AND ECONOMIC ANALYSIS

For the proposed measure, this section provides the CEC's assessment of product availability, incremental cost, potential market size, and potential economic and fiscal impacts to the state – including potential impacts on the creation or elimination of jobs in the state.

2.1 Market Structure and Availability

Several manufacturers offer commercial rooftop heat pump units in capacities ranging from 5.4 tons and up to 20 tons (greater than 65,000 Btu/h and up to 240,000 Btu/h). At least two manufacturers offer heat pumps with 25 tons or greater capacity. However, since heat pump RTUs of this capacity are less common, this size was not included in the proposal. The market for commercial heat pumps has steadily grown, and mechanical, electrical, plumbing (MEP) project engineers are increasingly specifying heat pumps, spurred by regulations adopted by several air quality management districts that require the use of ultra-low NOx or zero NOx furnaces.

A recent market characterization study (Sathe 2025) estimated that single-zone rooftop units (RTUs) are used to condition 54% of commercial floor space in California. Among the single zone RTU installations in California, 79% are for alterations projects – replacements of existing units. The 2025 Energy Code added requirements that alterations of small (<65,000 Btu/h or 5.4 tons) single zone RTUs be replaced with heat pumps. Larger units (between 5.4 tons and 20 tons rated capacity represent 40% of the commercial single-zone RTU market (Sathe 2025). This proposal focuses on the opportunity for energy savings and environmental impact reduction potential of extending code requirements to RTU replacements in this size range.

The CalMTA market characterization study (Sathe 2025) also demonstrated that heat pumps have a significant market share in alteration projects, with heat pumps used in 19% of RTU replacements. Dual-fuel systems that use gas heating as backup supplemental heat to heat pumps are less common in California.

Often, RTU replacement projects are unplanned, emergency replacement projects. In California, 85% of RTU replacements are emergency replacements (Sathe 2025), which makes replacements with heat pumps more difficult. The Energy Code does not provide exceptions for emergency replacements. Since heat pump RTU equipment in the range of capacities covered under this proposal is readily available from several manufacturers, businesses should not encounter significant obstacles, even with emergency replacements. Scheduled replacements for equipment near the end of useful life can more

readily incorporate building load evaluations and the opportunity for right-sizing of replacement equipment .

Commercial heat pumps in the capacity range considered in this measure – 5.4 to 20 tons – are readily available from several manufacturers, for both newly constructed buildings and replacement projects. Heat pumps with these capacities have two or more cooling stages and a variable speed supply fan to meet Energy Code requirements. Gas furnace RTUs have multiple burner stages. Heat pumps stage heating based on demand (thermostat reading) and typically operate the supply fan on high speed in heating mode. In colder climates outside of California, heat pumps usually have electric resistance supplemental heating; in California, the design heating load can be met through the heat pump compressor alone.

Recent EPA regulations limit the global warming potential (GWP) of refrigerants in RTUs to 750. Manufacturers typically use R-32 and R-454B; these A2L refrigerants require leak detectors, which adds cost to both gas furnace RTUs (with air conditioners) or heat pump RTUs.

Recently, local regulations have been adopted that require either ultra-low NOx or zero-NOx furnaces be installed. These local regulations will increase the price of gas furnace RTUs and spur the adoption of heat pumps RTUs for replacement units. The steady increase in market adoption of heat pumps indicates significant naturally occurring market adoption in the absence of an energy code regulation; see the Statewide Energy and Energy Cost Savings section (5.1) for details.

2.2 Design and Construction Practices

Best practices for rooftop unit replacement with heat pump-based units include the following approaches.

Use the existing roof curb where possible. Albin 2025 found that several manufacturers with high market share offer heat pumps for direct-fit replacements that fit existing roof curbs. Several surveyed respondents indicated that the need for a roof adapter curb could be a significant physical constraint. Some respondents noted that adapter curbs were needed regardless of whether the retrofit specified a single zone air conditioning unit or a single zone heat pump (Albin 2025).

An adapter curb can add some modest additional cost; since multiple manufacturers offer direct-fit replacements, the cost of an adapter curb is not included in the cost-effectiveness estimate.

Use reverse cycle for defrost, with no supplemental resistance heat. Albin 2025 determined that supplemental electric resistance heating is not required in all California climate zones, except for climate zone 16. Sathe 2025 found that 11 out of 17 respondents who sold heat pump RTUs rarely or never sold them with

supplemental resistance heat. Three of the remaining 6 respondents only occasionally use supplemental resistance heat. One contractor who frequently installs supplemental heat used it to improve performance in cold weather. During occupied hours, the outdoor temperatures are rarely below freezing in most climate zones. The heat pump reverse cycle can be used for the occasional defrost condition, without sacrificing thermal comfort. For systems with variable occupancy requirements, demand control ventilation can reduce ventilation needs during periods of lower occupancy, reducing any potential comfort risks during a morning warmup defrost cycle. Further, larger units typically use an on-demand defrost cycle, which is less frequent and slightly shorter in duration. Eliminating a requirement for supplemental heating both keeps the unit weight comparable or less than the replaced gas furnace RTUs and avoids any need for panel upgrades. Additionally, should a designer choose to include supplemental resistance heat, the Energy Code includes requirements that limit the capacity of that system (see Restructured 2025 Energy Code, section 401.3.9; 2025 Energy Code section 140.4(g)).

Size system for the greater of cooling capacity and heating capacity. For commercial applications, the cooling load for the served areas usually dictates the sizing requirements. Instead of replacing existing equipment with an equivalent capacity heat pump, a sizing calculation should be performed, with current lighting and occupancy levels, and incorporating any building efficiency upgrades, to determine if a smaller capacity system can meet cooling loads and heating loads.

For all California climate zones except the high mountains (CZ16), the cooling load dictates the required capacity of the unit. Since rooftop units have an expected useful life of 15 to 20 years, any building upgrades, such as lighting upgrades, more efficient interior equipment to reduce plug loads, or building envelope upgrades will reduce the required system capacity. In many cases, the existing rooftop unit can be replaced with a system with lower capacity, resulting in additional energy savings. Downsizing, however, is best considered on a case-by-case basis, since the existing conditions will vary across project sites.

Perform a sizing calculation to replacement units. End-of-life units to be replaced can be 15 to 20 years old. If the building has undergone any lighting upgrades, replacement of interior equipment, or building envelope upgrades, space reconfiguration, or occupancy changes, the existing system may be greatly oversized. Trend logs, if available, for a period corresponding to design summer conditions, would indicate if there is potential to downsize the replaced equipment. Rightsizing can be a standalone evaluation, or part of a broader existing building commissioning process. If there is potential to downsize the unit, additional energy savings and demand savings can be

realized. This proposal assumes a replacement with an equivalent capacity heat pump, since downsizing potential is project specific.

2.3 Impacts on Market Actors

This measure could result in a slight increase in installation costs for replacement RTUs. This measure will benefit disadvantaged communities that live disproportionately in areas with poor air quality, due to reduction of NOx emissions from gas furnaces.

Impacts from increased replacement project costs would likely be mitigated through likely product cost decreases over time, as market adoption of large heat pump RTU products continues to rise.

2.4 Impacts on Jobs and Businesses

This measure encourages the installation of heat pumps at the end of the useful life of the currently installed space conditioning equipment. The installation requires slightly higher total labor expenditures, but otherwise, there is no expected impact on jobs or businesses.

2.5 Cost of Compliance and Enforcement

There is no anticipated increase in the cost of compliance and enforcement. Enforcement agencies have experience with heat pump RTU installation requirements from the newly constructed building requirements, and there are no additional steps. Heat pumps used to meet the proposed regulation are not expected to require supplementary resistance heat, so no changes to the electrical panel should be required. Alterations that do exceed the existing main service panel or service transformer capacity are excepted from the requirement.

3. COST-EFFECTIVENESS

This section provides a summary of energy savings estimates, costs, and overall cost-effectiveness analysis for the proposed measure. Energy savings, costs, and cost effectiveness of proposed measures are assessed incrementally, in comparison to the latest adopted version of the Energy Code. Best available data is used and references to those data sources are provided to clearly substantiate energy savings, costs, and cost effectiveness. Details required for the cost-effectiveness analysis are included in Appendix E.

3.1 Energy Savings Methodology

Consistent with Public Resources Code 25402(b)(3), an energy standard is cost-effective if the life-cycle value of the energy savings (benefits) exceed the life-cycle costs, when amortized over the economic life of the structure. This corresponds to a Benefit-Cost Ratio (BCR) that is 1.0 or greater. BCR is calculated by dividing the total dollar benefit of the measure by the total dollar cost of the measure, over a period of analysis of 30 years.

To calculate benefit, Long-term System Cost (LSC) is used to determine the dollar value of energy efficiency measures in the Energy Code. LSC hourly factors help the state account for long-term benefits associated with policies needed to meet the statewide energy and climate goals – such as 100% renewable generation, proliferation of electric transportation, and reductions in fossil fuel combustion occurring in buildings. Today's energy costs do not adequately account for these long-term values to California's energy system. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are more valuable, and times off-peak demand are less valuable. LSC hourly factors are not utility rates or energy rate forecasts. LSC is not a predicted utility bill.

LSC hourly conversion factors are developed and published by the CEC for each code cycle. These LSC hourly factors are used to convert predicted site energy use – an output common to building energy modeling (BEM) software – to 30-year present value to California's energy system.

Energy savings for proposed measures are estimated using both LSC hourly factors and CEC-established model prototypes. Large sets of survey data are used to create prototypes that act as typical representations of common building types in California. These prototypes are created for use in BEM software to provide accuracy and consistency amongst energy models that are used to determine energy savings for the state. CEC-developed prototypes and LSC hourly factors are published by the CEC ahead of each code cycle integral to research versions of CEC's reference Energy Code compliance software (CBECC-Res and CBECC). For this reason, CBECC-Res

and CBECC are the CEC-recommended BEM software tools when assessing energy savings of proposed measures.

To calculate cost, first costs and ongoing maintenance costs must be assessed for proposed measures and accounted for over a period of analysis of 30 years. In the BCR, both the benefits and the costs are assessed incrementally, meaning in comparison to the latest adopted version of the Energy Code.

Like LSC hourly factors, the CEC develops and publishes conversion factors for Source Energy, and for GHG Emissions for each code cycle. These three sets of hourly factors are published on CEC's website and formatted to be accessible and usable in combination with broadly available BEM tools.

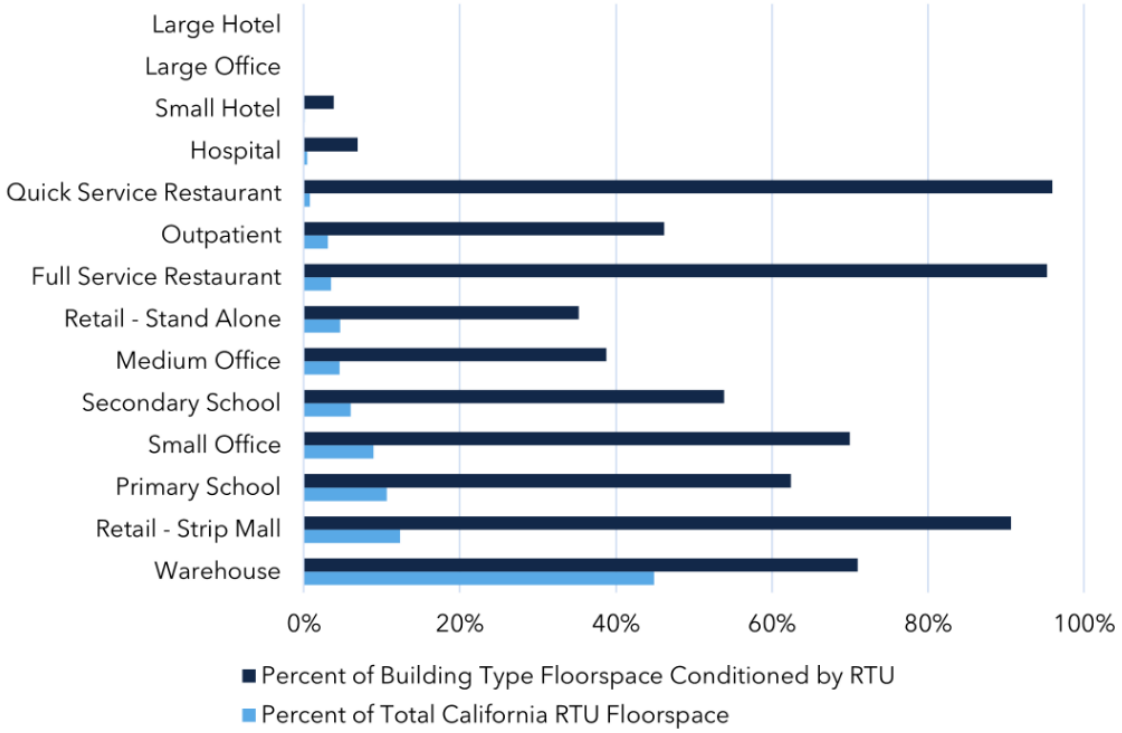
Measure Savings Approach. Replacement of existing packaged single-zone air-conditioning rooftop units (SZAC-existing) with gas furnace with packaged single-zone variable-air-volume heat pump RTUs (System 7B-SZVAVHP) is being evaluated for nonresidential alteration applications in support of the 2028 Energy Code. Under the 2025 Energy Code, the prescriptive and performance standard baseline for these buildings is a packaged single-zone variable-air-volume air-conditioning rooftop unit (System 7A-SZVAVAC) with gas furnace (Section 140.4(e)2F of the 2025 Energy Code; section 401.3.7.1.6(2) of the Restructured 2025 Energy Code; System 7A in Table 2 of the 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual). For purposes of this proposal, this system is referred to as the 2025 code-compliant System7A-SZVAVAC with gas furnace. The proposal focuses on SZAC-existing rooftop units with cooling capacities greater than 5.4 tons and up to 20 tons (greater than 65,000 Btu/h and up to 240,000 Btu/h). The objective of the analysis is to develop the technical basis for a proposed alteration measure by quantifying statewide energy, demand, and cost-effectiveness impacts and by developing draft code language, compliance requirements, and supporting documentation provisions.

The measure applies when an SZAC-existing rooftop unit within the applicable size range is replaced as part of an alteration project. The analysis considers representative nonresidential prototype buildings that commonly include rooftop units in this size range, with primary emphasis on large retail, sit-down restaurant, and warehouse prototype buildings. These prototypes were selected because they commonly include SZAC-existing rooftop units within the targeted size range and provide representative applications for evaluating the performance, feasibility, and cost-effectiveness of the proposed measure across a range of nonresidential alteration conditions.

Building Type Selection. According to the 2014 California Commercial Saturation Survey (CSS) and the 2025 Nonresidential Alterations: Reach Code Study (Albin 2025), SZAC-existing rooftop units serve a substantial share of conditioned floor area in several California nonresidential building types relevant to the proposed alteration measure. The reviewed market data

(Figure 1) shows especially high single-zone RTU saturation in full-service restaurants, retail strip malls, and warehouses, while warehouse and retail-related building types also account for a meaningful share of total California floor area conditioned by RTUs.

Figure 1: California statewide saturation and distribution of single-zone RTU conditioned floor area, by building type



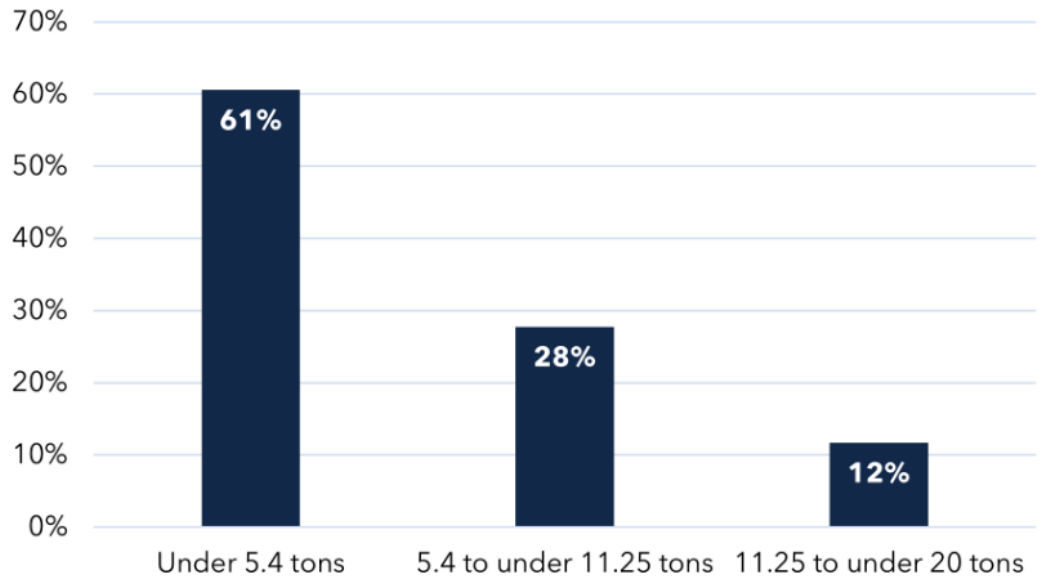
Source: Comstock, California baseline metadata (U.S. commercial sector circa 2018) as reported in Commercial Rooftop Units Market Characterization Report (Sathe 2025)

Consistent with these findings, the prototype screening conducted for this proposal identified Sit-Down Restaurant, Large Retail, and Warehouse as the strongest candidates for evaluating RTU replacement in the target size range because these building types commonly include SZAC-existing RTUs and align well with the measure scope. In particular, the Sit-Down Restaurant prototype is a strong fit because both kitchen and dining RTUs typically fall within the size range of the proposal. The Large Retail prototype includes many RTUs in the target range and represents a high-impact building type. The Warehouse prototype includes in-scope RTUs serving office and fine-storage areas, although bulk storage areas are often served by gas unit heaters rather than RTUs.

Capacity Selection. The available RTU size-distribution data further support the focus of this proposal. Figure 2 shows the distribution of California rooftop units by system capacity. Although units below 5.4 tons represent the largest share

of the installed market, the 5.4 to less than 20-ton segment still represents a significant portion of the RTU stock and captures an important number of replacement opportunities relevant to this proposed alteration measure. These findings support focusing the proposal on replacements of SZAC-existing RTUs with cooling capacities greater than 5.4 tons and up to 20 tons.

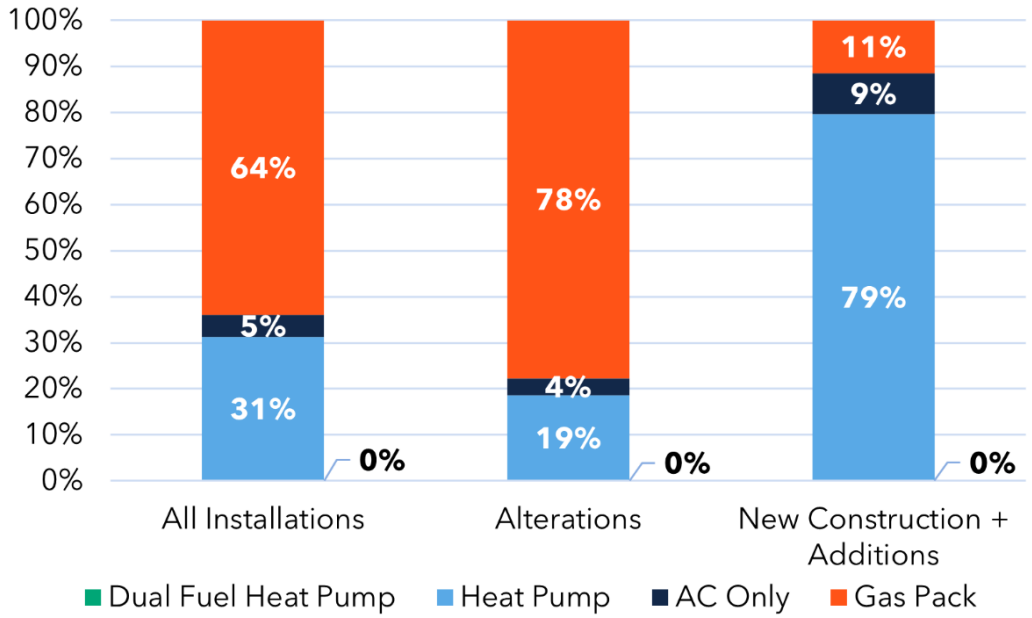
Figure 2: Distribution of California RTUs under 20 tons by cooling capacity



Source: 2024 VCA & EnergyPro data, Weighted as reported in Commercial Rooftop Units Market Characterization Report (Sathe 2025)

Installation-type data also indicates that packaged gas furnace RTUs remain dominant in the replacement market. According to 2024 Virtual Compliance Assistant and EnergyPro (VCA & EnergyPro)data, reported in Sathe 2025, for RTUs under 20 tons, gas furnace RTUs account for 78 percent of alteration installations, while heat pumps account for only 19 percent and AC-only units account for 4 percent (Figure 3). By comparison, heat pumps account for a much larger share of newly constructed buildings and additions. These data suggest that the alterations market remains heavily reliant on gas furnace RTU equipment and that this market segment presents a meaningful opportunity for code intervention to accelerate heat pump RTU adoption in replacement applications.

Figure 3: Distribution of RTUs under 20 tons by construction type



Source: 2024 VCA & EnergyPro data, Weighted as reported in Commercial Rooftop Units Market Characterization Report (Sathe 2025)

Vintage Selection. The distribution of existing California commercial floor area by vintage, based on Dodge Data & Analytics (2023), further supports the selection of these prototype building types for an alterations-focused proposal. The vintage distribution indicates that a substantial share of floor area in the restaurant, retail, and warehouse categories was constructed prior to 1998, with particularly large building stocks in the pre-1978 and 1978–1997 periods. This indicates a large population of older buildings in which existing rooftop equipment is likely to be at or near replacement age and alteration opportunities are therefore likely to be concentrated. Based on these data, Vintage bins: Pre-1978 and 1978–1997 were selected for analysis for the Large Retail and Sit-Down Restaurant prototypes, while Vintage bins pre-1978, 1978–1997, and 1998-2007 were selected for the Warehouse prototype. The detailed characteristics and assumptions for each prototype and vintage are described in Appendix E. Taken together, the RTU saturation data, RTU size distribution, installation-type market shares, and vintage floor area distribution support the use of Large Retail, Sit-Down Restaurant, and Warehouse as representative prototypes for evaluating replacement of existing packaged single-zone gas furnace RTUs with packaged single-zone heat pump RTUs in the greater-than-5.4-ton and up-to-20-ton range.

Table 4: Percentage of floor area by building type and vintage

Floor area % considering demolished area ((BSD1970 -Demolished) +NEW+ ADD))						
Building Type	Proposed vintage bins					Total %
	Pre-1978	1978-1997	1998-2007	2008-2018	New Construction (2019+)	
Retail - All Sizes	37.5%	33.1%	18.1%	9.7%	1.7%	100.0%
Retail > 50,000 sf	31.5%	25.8%	25.5%	15.2%	2.0%	100.0%
Restaurant - All Sizes	49.6%	28.9%	13.2%	5.8%	2.5%	100.0%
Restaurant > 3,500 sf	48.7%	27.9%	13.4%	6.8%	3.2%	100.0%
Warehouse - All Sizes	22.9%	37.5%	21.1%	11.2%	7.2%	100.0%
Warehouse > 50,000 sf	12.3%	29.6%	29.3%	17.2%	11.5%	100.0%

Source: Dodge Data & Analytics (2023)

Measure Scenarios. Two scenarios were evaluated for this proposal:

- The heat pump RTU baseline measure replaces the SZAC-existing rooftop unit with gas furnace with a System7B-SZVAVHP rooftop unit. This measure is intended to serve as the baseline compliance approach and the primary basis for evaluating the cost-effectiveness of the proposed measure. The analysis is designed to reflect realistic rooftop unit operation in alteration projects, including defrost operation where applicable. The heat pump RTUs modeled in this proposal for Climate Zones 1 through 15 were simulated without supplemental heat, as load analysis indicated that supplemental heating was not required in those climate zones. For Climate Zone 16, two heat pump configurations were evaluated: one with supplemental electric resistance heat and one with supplemental gas furnace heat in a dual-fuel heat pump configuration. Because Climate Zone 16 is heating-dominated, supplemental heating is expected to contribute more significantly to winter heating operation, and the dual-fuel configuration was included to evaluate its effect on winter electric heating demand and associated LSC outcomes.
- To add flexibility, an alternative gas furnace RTU compliance option was also evaluated. The replacement system consists of a System 7A-SZVAVAC rooftop unit with gas heat, paired with a defined bundle of practical efficiency measures to achieve system-level equivalency with the heat

pump RTU baseline measure, including equivalency in LSC and Source Energy performance (Refer to Section 5.1 for proposed code language).

The efficiency measures for the alternative gas furnace RTU compliance option are limited to strategies that are practical for alteration projects and do not require intrusive building reconfiguration or impose excessive incremental cost burdens. The efficiency measures analyzed are the following:

- Adding heat recovery to reduce heating and cooling loads by recovering energy from exhaust air.
- Reducing fan power by 15 percent in addition to not taking the extra fan power allowance permitted under Table 401.5-A of the Restructured 2025 Energy Code (Table 141.0-D of the 2025 Energy Code).
- Using three-stage DX cooling to improve part-load performance.
- Using two-stage gas heating to improve heating control and part-load efficiency.
- Reducing no-load minimum fan speed to 25 percent of design airflow to result in lower fan energy during deadband and ventilation operation.

A key objective of the proposal is to determine the conditions under which the heat pump RTU replacement measure is cost-effective and to establish an alternative gas furnace RTU compliance option with required efficiency co-measures to maintain comparable overall LSC and Source Energy performance. Cost-effectiveness is evaluated using the California Energy Commission Long-term Systemwide Cost metric.

3.2 Energy Savings Results

All prototype building models were first created in CBECC 2025 and then modeled in EnergyPlus (version 25.1) with parametric simulations of combinations of energy efficiency measures in all 16 California climate zones.

The building prototype models used for the proposal are shown in Table 5. These building types most commonly use large single zone unitary equipment for space cooling and heating. For the cost analysis, the smallest available nominal rated equipment capacity that would meet zone loads was selected. Large, modeled zones that had capacity greater than the largest unit size considered, 20 tons, were assigned combinations of smaller tonnage units to meet the peak zone load.

Table 5: Prototype(s) Used for Energy, Cost, and Environmental Analysis

Occupancy Type (Residential, Retail, Office, etc.)	Floor Area (ft^2)	Number of Stories	Statewide Floor Area (Million ft^2)
Large Retail	240,023	1	470
Warehouse	52,050	1	1208
Restaurant Sit-Down	5,503	1	195

Although the Warehouse prototype was included in the preliminary analysis and showed cost-effectiveness in all climate zones, it was excluded from the measure scope for this report because a practical and viable alternative gas RTU compliance option was not identified for this building type. Given the proposal framework, which requires evaluation of both the heat pump RTU measure and a feasible alternative gas furnace plus efficiency compliance option in climate zones where applicable, Warehouse was not carried forward. Therefore, this report focuses on Large Retail and Sit-Down Restaurant, which better aligns with the proposed measure scope and compliance structure.

Table 6 through Table 9 and Table 10 through Table 13 summarize the 30-year LSC savings and source energy savings, respectively, for the selected prototypes and vintages evaluated in this proposal. The analysis compares replacement of SZAC-existing with gas furnace with both System7B-SZVAVHP and 2025 code-compliant System7A-SZVAVAC with gas furnace.

Dual-Fuel Heat Pump Scenario. For CZs 1 through 15, the heat pump RTU systems were modeled without supplemental heat, as supplemental heating was not required for those climate zones in this proposal. For CZ 16, comparison of the SZAC-existing scenario, two heat pump configurations were evaluated: a conventional heat pump with electric resistance supplemental heat and a dual-fuel heat pump with gas furnace supplemental heat. Because CZ 16 is heating-dominated, a substantial portion of the winter heating load is expected to be met by supplemental heat. The analysis showed that a conventional heat pump with electric resistance supplemental heat resulted in negative LSC and caused the measure to not be cost-effective in that climate zone. Therefore, the dual-fuel heat pump configuration was also evaluated and applied to reduce winter electric heating demand, resulting in positive LSC savings compared to the existing equipment. Unless otherwise noted, all results presented for CZ 16 in this report are based on the dual-fuel heat pump configuration.

Sit-Down Restaurant Results. For the Sit-Down Restaurant prototype, both Vintage bins: Pre-1978 and 1978–1997 buildings show positive source energy savings for the System7B-SZVAVHP relative to the SZAC-existing unit with gas heat across all climate zones. The heat pump RTU measure also shows positive

LSC and Source Energy savings relative to the SZAC-existing unit with gas heat in most climate zones. However, when compared to the 2025 code-compliant System7A-SZVAVAC with gas furnace, the incremental LSC savings are small in several cases and become very limited in CZs 7 and 15, particularly for Vintage 2. In these climate zones, the 2025 code-compliant System7A-SZVAVAC with gas furnace performs similarly to the heat pump measure, resulting in only a narrow cost-effectiveness margin for the proposed measure. The proposed measure is excepted for climate zones where it is not cost effective.

Large Retail Results. For the Large Retail prototype, both Vintage bins: Pre-1978 and 1978–1997 buildings show positive source energy savings for the System7B-SZVAVHP relative to the SZAC-existing unit with gas heat in nearly all climate zones. The heat pump RTU measure also shows positive LSC savings relative to the SZAC-existing unit with gas heat across all climate zones. However, when compared to the 2025 code-compliant System7A-SZVAVAC with gas furnace, the incremental LSC savings are small in several cases and become slightly negative in CZ 15 for both vintages. In CZ 15, the heat pump RTU measure does not appear cost-effective, primarily because its cooling energy use is approximately 3 to 5 percent higher than that of the 2025 code-compliant System7A-SZVAVAC with gas furnace. In the very hot Palm Springs climate, this cooling penalty is not fully offset by heating savings. Based on these results, CZ 15 is excluded from the proposed code language.

Overall, the results indicate that the System7B-SZVAVHP measure provides positive LSC savings relative to the SZAC-existing unit with gas heat while also delivering positive source energy savings across most climate zones for the building types carried forward in the proposal. To assess the cost-effectiveness of the heat pump RTU measure, the analysis evaluates the incremental LSC savings between System7B-SZVAVHP and the 2025 code-compliant System7A-SZVAVAC with gas furnace. These results show that the System7B-SZVAVHP is cost-effective in some climate zones but not in others, depending on prototype, vintage, and climate conditions. The smallest incremental LSC margins occur in Restaurant Sit-Down 1978–1997 buildings in CZs 7 and 15, in Large Retail 1978–1997 buildings in CZs 7 and 15, and in Large Retail Vintage bin: pre-1978 buildings in CZs 7, 8, and 15, where the incremental LSC savings are near zero or slightly negative. Overall, the proposed heat pump measure in several climate zones provides both meaningful source energy savings and a sufficient LSC margin over the 2025 code-compliant System7A-SZVAVAC with gas furnace to be cost effective.

Table 6: Large Retail Prototype (Pre-1978) LSC Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity LSC Savings (PV$/sf)	30-Year Natural Gas LSC Savings (PV$/sf)	30-Year Total Energy LSC Savings (PV$/sf)
1	(7.41)	11.52	4.10
2	(6.91)	9.35	2.44
3	(3.81)	6.57	2.76
4	(6.39)	8.25	1.86
5	(2.97)	4.64	1.67
6	(1.21)	2.31	1.10
7	(0.79)	1.38	0.59
8	(1.22)	2.06	0.84
9	(1.70)	3.33	1.63
10	(1.88)	3.25	1.37
11	(6.74)	10.99	4.25
12	(5.04)	8.17	3.13
13	(3.63)	5.76	2.13
14	(7.47)	9.75	2.28
15	(1.76)	1.60	(0.16)
16	(11.94)	19.84	7.90

Table 7: Large Retail Prototype (1978 – 1997) LSC Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity LSC Savings (PV$/sf)	30-Year Natural Gas LSC Savings (PV$/sf)	30-Year Total Energy LSC Savings (PV$/sf)
1	(6.06)	9.13	3.07
2	(5.83)	7.73	1.90
3	(3.13)	5.33	2.20
4	(5.32)	6.75	1.43
5	(2.50)	3.50	1.00
6	(0.96)	1.97	1.02
7	(0.55)	1.14	0.59
8	(0.88)	1.76	0.89
9	(1.45)	2.92	1.47
10	(1.53)	2.83	1.30
11	(5.96)	9.68	3.71
12	(4.29)	7.05	2.76
13	(2.85)	4.97	2.12
14	(6.23)	8.31	2.08
15	(1.47)	1.24	(0.23)
16	(10.56)	17.26	6.70

Table 8:Restaurant Sit-Down Prototype (Pre-1978) LSC Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity LSC Savings (PV$/sf)	30-Year Natural Gas LSC Savings (PV$/sf)	30-Year Total Energy LSC Savings (PV$/sf)
1	(22.85)	37.50	14.65
2	(19.22)	29.66	10.45
3	(10.75)	17.47	6.72
4	(19.67)	28.31	8.63
5	(10.39)	17.50	7.10
6	(3.92)	5.89	1.97
7	(1.91)	3.77	1.86
8	(4.29)	7.24	2.95
9	(6.15)	10.46	4.32
10	(6.48)	11.17	4.68
11	(18.55)	30.55	12.00
12	(15.03)	25.18	10.15
13	(11.44)	18.59	7.15
14	(21.14)	30.43	9.29
15	(5.15)	5.81	0.66
16	(25.50)	35.06	9.56

Table 9: Restaurant Sit-Down Prototype (1978 – 1997) LSC Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity LSC Savings (PV$/sf)	30-Year Natural Gas LSC Savings (PV$/sf)	30-Year Total Energy LSC Savings (PV$/sf)
1	(18.25)	29.56	11.31
2	(16.07)	23.30	7.23
3	(8.00)	12.96	4.96
4	(15.13)	20.97	5.84
5	(7.87)	13.07	5.20
6	(2.70)	4.02	1.33
7	(1.79)	2.50	0.72
8	(2.94)	4.83	1.89
9	(4.45)	7.12	2.66
10	(4.59)	7.60	3.01
11	(13.98)	22.52	8.54
12	(11.41)	18.74	7.33
13	(8.40)	13.35	4.95
14	(16.32)	22.63	6.31
15	(3.68)	3.63	(0.05)
16	(19.47)	27.85	8.38

Table 10: Large Retail Prototype (Pre-1978) Source Energy Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity Source Energy Savings (kBtu/sf)	30-Year Natural Gas Source Energy Savings (kBtu/sf)	30-Year Total Source Energy Savings (kBtu/sf)
1	(1.74)	10.97	9.23
2	(1.81)	8.63	6.82
3	(0.96)	6.12	5.16
4	(1.86)	7.56	5.70
5	(0.85)	4.32	3.47
6	(0.36)	2.04	1.68
7	(0.24)	1.21	0.97
8	(0.42)	1.80	1.37
9	(0.62)	2.91	2.29
10	(0.63)	2.84	2.21
11	(2.07)	10.04	7.96
12	(1.58)	7.47	5.89
13	(1.15)	5.21	4.06
14	(2.49)	8.60	6.11
15	(0.41)	1.39	0.98
16	(3.05)	18.20	15.15

Table 11: Large Retail Prototype (1978 – 1997) Source Energy Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity Source Energy Savings (kBtu/sf)	30-Year Natural Gas Source Energy Savings (kBtu/sf)	30-Year Total Source Energy Savings (kBtu/sf)
1	(1.40)	8.66	7.26
2	(1.54)	7.11	5.57
3	(0.79)	4.95	4.16
4	(1.56)	6.16	4.60
5	(0.69)	3.24	2.55
6	(0.30)	1.74	1.44
7	(0.19)	1.00	0.81
8	(0.35)	1.54	1.19
9	(0.55)	2.56	2.01
10	(0.54)	2.47	1.93
11	(1.85)	8.83	6.97
12	(1.38)	6.43	5.05
13	(0.96)	4.49	3.52
14	(2.12)	7.32	5.20
15	(0.32)	1.08	0.76
16	(2.68)	15.81	13.12

Table 12: Restaurant Sit-Down (Pre-1978) Source Energy Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity Source Energy Savings (kBtu/sf)	30-Year Natural Gas Source Energy Savings (kBtu/sf)	30-Year Total Source Energy Savings (kBtu/sf)
1	(5.78)	36.44	30.66
2	(5.58)	27.98	22.40
3	(3.00)	16.49	13.49
4	(6.08)	26.36	20.28
5	(3.09)	16.77	13.69
6	(1.11)	5.27	4.15
7	(0.74)	3.34	2.60
8	(1.59)	6.37	4.79
9	(2.19)	9.26	7.08
10	(2.26)	9.93	7.67
11	(6.08)	28.12	22.05
12	(4.98)	23.29	18.31
13	(3.88)	16.93	13.05
14	(7.62)	27.04	19.43
15	(1.52)	5.06	3.54
16	(6.81)	32.55	25.73

Table 13:Restaurant Sit-Down Prototype (1978 – 1997) Source Energy Savings Over 30-Year Period of Analysis

Climate Zone	30-Year Electricity Source Energy Savings (kBtu/sf)	30-Year Natural Gas Source Energy Savings (kBtu/sf)	30-Year Total Source Energy Savings (kBtu/sf)
1	(4.65)	28.65	23.99
2	(4.68)	21.88	17.20
3	(2.29)	12.19	9.90
4	(4.73)	19.45	14.72
5	(2.38)	12.47	10.09
6	(0.78)	3.58	2.81
7	(0.58)	2.20	1.63
8	(1.09)	4.23	3.14
9	(1.57)	6.27	4.70
10	(1.61)	6.73	5.12
11	(4.65)	20.66	16.01
12	(3.85)	17.27	13.42
13	(2.88)	12.12	9.25
14	(5.94)	20.05	14.11
15	(1.00)	3.16	2.16
16	(5.21)	25.78	20.57

3.3 Economic and Fiscal Impacts

Fiscal impacts are realized primarily through reduction of natural gas consumption onsite, which offsets electricity consumption for heating. An indirect benefit, described in this report, is improvement of outdoor air quality through reduced emissions. Since the equipment required in this proposal is readily available, there is no expected impact on contractors and distributors.

This measure does not impact municipal buildings and creates no cost burden for state and local government. Existing enforcement policies apply equally to heat pumps.

3.4 Incremental First Cost

Incremental costs for this measure are the cost differences between installing replacement rooftop units (RTUs) that comply with the 2025 Energy Code and installing equivalent-capacity heat pump RTUs (or dual-fuel heat pump RTUs, for climate zone 16). Costs include incremental equipment and labor costs, and incremental replacement costs in year 15, at the end of the expected useful life of the heat pump equipment. See Appendix D on detailed cost estimates by climate zone.

Incremental cost estimates for this measure were derived from multiple sources:

1) Costs developed from 2025 Reach Code Study. A 2025 Reach Code Study obtained costs from two different manufacturers for rooftop heat pump units in nominal capacities from 7.5 tons to 20 tons.
2) Costs obtained through outreach to manufacturer representatives and distributors. Additional equipment costs from RTU heat pump manufacturers were collected.
3) Cost estimating from a specialist cost-estimating team using primarily RSMeans data.

A detailed estimate of labor costs by climate zone region was developed. Labor estimates consisted of the following:

- Removal of existing units
- Disconnection and capping of gas line
- Rental of truck-mounted lattice boom crane
- Supply and installation of heat pump RTU (varied size, 7.5 ton to 20 ton)
- Connection to existing electrical feeder

Among these cost line items, all items except for disconnection and capping of the gas line and supply and installation of the heat pump are cost-neutral between the HP RTU case and the gas furnace RTU case.

First costs were gathered for each climate zone. Labor costs, which are non-prevailing wages for the building types in the measure scope, vary by climate zone or region, but equipment costs are independent of region. The costs below are shown for Climate Zone 2 (Santa Rosa) as an example.

Separate cost estimates were gathered for each nominal equipment capacity. Heat pump incremental costs for the two largest capacity sizes in the proposal, 15 tons and 20 tons, are higher costs per ton than the smaller sizes.

Table 14: Incremental First Cost for Large Commercial Heat Pumps

Capacity	Heat Pump RTU Line Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$12,177	Equipment Cost	$11,564.50	$612.50
	Labor Cost	$4,663.58	Labor Cost	$4,497.39	$166.19
	Incremental Cost				**$923.89**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$15,972	Equipment Cost	$14,830	$1,142.00
	Labor Cost	$5,200.34	Labor Cost	$5,016.59	$183.75
	Incremental Cost				**$1,470.95**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$19,074	Equipment Cost	$18,744	$330.00
	Labor Cost	$6,078.68	Labor Cost	$5,860.07	$218.61
	Incremental Cost				**$693.81**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$22,308	Equipment Cost	$20,008	$2,300
	Labor Cost	$6,689.34	Labor Cost	$6,397.81	$291.53
	Incremental Cost				**$2,736.73**
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$28,776	Equipment Cost	$25,016	$3,760
	Labor Cost	$8,355.40	Labor Cost	$8,024.14	$331.26
	Incremental Cost				**$4,236.46**

Detailed cost estimates for large commercial heat pumps in each climate zone are provided in Appendix D: Cost Details.

3.5 Incremental Maintenance Costs

Maintenance costs for the 2025 code-compliant gas furnace RTUs and the heat pump RTUs were estimated from labor hours to perform routine maintenance tasks. The 2025 code-compliant gas furnace RTU has additional maintenance for burner and flame sensor cleaning, inspection of the heat exchanger and venting, and inspection of the ignition system. These tasks cause the 2025 code-compliant gas furnace RTU to have slightly higher annual maintenance costs than an equivalent-capacity heat pump RTU.

For simplicity, for this proposal, the 2025 code-compliant gas furnace RTU and heat RTU pump were assumed to have identical annual maintenance costs. Both systems have a 15-year expected useful life; the life-cycle cost estimate includes a complete system replacement after 15 years, for both the base case and the heat pump proposed case. A 3% annual discount rate was applied to the end-of-life replacement.

3.6 Cost Effectiveness

Cost-effectiveness analysis is used to determine the economic impact of proposed measures over a 30-year period of analysis. This analysis must consider and include incremental energy savings for all impacted energy sources (electricity and natural gas), incremental first costs, and incremental maintenance costs over a 30-year period of analysis. Design costs and incremental costs associated with code compliance are not included in this analysis.

For purposes of the California Energy Code, a measure is cost-effective if the life-cycle energy savings exceed the life-cycle costs to comply. This corresponds to a Benefit-Cost Ratio (BCR) equal to or greater than 1.0. BCR is calculated by dividing the total present value cost benefits by the total present value costs.

Replacement of existing single zone gas furnace rooftop units (RTUs) with single zone heat pump RTUs is cost-effective for most climate zones in California. Cost effectiveness was evaluated for different building vintages as well. In summary the energy and cost-effectiveness evaluation found the measure to be cost effective in the following climate zones:

- Retail Building Spaces:
  - <1978: Climate Zones 1-6, 9-14, 16
  - 1978-1997: all Climate Zones except CZ15
- Sit-Down Restaurant Spaces:
  - <1978: all Climate Zones except CZ15

- 1978-1997: Climate Zones 1-6, 8-14, 16

In climate zone 15 (Palm Springs), the combination of low heating loads and high cooling loads affected the measure. The federal minimum cooling efficiency for heat pumps is slightly lower than the minimum cooling efficiency for rooftop units with gas furnaces.

Alterations projects in climate zone 16 include a cost premium for dual-fuel units.

Additional climate zones were excluded from the proposed code language (Table_401.5-C) because a viable gas pathway could not be identified for those climate zones.

For warehouses, while replacement of gas furnace rooftop units (RTUs) with heat pump RTUs was cost effective, there were no viable efficiency measures to demonstrate a gas furnace RTU alternative to a heat pump RTU-based prescriptive requirement. Therefore, warehouses were excluded from the scope of this proposal.

Table 15: Cost-effectiveness Summary, Large Retail Prototype (Pre-1978)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
1	$ 4.10	$ 0.72	5.7
2	$ 2.44	$ 1.03	2.4
3	$ 2.76	$ 0.75	3.7
4	$ 1.86	$ 1.01	1.8
5	$ 1.67	$ 0.66	2.5
6	$ 1.10	$ 0.80	1.4
7	$ 0.59	$ 0.83	0.7
8	$ 0.84	$ 1.02	0.8
9	$ 1.63	$ 0.99	1.6
10	$ 1.37	$ 1.00	1.4
11	$ 4.25	$ 1.08	3.9
12	$ 3.13	$ 0.97	3.2
13	$ 2.13	$ 1.01	2.1
14	$ 2.28	$ 1.12	2.0
15	$ (0.16)	$ 1.15	N/A
16	$ 7.90	$ 2.49	3.2

Table 16: Cost-effectiveness Summary, Large Retail Prototype (1978 – 1997)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
1	$3.07	$ 0.51	6.0
2	$1.90	$ 0.70	2.7
3	$2.20	$ 0.62	3.6
4	$1.43	$ 0.77	1.9
5	$1.00	$ 0.62	1.6
6	$1.02	$ 0.53	1.9
7	$0.59	$ 0.68	0.9
8	$0.89	$ 0.75	1.2
9	$1.47	$ 0.77	1.9
10	$1.30	$ 0.75	1.7
11	$3.71	$ 0.90	4.1
12	$2.76	$ 0.71	3.9
13	$2.12	$ 0.83	2.5
14	$2.08	$ 0.90	2.3
15	($0.23)	$ 0.83	N/A
16	$6.70	$ 1.84	3.6

Table 17: Cost-effectiveness Summary, Sit-Down Restaurant Prototype (Pre-1978)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$/sf)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
1	$ 14.6	$ 1.39	10.6
2	$ 10.4	$ 0.99	10.5
3	$ 6.7	$ 1.24	5.4
4	$ 8.6	$ 0.90	9.6
5	$ 7.1	$ 1.00	7.1
6	$ 2.0	$ 1.20	1.6
7	$ 1.9	$ 0.91	2.0
8	$ 2.9	$ 1.33	2.2
9	$ 4.3	$ 1.33	3.2
10	$ 4.7	$ 1.33	3.5
11	$ 12.0	$ 1.74	6.9
12	$ 10.1	$ 0.84	12.1
13	$ 7.2	$ 1.54	4.6
14	$ 9.3	$ 1.53	6.1
15	$ 0.7	$ 1.58	0.4
16	$ 9.6	$ 3.34	2.9

Table 18: Cost-effectiveness Summary, Sit-Down Restaurant Prototype (1978 – 1997)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$/sf)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
1	$ 11.31	$ 1.14	9.9
2	$ 7.23	$ 1.59	4.5
3	$ 4.96	$ 0.86	5.8
4	$ 5.84	$ 1.42	4.1
5	$ 5.20	$ 0.82	6.3
6	$ 1.33	$ 0.82	1.6
7	$ 0.72	$ 1.53	0.5
8	$ 1.89	$ 1.36	1.4
9	$ 2.66	$ 1.09	2.4
10	$ 3.01	$ 1.09	2.8
11	$ 8.54	$ 1.10	7.7
12	$ 7.33	$ 1.37	5.4
13	$ 4.95	$ 1.10	4.5
14	$ 6.31	$ 1.09	5.8
15	$ (0.05)	$ 1.63	N/A
16	$ 8.38	$ 2.16	3.9

4. STATEWIDE IMPACTS

This section provides the first-year statewide savings of the proposed measure. This analysis is to help determine the overall value of the proposed measure to the State of California and is not used to determine cost effectiveness of the proposed measure. To assist with this analysis a statewide new construction forecast was developed by the CEC for 2029, which is presented in more detail in *Appendix A: Statewide Savings Methodology*. The first-year energy impacts represent the first-year annual savings from all buildings forecasted to be completed in 2029. This section also provides statewide greenhouse gas emissions savings, water use impacts, materials impacts and environmental impacts.

4.1 Statewide Energy and Energy Cost Savings

For the heat pump RTU alteration proposal, statewide savings were estimated using the applicable prototypes in the climate zones where the proposed prescriptive requirement applies (see Section 5). Prototype-level savings were scaled to statewide impacts using an assumed RTU useful life of 15 years, such that approximately 1/15 of the applicable existing RTU stock is assumed to be replaced each year. Accordingly, only 1/15 of the existing building floor area, for the applicable prototypes and climate zones, was used to convert prototype-level savings to first-year statewide savings. The statewide annual energy savings were then estimated using the forecasted floor area developed by the CEC. The resulting statewide savings are presented in Table 19 and 20.

The Restaurant construction forecast developed by the CEC includes both sit-down and fast-food restaurant categories. Based on Dodge Data 2023, the distribution of restaurant floor area shows that buildings in the 3,000 to 4,000 ft² range represent the highest share of restaurant projects. Dodge Data further indicate that approximately 70 percent of total restaurant floor area is associated with restaurants above 3,500 ft². Accordingly, a 3,500 ft² threshold was selected as a reasonable cutoff for representing the sit-down restaurant segment in this study.

Commercial rooftop heat pumps have gradually gained acceptance in the market, in the absence of regulations requiring their installation. A market characterization study for CalMTA (Sathe 2025) compiled commercial rooftop heat pump sales data and found that the heat pump market saturation increased from 9% in 2018 to 20% in 2020. Applying this adoption rate, the anticipated market saturation of heat pumps would be 26% by 2029. Further increasing the adoption of heat pumps are local air quality regulations that will

require ultra-low or zero-NOx emission heating by 2029[1]. Due to these supporting regulations, an adoption rate of 35% was estimated for large commercial heat pumps. Statewide savings are discounted by this naturally occurring market adoption rate.

Table 19:Estimated Statewide Energy Savings

	First Year Statewide Electricity Savings (GWh)	First Year Statewide Power Demand Reduction (MW)	First Year Statewide Natural Gas Savings (Million Therms)	First Year Statewide Electricity LSC Savings (PV Million $)	First Year Statewide Natural Gas LSC Savings (PV Million $)	First Year Statewide Total LSC Savings (PV Million $)	First Year Statewide Source Energy Savings (Million Btu)
Large Retail (Pre-1978)	(2.9)	0.5	0.5	(27.4)	42.8	15.4	29,467.9
Large Retail (1978 – 1997)	(4.5)	1.4	0.8	(41.9)	68.0	26.1	47,502.8
Sit-Down Restaurant (Pre-1978)	(2.3)	(0.2)	0.4	(24.1)	40.2	16.1	27,561.0
Sit-Down Restaurant (1978 – 1997)	(2.0)	(0.2)	0.4	(21.7)	33.8	12.1	22,580.8
Total	(11.6)	1.5	2.0	(115.1)	184.8	69.7	127,112.5

* These results incorporate the 35% adoption rate.

4.2 Statewide Greenhouse Gas Emissions Savings

GHG emissions reductions are a co-benefit of this proposal. The GHG emissions were estimated based on hourly factors developed by the CEC. The results are presented in Table 20.

[1] For example, Bay Area Air Quality Management District Regulation 9, Rule 4 FAQ-Appliance Rules_1-30-25

Table 20: Estimated Statewide Greenhouse Gas Emissions Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)
Large Retail (Pre-1978)	2,027.9
Large Retail (1978 – 1997)	3,251.7
Sit-Down Restaurant (Pre-1978)	1,924.7
Sit-Down Restaurant (1978 – 1997)	1,593.6
Total	8,797.9

4.3 Statewide Water Savings

No on-site water impacts are associated with the proposed measure.

4.4 Statewide Material Impacts

No on-site material impacts are associated with the proposed measure.

4.5 Environmental Impacts

Combustion of fossil fuels release significant amounts of NOx and other pollutants that have been demonstrated to impact outdoor air quality and human health[2]. Reducing combustion will reduce the environmental impacts resulting from the operation of these building features. The Bay Area Air Quality Management District and other air quality districts have added regulations requiring zero-NOx emissions or ultra-low NOx furnaces in the future.

Environmental impacts from refrigerants are expected to be minimal, since the difference in refrigerant volume for an air conditioning unit is not expected to be significant compared to the refrigerant volume in a heat pump unit.

4.6 Other Impacts

No other impacts are associated with the proposed measure.

[2] California Air Resources Board summary on common air pollutants - https://ww2.arb.ca.gov/resources/common-air-pollutants

5. PROPOSED CODE LANGUAGE

5.1 Restructured Energy Code (Title 24, Part 6)

The revision to code language primarily consists of a new table in the prescriptive alterations requirements, which requires installation of heat pumps for all systems with a rated capacity equal to or greater than 65 kBtu/h and not exceeding 240 kBtu/h, serving retail spaces or sit-down restaurant spaces newly constructed on December 31, 1997 or earlier.

New Code Language:

401.5.2.2.1.2- New or replacement single zone packaged rooftop systems with direct expansion cooling with rated cooling capacity of at least 65,000 Btu/hr but not exceeding 240,000 Btu/hr shall meet the applicable requirements specified in Table 401.5-C [or shall meet the performance compliance requirements of Section 401.5.2.3 [Section 141.0(b)3].

Exception to Section 401.5.2.2.1.2: This requirement is not applicable if the alteration requires both 1) a system that exceeds the rated heating and cooling capacity of the existing replaced unit, and 2) an increase to the existing main service panel or service transformer capacity. An electrical load calculation shall be submitted by a registered professional engineer in accordance with Article 220 of the California Electrical Code, and verification by a licensed engineer is required to confirm that additional heating and cooling capacity is required.

Table 401.5-C New or Replacement Single Zone Air Conditioner or Heat Pump Requirement in Retail or Restaurant Spaces Newly Constructed on December 31, 1997 or Earlier, Replaced System Capacity between 65,000 and 240,000 Btu/h

For Buildings Newly Constructed Between 1978 and 1997																
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1
For Buildings Newly Constructed Before 1978																
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1

SZVAVAC 1 = Single-zone VAV air conditioner with economizer, heat recovery (ERR = 85%), three-stage DX cooling coil, two-stage gas heating coil, no-load fan speed reduced to 25%, and fan power reduced by 15% in addition to not taking the extra fan power allowance permitted under Table 141.0-D.

5.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

5.3 Compliance Manuals

There are no proposed changes to the Compliance Manuals.

5.4 ACM Reference Manuals

In Section 5.1.4 of the 2028 Nonresidential ACM Reference Manual, Table 4 will be modified to designate a single zone variable air volume heat pump (System7B-SZVAVHP) as the standard design (baseline) system designation for retail buildings and sit-down restaurants in climate zones where it was shown to be cost effective.

Where it is cost effective, the baseline system type will apply to all retail and sit-down restaurant spaces with peak cooling or heating load of at least 65 kBtu/h and not exceeding 240 kBtu/h.

5.5 Compliance Forms

There are no proposed changes to the compliance forms.

6. REFERENCES

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APPENDICES

Appendix A: Statewide Savings Methodology

Estimated statewide energy savings for the first year that the Energy Code becomes in effect (2029) were generated by multiplying the proposed measure's per unit savings by the statewide construction forecasts in this appendix. The CEC has provided residential and nonresidential new construction and existing forecasts for 2029, broken out by building type and climate zones. For each prototype, the forecasted construction area was first multiplied by 1/15 to represent the portion of the existing equipment stock expected to be replaced annually, assuming a 15-year useful life. The resulting applicable statewide construction forecast floor area was then multiplied by the assumed 35 percent naturally occurring adoption rate to estimate the share of the stock expected to adopt the commercial heat pump rooftop unit between 5 and 20 tons in the first year without the measure. Statewide savings were calculated by multiplying the statewide construction forecast floor area adjusted for naturally occurring adoption by the corresponding per-square-foot savings for each applicable building type and climate zone and then summing the results across all applicable climate zones to estimate the total first-year statewide savings in 2029.

Table 21: Statewide Nonresidential New Construction Building Types

Forecast Building Types	Uses	Number of Stories	Floor Area (sf)
Assembly	Gatherings including, but not limited to: Arenas, Coliseums, Auditoriums, Transportation Terminals, Clubs and Lodges, Exhibition Halls, Funeral or Internment Facilities, Religious Buildings, Libraries, Museums, Theaters, Recreational and Exercise Facilities.	Any	Any
Controlled-environment Horticulture	Buildings with indoor conditioned spaces used for agriculture.	Any	Any
Hospital	Hospitals, Clinics, and Nursing Convalescent Facilities	Any	Any
Hotel	Hotels and Motels	Any	Any
Laboratory	Laboratories	Any	Any
Large Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	≥ 5	Any
Medium Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	2 - 4	Any
Small Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	1	Any
Restaurant	Food and/or Beverage Service	Any	Any
Large Retail	Stores and Other Mercantile Buildings	Any	≥ 50k
Medium Retail	Stores and Other Mercantile Buildings	Any	< 50k
Grocery	Stores and Other Mercantile Buildings used for the sale of food items	Any	Any
Strip Mall Retail	Shopping Centers	Any	Any

Large School	Schools and Educational Facilities	Any	≥ 50k
Small School	Schools and Educational Facilities	Any	< 50k
Warehouse	Warehouses and Freight Terminals	Any	Any
Refrigerated Warehouse	Refrigerated Warehouses	Any	Any
Vehicle Service	Auto, Aircraft, Bus, Truck, Railroad, Boat, or any other Vehicle Servicing Facility	Any	Any
Manufacturing	Manufacturing Facilities	Any	Any
Enclosed Parking Garage	Parking Garages enclosed by walls and a roof with rooftop parking.	Any	Any
Open Parking Garage	Parking Garages that are open to the ambient environment. Parking lots with canopies are not considered Parking Garages.	Any	Any
Miscellaneous	Miscellaneous Non-Residential Buildings.	Any	Any

Table 22: Statewide Nonresidential Construction (2029 in Million ft²)

Space Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Large Office	0.0565	2.805	132.12	66.18	1.677	106.03	74.40	170.77	301.78	62.35	2.759	88.00	8.659	20.67	4.130	4.480
Medium Office	2.816	29.28	71.22	39.58	12.68	49.01	44.83	61.07	83.34	69.54	17.00	95.23	24.95	13.37	10.34	4.109
Small Office	4.464	12.41	19.56	9.022	7.015	13.19	8.446	13.18	22.07	24.63	10.64	40.87	22.73	5.575	7.389	2.948
Large Retail	1.045	9.470	61.37	28.14	4.565	34.86	27.11	47.31	70.07	59.46	12.58	63.03	24.77	12.00	10.56	3.552
Medium Retail	1.230	13.28	45.94	25.98	5.378	47.41	35.90	71.11	111.65	73.07	10.69	63.99	26.05	16.86	9.831	5.659
Strip Mall	3.462	10.14	38.11	18.88	5.214	42.85	28.96	59.78	86.14	72.63	12.43	50.86	26.03	16.61	9.578	4.949
K-8 School	0.643	10.804	28.00	18.16	2.960	20.64	22.97	40.91	56.55	55.15	13.461	45.69	28.04	11.962	7.824	3.908
High School	1.448	9.951	28.70	17.06	3.604	24.09	23.23	42.97	66.34	48.91	9.837	40.57	26.98	11.92	6.847	3.944
Large School	2.4629	6.45	55.63	21.61	5.067	35.87	17.35	30.95	51.35	17.18	4.69	35.17	6.30	3.06	1.115	1.641
Hotel	1.722	10.23	45.42	23.33	4.758	31.04	33.89	42.84	64.99	36.99	6.897	39.47	12.76	7.897	5.625	2.383
Restaurant	0.6137	3.646	14.59	7.424	1.519	17.00	10.74	24.60	39.73	33.66	3.599	17.27	7.881	7.077	3.576	1.954
Assembly	3.204	14.71	62.75	26.13	4.953	48.15	29.72	76.39	101.41	79.83	14.48	60.60	25.82	16.56	10.82	5.492
Hospital	1.998	11.87	50.95	25.95	5.498	30.85	29.47	44.54	72.89	41.81	11.53	55.81	24.32	9.286	4.835	3.401
Laboratory	0.4082	4.226	43.44	37.31	0.8915	11.33	19.53	15.90	16.39	16.94	0.9838	14.89	5.376	2.212	0.5969	0.7177
Non-ref. Warehouse	3.525	20.52	107.79	53.77	9.756	95.70	50.80	137.48	211.45	194.41	33.21	141.57	55.70	41.48	30.80	12.40
Open Parking Garage	0.2344	7.980	59.52	44.31	4.143	44.66	40.79	90.23	108.16	40.40	6.058	43.30	6.503	12.37	2.206	6.103
Enclosed Parking Garage	0.0181	0.6171	44.03	32.78	0.3204	31.64	23.98	63.93	76.63	3.124	0.4684	3.348	0.5029	0.9565	0.1706	0.4719

Table 22: (Continued, Non-Prototype Building Types)

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Refrigerated Warehouse	0.0366	1.053	1.480	0.5559	0.6446	0.9453	0.0702	0.98	1.622	1.348	0.6032	4.754	4.857	0.3981	0.3215	0.2544
Grocery	0.0935	1.751	5.002	3.597	0.74	3.000	2.16	4.271	6.781	4.389	0.6612	3.869	1.565	1.013	0.5963	0.3846
CEH	0.5147	0.4388	2.145	0.6292	5.332	6.593	0.8460	0.6048	1.302	8.039	2.282	4.207	4.381	2.173	0.6638	0.3778
Vehicle Service	0.9804	5.647	22.49	8.733	2.737	28.06	15.62	42.09	67.77	47.32	6.296	33.65	16.02	13.14	5.672	3.291
Manufacturing	3.416	14.55	48.90	69.68	4.607	67.47	30.56	114.29	156.12	44.31	9.541	42.35	21.11	15.31	4.368	8.313
Miscellaneous	0.4301	6.498	11.37	4.957	1.332	8.673	3.932	10.33	19.37	9.207	3.684	17.00	5.292	2.407	1.302	1.295

Appendix B: Environmental Impacts Methodology

Greenhouse Gas Emissions Impacts Methodology

GHG emission reductions are a co-benefit of this proposal and are calculated using the latest applicable GHG Emissions hourly factors published by the CEC, which are used by the CEC's reference code compliance software (CBECC-Res and CBECC).

Water Use and Water Quality Impacts Methodology

No on-site water impacts are anticipated with the proposed measure.

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2028 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed Energy Code. A "significant effect on the environment" is "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." (Cal. Code Regs., tit. 14, § 15002(g).)

CEC 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 determined that the proposal will not result in a significant effect on the environment.

Direct Environmental Impacts

Direct Environmental Benefits

This proposal is expected to result in energy savings, and also result in a co-benefit of GHG emission reductions. While the proposed code change increases electricity use for heating, the affected buildings consume less energy overall. These benefits are described throughout the body of this report.

Direct Adverse Environmental Impacts

This proposal is not expected to result in direct adverse environmental impacts, apart from the expected increase in electric load that may occur from the HP systems. The measure is expected to increase grid demand by approximately

1.5 MW, see Table 2. Based on the state's expected capacity build-out[3], this increase does not have a significant direct impact on the environment. Further, this increase in electric load is addressed through specification of design conditions to ensure efficient heat pump operation and minimal use of electric resistance supplemental heating. For example, see Section 140.4(a) of the 2025 Energy Code, Section 401.3.3 of the Restructured 2025 Energy Code.

Direct environmental impacts from refrigerants are expected to be minimal, since the difference in refrigerant volume for an air conditioning unit is not expected to be significant compared to the refrigerant volume in the heat pump unit.

Indirect Environmental Impacts

The measures in this proposal are not expected to result in indirect environmental benefits or adverse impacts.

Mitigation Measures

CEC has considered opportunities to minimize the environmental impact of the proposal, including an evaluation of "specific economic, environmental, legal, social, and technological factors." (Cal. Code Regs., tit. 14, § 15021.)

We note that both air conditioners and heat pumps use refrigerants. Refrigerants vary in their global warming potential. Limiting leakage and ensuring responsible refrigerant disposal at the end of a product's life are critical steps to mitigate environmental impact of this equipment.

[3] California Energy Commission staff. 2026. *2025 Integrated Energy Policy Report.* Publication Number: CEC-100-2026-001. https://www.energy.ca.gov/publications/2026/2025-integrated-energy-policy-report

Appendix C: CBECC Software Specification

A key aspect of the proposed software specification is the modeling approach used to represent the heat pump system in the simulation engine. For the heat pump RTU case, the AirLoopHVAC:UnitarySystem object in EnergyPlus was used to ensure that the no-load fan speed could be explicitly defined and controlled in a way that reflects the intended system operation under the proposed measure. In addition, the AirLoopHVAC:UnitarySystem object was also used to model the gas furnace RTU case with a three-stage DX cooling coil and a two-stage gas heating coil, consistent with the assumptions for improved part-load performance, staged heating and cooling operation, and reduced fan energy use in the System7A-SZVAVAC system included in the proposal.

The simulation inputs for this modeling approach were based on several specific operational assumptions that should be clearly reflected in the compliance software implementation. For the heat pump RTU case, full airflow was modeled in both low and high heating stages. For the gas furnace RTU case, airflow was modeled at 70 percent in the low heating stage and 100 percent in the high heating stage. The heat pump RTU's defrost operation was modeled as timed reverse-cycle defrost without supplemental heating, for all climate zones except 16. In addition, for the proposed efficiency measures, the no-load fan speed was modeled as reduced down to 25 percent, consistent with the assumption that fan speed is reduced during deadband operation to result in lower fan energy use.

Appendix D: Cost Details

Cost estimates were developed separately for alterations projects in each California climate zone. The labor portion of the estimate varies by five cost regions, associated with each climate zone, see Table 28. Labor estimates assume non-prevailing wage labor rates, since projects are not municipal projects. The non-labor portion of the estimate did not vary by region.

Incremental First Cost

Incremental first costs consist of equipment costs (commercial gas furnace RTUs and commercial heat pump RTUs) and installation costs. Equipment costs were gathered from manufacturers, from sources including: Outreach by CEC subcontractor, NORESCO, to multiple manufacturer representatives in California, a 2025 Reach Code study, and a NORESCO-led energy services costing estimating team using primarily RSMeans data All studies gathered costs for single zone gas furnace RTUs and heat pump RTUs for a range of rated capacities from 7.5 tons to 20 tons.

Single-zone RTUs, whether gas furnace RTUs or heat pump RTU, come in discrete sizes: 7.5-ton, 10-ton, 12.5-ton, 15-ton, and 20-ton rated capacity options. (Less common sizes are 6 tons and 8.5 tons.) After the energy model applies standard ACM oversizing factors, the smallest unit size that can meet the design cooling loads and heating loads is used. For instance, a building zone with a peak cooling load of 108,000 Btu/h (9 tons) would use the incremental costs for a 10-ton unit.

Table 23: Cost Estimate, Region 1 – California Climate Zone 1, 2

Capacity	Heat Pump RTU Line Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 12,177.00	Equipment Cost	$ 11,564.50	$ 612.50
	Labor Cost	$ 6,222.90	Labor Cost	$ 6,001.15	$ 221.75
	Incremental Cost				**$979.45**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 15,972.00	Equipment Cost	$ 14,830.00	$ 1,142.00
	Labor Cost	$ 6,939.14	Labor Cost	$ 6,693.95	$ 245.20
	Incremental Cost				**$1,532.40**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 19,074.00	Equipment Cost	$ 18,744.00	$ 330.00
	Labor Cost	$ 8,111.17	Labor Cost	$ 7,819.46	$ 291.70
	Incremental Cost				**$766.90**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 22,308.00	Equipment Cost	$ 20,008.00	$ 2,300.00
	Labor Cost	$ 8,926.01	Labor Cost	$ 8,537.00	$ 389.00
	Incremental Cost				$2,834.20
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 28,776.00	Equipment Cost	$ 25,016.00	$ 3,760.00
	Labor Cost	$ 11,149.13	Labor Cost	$ 10,707.11	$ 442.02
	Incremental Cost				**$4,347.22**

Table 24: Cost Estimate, Region 2 – California Climate Zone 3

Capacity	Heat Pump Line RTU Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 12,177.00	Equipment Cost	$ 11,564.50	$ 612.50
	Labor Cost	$ 5,619.40	Labor Cost	$ 5,419.15	$ 200.25
	Incremental Cost				**$957.95**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 15,972.00	Equipment Cost	$ 14,830.00	$ 1,142.00
	Labor Cost	$ 6,266.18	Labor Cost	$ 6,044.76	$ 221.42
	Incremental Cost				**$1,508.62**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 19,074.00	Equipment Cost	$ 18,744.00	$ 330.00
	Labor Cost	$ 7,324.54	Labor Cost	$ 7,061.12	$ 263.41
	Incremental Cost				**$738.61**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 22,308.00	Equipment Cost	$ 20,008.00	$ 2,300.00
	Labor Cost	$ 8,060.35	Labor Cost	$ 7,709.08	$ 351.28
	Incremental Cost				**$2,796.48**
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 28,776.00	Equipment Cost	$ 25,016.00	$ 3,760.00
	Labor Cost	$ 10,067.88	Labor Cost	$ 9,668.73	$ 399.15
	Incremental Cost				**$4,304.35**

Table 25: Cost Estimate, Region 3 – California Climate Zone 4

Capacity	Heat Pump RTU Line Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 12,177.00	Equipment Cost	$ 11,564.50	$ 612.50
	Labor Cost	$ 5,852.80	Labor Cost	$ 5,644.23	$ 208.57
	Incremental Cost				**$966.27**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 15,972.00	Equipment Cost	$ 14,830.00	$ 1,142.00
	Labor Cost	$ 6,526.44	Labor Cost	$ 6,295.83	$ 230.61
	Incremental Cost				**$1,517.81**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 19,074.00	Equipment Cost	$ 18,744.00	$ 330.00
	Labor Cost	$ 7,628.76	Labor Cost	$ 7,354.40	$ 274.36
	Incremental Cost				**$749.56**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 22,308.00	Equipment Cost	$ 20,008.00	$ 2,300.00
	Labor Cost	$ 8,395.14	Labor Cost	$ 8,029.27	$ 365.87
	Incremental Cost				**$2,811.07**
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 28,776.00	Equipment Cost	$ 25,016.00	$ 3,760.00
	Labor Cost	$ 7,963.62	Labor Cost	$ 7,647.89	$315.73
	Incremental Cost				**($4,220.93)**

Table 26: Cost Estimate, Region 4 – California Climate Zones 5-10, 14, 15

Capacity	Heat Pump Line RTU Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 12,177.00	Equipment Cost	$ 11,564.50	$ 612.50
	Labor Cost	$ 4,444.90	Labor Cost	$ 4,286.51	$ 158.40
	Incremental Cost				**$916.10**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 15,972.00	Equipment Cost	$ 14,830.00	$ 1,142.00
	Labor Cost	$ 4,956.50	Labor Cost	$ 4,781.36	$ 175.14
	Incremental Cost				**$1,462.34**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 19,074.00	Equipment Cost	$ 18,744.00	$ 330.00
	Labor Cost	$ 5,793.66	Labor Cost	$ 5,585.30	$ 208.36
	Incremental Cost				**$683.56**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 22,308.00	Equipment Cost	$ 20,008.00	$ 2,300.00
	Labor Cost	$ 6,375.68	Labor Cost	$ 6,097.82	$ 277.86
	Incremental Cost				**$2,723.06**
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 28,776.00	Equipment Cost	$ 25,016.00	$ 3,760.00
	Labor Cost	$ 7,963.62	Labor Cost	$ 7,647.89	$ 315.73
	Incremental Cost				**$4,220.93**

Table 27: Cost Estimate, Region 5 – California Climate Zones 11, 12, 13, 16

Capacity	Heat Pump Line RTU Item	Heat Pump RTU Cost	Gas Furnace RTU Line Item	Gas Furnace RTU Cost	Incremental Cost
7.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 12,177.00	Equipment Cost	$ 11,564.50	$ 612.50
	Labor Cost	$ 4,663.58	Labor Cost	$ 4,497.39	$ 166.19
	Incremental Cost				**$923.89**
10 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 15,972.00	Equipment Cost	$ 14,830.00	$ 1,142.00
	Labor Cost	$ 5,200.34	Labor Cost	$ 5,016.59	$ 183.75
	Incremental Cost				**$1,470.95**
12.5 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 19,074.00	Equipment Cost	$ 18,744.00	$ 330.00
	Labor Cost	$ 6,078.68	Labor Cost	$ 5,860.07	$ 218.61
	Incremental Cost				**$693.81**
15 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 22,308.00	Equipment Cost	$ 20,008.00	$ 2,300.00
	Labor Cost	$ 6,689.34	Labor Cost	$ 6,397.81	$ 291.53
	Incremental Cost				**$2,736.73**
20 ton	Disconnection and capping of gas line	$1,138.48	Connection of Gas Line	$993.28	$145.20
	Equipment Cost	$ 28,776.00	Equipment Cost	$ 25,016.00	$ 3,760.00
	Labor Cost	$ 8,355.40	Labor Cost	$ 8,024.14	$ 331.26
	Incremental Cost				**$4,236.46**

Table 28: Cost Region Breakdown for Labor Cost Component

Cost Region	Climate Zones	Representative Cities
L1	1, 2	Arcata, Santa Rosa
L2	3	Oakland
L3	4	San Jose
L4	5	Santa Maria
	6	Torrance
	7	San Diego
	8	Fullerton
	9	Burbank
	10	Riverside
	14	Palmdale
	15	Palm Springs
L5	16	Truckee
	11, 12, 13	Red Bluff
	12	Sacramento
	13	Fresno

Table 27: Cost Estimate, Dual-Fuel Heat Pump Cost Premium (used in CZ 16)

Capacity	Dual-Fuel Heat Pump Cost	Heat Pump RTU Cost	Gas Furnace RTU Cost	Dual-Fuel Incremental Cost
7.5 ton	$13,677	$ 12,177.00	$ 11,564.50	$1,500
10 ton	$17,902	$ 15,972.00	$ 14,830.00	$1,930
12.5 ton	$21,004	$ 19,074.00	$ 18,744.00	$1,930
15 ton	$24,238	$ 22,308.00	$ 20,008.00	$1,930
20 ton	$32,986	$ 28,776.00	$ 25,016.00	$4,210

Appendix E: Key assumptions, modeling approaches used in Cost-effectiveness analysis

This Appendix details key assumptions and modeling approaches used to develop energy savings estimates and costs used in the overall cost-effectiveness analysis for the proposed measure, which is summarized in Chapter 4.

Modeling Approach

This section describes the modeling approach used to estimate the energy savings for the proposed measure and documents the key assumptions needed to reproduce the analysis. The analysis compares replacement of a SZAC-existing unit with gas furnace RTU systems with both System7B-SZVAVHP RTUs and a 2025 Energy Code-compliant System7A-SZVAVAC RTU with gas furnace.

A key aspect of the modeling approach was the use of the AirLoopHVAC:UnitarySystem object for the heat pump RTU case. This approach was adopted to ensure that the no-load fan speed could be explicitly modeled and controlled in a manner consistent with the proposed system operation. Using the AirLoopHVAC:UnitarySystem object also allowed the gas furnace RTU + efficiency case to be modeled with a three-speed DX cooling coil and a two-stage gas heating coil, consistent with the assumptions for improved part-load performance and fan control.

The following operational assumptions were used in the modeling:

- Heat Pump RTU – full airflow was used in both low and high heating stages.
- Airside heat recovery - sensible heat recovery effectiveness of 85%.
- Gas furnace RTU – airflow was modeled at 70 percent in the low heating stage and 100 percent in the high heating stage.
- Defrost Mode – heat pump defrost was modeled as timed reverse cycle with no supplemental heating for the applicable cases.
- No-Load Fan Speed – for the proposed cases, no-load fan speed was modeled as reduced down to 25 percent, consistent with the assumptions for reduced fan energy use during deadband operation.

Two vintages were used to represent the efficiency characteristics of buildings constructed during different periods. Vintage bin: Pre-1978 represents buildings constructed prior to 1978, before the initial development of California energy standards and Vintage bin:1978–1997 represents buildings constructed during 1978–1987. These vintages were selected to reflect differences in envelope performance, lighting power, and existing HVAC system characteristics that affect the savings potential of the proposed measure.

For this study, the Vintage bins: Pre-1978 and 1978–1997 prototypes are assumed to represent older existing buildings that, through typical replacement cycles, have rooftop HVAC equipment consistent with a 2008 Energy Code SZAC-existing unit with gas furnace by the start of the 2028 analysis period. This assumption reflects a realistic alteration scenario in which RTUs installed or replaced fifteen to twenty years earlier are now reaching replacement age. Using a 2008 Energy Code-level existing HVAC system provides a reasonable basis for evaluating the savings and cost-effectiveness of the proposed alteration measure, while also recognizing that many older buildings have undergone equipment replacement without full building modernization.

For the non-HVAC features, the prototype assumptions reflect a combination of original vintage characteristics and likely upgrades over time. For both the Large Retail and Sit-Down Restaurant prototypes, the exterior wall, roof, fenestration, and lighting inputs were selected to represent conditions expected in the existing building stock at the time of RTU replacement. Roof thermal performance was assumed to reflect later replacement cycles consistent with a 1992 Energy Code-level roof/insulation replacement, recognizing the longer service life of roof assemblies. Interior lighting was assumed to reflect more recent upgrades consistent with 2016 Energy Code prescriptive lighting power densities by space type.

The existing HVAC system was modeled as a constant-volume SZAC-existing unit with gas furnace, consistent with rooftop equipment that would have been installed under 2008 Energy Code requirements. The modeled systems include two-stage cooling control, 81 percent gas furnace efficiency, and economizer operation where required under 2008 Energy Code. Heat recovery was not included, and ventilation rates were modeled in accordance with 2008 Energy Code Table 121-A. This existing-system framework serves as the basis for comparison to both the System7B-SZVAVHP RTU measure and the 2025 code-compliant System7A-SZVAVAC with gas furnace evaluated in this study. The detailed characteristics and assumptions for each prototype and vintage are provided in Table 30 and 31.

Table 28: Retail Building Model Existing Conditions

	Vintage Bin: Pre-1978	Vintage Bin: 1978-1987	Comments
Envelope-Exterior Walls	U-0.352 (No or very small insulation)	U-0.152	
Envelope-Roof	U-0.057	U-0.057	Considering 30 years for roof/insulation replacement using 1992-T24
Envelope-Fenestration	Single and double pane mix U-0.74, SHGC-0.52	Single and double pane mix U-0.74, SHGC-0.52	
Lighting	Retail – 1.2 W/sf Corridor – 0.6 W/sf Storage – 0.5 W/sf Office Area – 0.75 W/sf	Retail – 1.2 W/sf Corridor – 0.6 W/sf Storage – 0.5 W/sf Office Area – 0.75 W/sf	2016-T24 Prescriptive Area Category
HVAC (Existing Eqp)	SZAC-existing+Gas Furnace RTU	SZAC-existing+Gas Furnace RTU	2008-T24
SZAC-existing Gas Furnace	Gas Eff 81%	Gas Eff 81%	
Economizer	Required	Required	2008-T24
Fan	Constant Volume	Constant Volume	
Cooling Control	Two stages	Two stages	
Heat Recovery	Not Required	Not Required	
Ventilation	T24, 2008, Table 121-A	T24, 2008, Table 121-A	

Table 29: Restaurant Sit-Down Building Model Existing Conditions

	Vintage Bin: Pre-1978	Vintage Bin: 1978-1987	Comments
Envelope-Exterior Walls	U-0.352 (No or very small insulation)	U-0.132	
Envelope-Roof	U-0.057	U-0.057	Considering 30 years for roof/insulation replacement using 1992-T24
Envelope-Fenestration	Single and double pane mix U-0.588, SHGC-0.415	Single and double pane mix U-0.588, SHGC-0.415	Based on CEUS 2023
Lighting	Kitchen/Food Preparation Area – 1.2 W/sf Dining Area (Bar/Lounge and Fine Dining)– 1.0 W/sf	Kitchen/Food Preparation Area – 1.2 W/sf Dining Area (Bar/Lounge and Fine Dining)– 1.0 W/sf	2016-T24 Prescriptive Area Category
HVAC (Existing Eqp)	SZAC+Gas Furnace RTU	SZAC+Gas Furnace RTU	2008-T24
SZAC Gas Furnace	Gas Eff 81%	Gas Eff 81%	
Economizer	Required	Required	2008-T24
Fan	Constant Volume	Constant Volume	
Cooling Control	Two stages	Two stages	
Heat Recovery	Not Required	Not Required	
Ventilation	T24, 2008, Table 121-A	T24, 2008, Table 121-A	