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2025 California Energy Code

Technical Measure Report

Single Family Two Heat Pump Baseline

MEASURE CATEGORY: Residential HVAC, Residential Water Heating

Prepared by: California Energy Commission January 2024

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EXECUTIVE SUMMARY

Introduction

This report proposes specific energy efficiency actions that could result in further reductions of wasteful, uneconomic, inefficient, or unnecessary consumption of energy in the state of California. The code change proposal, or "measure", described in this report is provided by the California Energy Commission (CEC) for consideration and possible inclusion in the California Energy Code (also known as the Energy Code, or Building Energy Efficiency Standards, or Title 24 Part 6). This measure will be considered, may be modified, and could be assembled 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.

Code Change Description

This report proposes changes to how the Energy Code performance approach budgets or "baselines" are set for single-family homes. The 2022 Energy Code baseline currently utilizes a heat pump for either space heating or water heating, depending on the climate zone location of the building. The proposed change for the 2025 baseline is to utilize heat pumps for both space heating and water heating in all climate zones. Additionally, the proposal includes lowering the prescriptive window solar heat gain coefficient (SHGC) to 0.20 in Climate Zone 15.

Scope of Work

The two heat pump baseline for single-family homes will modify the following Energy Code sections, reference appendices and supporting documents listed in Table 1.

Table 1: Code Change Scope of Work

	Energy Code Section(s)	Regulation Type(s): M, Ps, or Pm	Reference Appendices	Modeling Tools	Forms	Other Supporting Documents
Heat Pump Space Heating	Section 150.1(c)6	Ps, Pm	N/A	CBECC-Res	N/A	N/A
Heat Pump Water Heating	Section 150.1(c)8	Ps, Pm	N/A	CBECC-Res	CF2R-PLB-02a, CF2R-PLB-22a	N/A

An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

Compliance and Enforcement

Compliance and enforcement would remain the same for heating, ventilation, and air conditioning (HVAC) and water heating designs even though the choice of standard design will change to a two heat pump system. The 2025 prescriptive standard would require the applicant to use heat pump systems for both space and water heating, however the specifications for these heat pumps are the same as those currently used to comply with the 2022 Title 24, Part 6 Standards.

Market Assessment

Heat pump space heating and heat pump water heating are established technologies and readily available in the market. In the 2022 code cycle, prescriptive requirements were adopted for either heat pump space heating or heat pump water heating depending on climate zone. This approach was successfully implemented and has demonstrated that heat pump manufacturers are able to meet the increased demand for heat pump installations.

Cost-effectiveness

Table 2 and Table 3 summarize the estimated benefits, costs, and resulting Benefit-Cost Ratios (BCR) by climate zone for the proposed measures. Cost-effectiveness analyses results on a per-unit basis are presented in Table 2 and Table 3 for the 500 ft^2 and 2,100 / 2,700 ft^2 (area weighted) single family prototypes respectively. The benefit-cost (B/C) ratio is the incremental Long-term System Cost (LSC) Savings divided by the Total Incremental Costs. When the B/C ratio is greater than 1.0, the added cost of the measure is more than offset by the long-term system energy cost savings and the measure is determined to be cost effective. The analysis demonstrates that the measure is cost effective in all climate zones for all prototypes. LSC savings of heat pumps indicate that over long-term (30-year analysis period), heat pumps will save energy cost to the building owners and avoid the pricing volatility of natural gas, represented in present value (PV$) savings.

Table 2: Cost-effectiveness Summary (500 ft² prototype)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
Climate Zone 1	$1,250	-$1,640	Infinite
Climate Zone 2	$640	-$1,640	Infinite
Climate Zone 3	$4,780	$3,120	1.5
Climate Zone 4	$3,870	$3,120	1.2
Climate Zone 5	$25	-$1,640	Infinite
Climate Zone 6	$0	-$1,640	Infinite
Climate Zone 7	$0	-$1,640	Infinite
Climate Zone 8	$0	-$1,640	Infinite
Climate Zone 9	-$5	-$1,640	328.0
Climate Zone 10	$0	-$1,640	Infinite
Climate Zone 11	$515	-$1,640	Infinite
Climate Zone 12	$555	-$1,640	Infinite
Climate Zone 13	$3,990	$3,120	1.3
Climate Zone 14	$3,460	$3,120	1.1
Climate Zone 15	$270	-$1,640	Infinite
Climate Zone 16	$1,105	-$1,640	Infinite

Table 3: Cost-effectiveness Summary (2,100/2,700 ft² prototypes)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Maintenance Costs (PV$)	Benefit-Cost Ratio (BCR)
Climate Zone 1	$18,807	$2,423	7.8
Climate Zone 2	$11,307	$84	134.9
Climate Zone 3	$6,079	$1,572	3.9
Climate Zone 4	$5,954	$1,572	3.8
Climate Zone 5	$4,844	$84	57.8
Climate Zone 6	$2,293	$84	27.3
Climate Zone 7	$2,108	$84	25.1
Climate Zone 8	$1,769	-$557	Infinite
Climate Zone 9	$2,691	-$557	Infinite
Climate Zone 10	$2,555	-$557	Infinite
Climate Zone 11	$10,054	$84	119.9
Climate Zone 12	$10,574	-$557	Infinite
Climate Zone 13	$6,400	$1,572	4.1
Climate Zone 14	$5,601	$1,572	3.6
Climate Zone 15	$1,232	$495	2.5
Climate Zone 16	$14,804	$4,714	3.1

Statewide Energy Impacts

Table 4 and Table 5 summarize the estimated statewide energy and greenhouse gas (GHG) emissions savings for the first year that the proposed measure is implemented. Electricity LSC savings (in present value, PV$) for all building types and climate zones are mostly negative, meaning heat pumps consume more electricity than gas furnace RTUs. While this measure will increase statewide electricity use, it will also reduce natural gas use, which results in net source energy savings and energy cost savings statewide.

Table 4: 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$ Millions)	First Year Statewide Natural Gas LSC Savings (PV$ Millions)
Heat Pump Space Heating	(53.05)	(18.68)	5.94	356.55	$314.45
Heat Pump Water Heating	(19.72)	(2.05)	1.95	140.38	$100.10
TOTAL	**(72.77)**	**(20.74)**	**7.88**	**$496.93**	**$414.56**

Table 5: Estimated Statewide Greenhouse Gas Emission Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide GHG Emissions Savings (PV$)
Heat Pump Space Heating	16,226	$1,998,185
Heat Pump Water Heating	7,594	$935,128
TOTAL	**23,820**	**$2,933,313**

ACRONYMS

Acronym	Definition
ACM	Alternate Calculation Method
BCR	Benefit-Cost Ratio
BEM	Building Energy Modeling
BTU	British Thermal Units
CARB	California Air Resources Board
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
CPUC	California Public Utilities Commission
CZ	California Climate Zone
DEER	Database for Energy Efficient Resources
DHW	Domestic Hot Water
DOE	Department of Energy
EIR	Environmental Impact Report
EUL	Effective Useful Life
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
HERS	Home Energy Rating System
HSPF	Heating Seasonal Performance Factor
HPSH	Heat Pump Space Heating

HPWH	Heat Pump Water Heating
HVAC	Heating, Ventilation and Air Conditioning
kWh	Kilowatt-Hour
LSC	Long-term System Cost (30-year $)
MAEDbS	Modernized Appliance Efficiency Database System
MT CO_2e	Metric Tons of Carbon Dioxide Equivalent
MW	Megawatt
NAICS	North American Industry Classification System
NEEA	Northwest Efficiency Energy Alliance
PV$	Present Value Dollars
SHGC	Solar Heat Gain Coefficient

1. INTRODUCTION

This report proposes specific energy efficiency actions that could result in further reductions of wasteful, uneconomic, inefficient, or unnecessary consumption of energy in the state of California. The code change proposal, or "measure", described in this report is provided by the California Energy Commission (CEC) for consideration and possible inclusion in the California Energy Code (also known as the Energy Code, or Building Energy Efficiency Standards, or Title 24 Part 6). This measure will be considered, may be modified, and could be included 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 California Law (Public Resources Code 25402(b)(3), which requires the Energy Code to be cost-effective when taken in its entirety, an energy efficiency measure would also be cost-effective if the life-cycle value of the energy savings exceeds the life-cycle cost of the measure. This occurs when the life-cycle Benefit-Cost Ratio (BCR) is 1.0 or greater, when amortized over the economic life of the structure. BCR is calculated by dividing the total dollar energy savings 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 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 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 tool when assessing energy savings of proposed measures.

To calculate cost, first costs, replacement 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.

Similar to 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.

2. MEASURE DESCRIPTION

This report proposes changes to the Energy Code prescriptive requirements and how the performance approach baselines are set for single-family residential newly constructed buildings and additions. The 2022 Energy Code baseline currently utilizes heat pumps for either space heating or water heating, depending on the climate zone location of the building. The proposed change for the 2025 baseline is to utilize heat pumps for both space heating and water heating in all climate zones. For Climate Zone 15 this is also a proposed change reducing prescriptive window solar heat gain coefficient (SHGC) to 0.20.

This measure reduces “the wasteful, uneconomic, inefficient, or unnecessary consumption of energy” consistent with Public Resources Code 25402. The measure also has a co-benefit of decarbonizing buildings by reducing source and on-site emissions associated with space conditioning and water heating.

2.1 Measure Modifications to Energy Code Documents

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

2.1.1 Energy Code Change Summary

This proposal would modify the following sections of the building energy efficiency standards as shown below. See Section 6.1 Energy Code (Title 24, Part 6) of this report for the detailed proposed revisions to the standards language. **SECTION 150.0 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS**

Subsection 150.1(c):

The proposed code change would prescriptively require:

• Heat pump space conditioning system in all Climate Zones.

• Heat pump water heating in all Climate Zones.

Subsection 150.2(a):

The proposed code change would prescriptively require:

• New or replacement space heating systems serving additions to be heat pump space conditioning systems.

• Additional water heaters installed as part of an addition to be heat pump water heaters.

2.1.2 Reference Appendices Change Summary

2.1.3 There are no proposed changes to the Reference Appendices.

2.1.4 There are no proposed changes to the Compliance Manuals

2.1.5 ACM Reference Manuals Change Summary

This proposal would modify the following sections of the Residential ACM Reference Manual as shown below.

Chapter 2 Proposed, Standard, and Reference Design

- **Section 2.4 Building Mechanical System**
  Subsection 2.4.1 Heating Subsystems – revisions to define that the Standard Design is space heating heat pump in all climate zones.
- **Section 2.9 Domestic Hot Water (DHW)**
  Subsection 2.9.2 Domestic Water Heating Systems – revisions to define that the Standard Design system is a HPWH in all climate zones. If a proposed design uses a baseline level HPWH, the Standard Design in Climate Zones 1 and 16 will additionally include Compact Distribution, and Climate Zone 1 will additionally include drain water heat recovery.

2.1.6 Compliance Forms Change Summary

The proposal would require modification to the following Energy Code Compliance Documents to remove the prescriptive allowance of gas furnaces and gas water heaters.

- CF1R-NCB-01-E
- CF2R-MCH-01c-E

2.2 Measure Context

2.2.1 Comparable Model Code or Standard

This topic builds on the 2022 Title 24, Part 6 Standards that allow a single heat pump baseline strategy wherein heat pump space conditioning systems are prescriptively required in Climate Zones 3, 4, 13, and 14, and heat pump water heating systems are prescriptively required in Climate Zones 1, 2, 5, 6, 7, 8, 9, 11, 12, 15, and 16. Title 10 of the CFR, specifically Part 430, contains energy conservation program regulations for energy-consuming appliances and equipment, including heating, ventilation, and air conditioning (HVAC) products. Manufacturers have been required to comply with the U.S. Department of Energy (DOE) energy conservation standards for air conditioners and heat pumps since 1992.

2.3 Compliance and Enforcement

Compliance and enforcement would remain the same for HVAC and water heating designs even though the choice of standard design will change to a heat pump system. The 2025 prescriptive standard would require the applicant to use heat pump systems for both space and water heating, however the specifications for these heat pumps are the same as those currently used to comply with the 2022 Title 24, Part 6 Standards.

3. Market and Economic Analysis

For the proposed measure, this section provides the author'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.

3.1 Market Structure and Availability

Heat Pump HVAC

During the 2022 code cycle, analysis was performed to review the product availability of split system heat pumps relative to federal and state required minimum efficiency levels (CEC 2021).

The Modernized Appliance Efficiency Database System (MAEDbS), which shows appliances compliant under Title 20, indicated that split system heat pumps are readily available. About 95 percent of split system heat pump models were at or above federal minimum efficiency levels indicating considerable market availability of higher efficiency products if desired.

According to data from the HERS registries (CHEERS and CalCERTS), market trends show that heat pump space heater (HPSH) systems became more prevalent and accounted for approximately 50 percent of installed residential space heating systems in single family newly constructed buildings in 2022 (Consol 2023).

Heat Pump Water Heaters

A wide variety of heat pump water heaters (HPWH) products are available to builders and consumers. Products used in California primarily consist of storage type HPWH ranging from 50 to 80 gallons in size. According to data from the HERS registries (CHEERS and CalCERTS), market trends show that HPWH systems became more prevalent and accounted for approximately 16 percent of installed residential water heaters in single family newly constructed buildings in 2022 (Consol 2023).

3.2 Impacts on Market Actors

Analysis performed during the 2022 Energy Code update demonstrated that adoption of heat pumps for space heating and water heating would result in relatively modest economic impacts through the additional direct spending by those in the residential building and remodeling industry, as well as indirectly as residents spend all or some of the money saved through lower utility bills on other economic activities (CEC 2021).

3.2.1 Impact on Builders

Builders of residential buildings are directly impacted by the measures proposed for the 2025 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training to remain compliant with changes to design practices and building codes.

Analysis performed during the 2022 Energy Code update showed that California's construction industry is comprised of about 80,000 business establishments and 860,000 employees with payroll of $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector.

The effects on the residential building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors including:

- Single family general contractors
- Residential electrical contractors
- Residential plumbing and HVAC contractors

3.2.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal course of business for building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training to remain compliant with changes to design practices and building codes.

Businesses that focus on residential building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 6: California Building Designer and Energy Consultant Sectors shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes would potentially impact all firms within the Architectural Services sector.

There is not a North American Industry Classification System (NAICS) code specific for energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings. It is not possible to determine which business establishments within the Building Inspection Services sector are focused on residential energy efficiency consulting. The information shown in Table 6 provides an upper bound indication of the size of this sector in California.

Table 6: Size of the California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billions $)
Architectural Services [a]	10,968	55,592	$3.6
Building Inspection Services [b]	6,095	37,933	$2.1

Source: (CEC 2021)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures.
b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential and nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

The authors do not anticipate that this measure will have a significant financial impact on building designers and energy consultants.

3.2.3 Impact on Occupational Safety and Health

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

3.2.4 Impact on Building Owners and Occupants (including homeowners and potential first-time homeowners)

The U.S. Census reported that 59,200 single family homes were constructed in California in 2019.

According to data from the U.S. Census, American Community Survey, there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 7). Most housing units (nearly 9.2 million were single family homes (either detached or attached (CEC 2021).

Table 7: California Housing Characteristics

Housing Measure	Estimate
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	Estimate
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (CEC 2021)

Table 8 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950.

Table 8: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
Built 2000 to 2009	1,553,769	10.9%	15.0%
Built 1990 to 1999	1,561,579	10.9%	26.0%
Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	14,277,867	100%	

Source: (CEC 2021)

Table 9 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 9: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
$15,000 to $19,999	456,076	156,790	299,286
$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total housing units	13,072,122	7,165,664	5,906,458
Median household income	$75,277	$99,245	$52,348

Source: (CEC 2021)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Likewise, impacts may differ for owners and renters, by home vintage, and by household income.

For newly constructed single-family homes, the 2025 Energy Code will have an incremental cost to construct a building of $939.98.

3.2.5 Impact on Building Component Retailers (including manufacturers and distributors)

The proposed change would increase demand for manufacturers, distributors, and retailers of HPWH and HPSH equipment. Supply chains for gas space heating and water heating equipment would experience a decrease in demand. Many manufacturers, distributors, and retailers produce and/or sell both heat pump and gas equipment. These businesses would not experience an increase or decrease in overall demand for space heating or water heating equipment.

3.2.6 Impact on Building Inspectors

Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The authors anticipate no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

3.3 Impacts on Jobs and Businesses

The authors do not anticipate significant employment or financial impacts to any particular sector of the California economy. Section 3.2 estimates the proposed change in electric HVAC systems would affect statewide employment and economic output directly and indirectly through its impact on builders, designers, and energy consultants, and building inspectors. In addition, the authors estimated how energy savings associated with the proposed change in electric HVAC and DHW systems would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.4 Economic and Fiscal Impacts

The estimated impacts that the proposed code change will have on California's economy are discussed below.

3.4.1 Creation or Elimination of Jobs

The authors do not anticipate that the measures proposed for the 2025 code cycle regulation would lead to the creation of new types of jobs or the elimination of existing types of jobs. The proposed change would not result in economic disruption to any sector of the California economy. Rather, the estimates of economic impacts discussed in Section 3.2 would lead to modest changes in employment of existing jobs.

The proposed measures would create additional economic impacts for residential newly constructed building costs due to the increased cost of heat pump HVAC and space heating equipment.

3.4.2 Creation or Elimination of Businesses in California

As stated in Section 3.2, the proposed change would not result in economic disruption to any sector of the California economy. The proposed change represents a modest change to HVAC and DHW systems, which would not excessively burden or competitively disadvantage California businesses, nor would it necessarily lead to a competitive advantage for California businesses. Therefore, the authors do not foresee any new businesses being created, nor do the authors think any existing businesses would be eliminated due to the proposed code changes.

3.4.3 Competitive Advantages or Disadvantages for Businesses within California

The proposed code changes would apply to all businesses incorporated in California, regardless of whether the business is located inside or outside of the state. Therefore, the authors do not anticipate that these measures proposed for the 2025 code cycle regulation would have an adverse effect on the competitiveness of California businesses. Likewise, the authors do not anticipate businesses located outside of California would be advantaged or disadvantaged.

3.4.4 Increase or Decrease of Investments in the State of California

The authors do not anticipate that the economic impacts associated with the proposed measure would lead to significant change (increase or decrease) in investment in any directly or indirectly affected sectors of California's economy.

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

The authors do not expect the proposed code changes would have a measurable impact on the California's general fund, any state special funds, or local government funds.

3.5 Cost of Compliance and Enforcement

The authors do not expect the proposed code changes would have a measurable impact on the cost of compliance and enforcement.

4. 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, meaning 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.

4.1 Energy Savings Methodology

Consistent with California Law (Public Resources Code 25402(b)(3)), which requires the Energy Code to be cost effective when taken in its entirety, an energy efficiency measure would also be cost-effective if the life-cycle value of the energy savings exceeds the life-cycle cost of the measure. This occurs when the life-cycle Benefit-Cost Ratio (BCR) is 1.0 or greater, when amortized over the economic life of the structure. 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 climate actions goals – such as 100 percent 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 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 tool when assessing energy savings of proposed measures.

To calculate cost, first costs, replacement 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.

Similar to 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.

4.2 Energy Savings Results

To assess the energy, demand, and energy cost impacts, the authors compared design practices that comply with the latest adopted version of the Energy Code to design practices that would comply with the proposed requirements.

For HVAC, the baseline condition includes a federal minimum efficiency forced air furnace for space heating and split system air conditioner for space cooling in Climate Zones 1, 2, 5, 6, 7 8, 9, 10, 11, 12, 15, and 16. Both systems were modeled to meet but not exceed federal appliance efficiency standards. In Climate Zones 3, 4, 13, and 14, the baseline condition is a federal appliance efficiency standards minimally compliant heat pump for space heating and cooling.

For water heating, the baseline condition is a code minimum HPWH in Climate Zones 1, 2, 5, 6, 7 8, 9, 10, 11, 12, 15, and 16. In Climate Zones 3, 4, 13, and 14, the baseline condition is an instantaneous gas water heater. In Climate Zone 16, the baseline condition includes compact distribution and drain water heat recovery compliance measures.

The proposed case was modeled to include a heat pump for space heating and cooling and a 65-gallon storage HPWH that is compliant with minimal federal appliance efficiency standards in all climate zones.

The proposed case also included 0.20 SHGC windows for Climate Zone 15 only. The baseline conditions reflect 0.23 SHGC windows to align with the current prescriptive standards.

Single family energy savings are calculated using three building prototypes (500 ft^2, 2100 ft^2 and a 2700 ft^2) available in CBECC-Res. 2% for the 500 ft^2 prototype, 42% for the 2,100 ft^2 prototype and 56% for the 2,700 ft^2 prototype. Energy savings and overall impacts are similar for the 2,100 and 2,700 square foot prototypes. In this report where individual prototype results are presented, results of the 2,100 and 2,700 square foot homes are presented as a weighted average based on the statewide distribution. Results are separately presented for the 500 square foot single family newly constructed building prototype since the impacts in some cases differ significantly for the smaller prototype. See Appendix A: Statewide Savings Methodology for further details on how the weighting was derived.

Table 10 summarizes the total LSC savings for the 500 ft² and the weighted 2,100 and 2,700 ft² prototypes.

Table 10: LSC Savings Over 30-Year Period of Analysis

Climate Zone	500 ft² Prototype 30-Year Total Energy LSC Savings (PV$)	2100/2700 ft² Prototype 30-Year Total Energy LSC Savings (PV$)
Climate Zone 1	$1,250	$18,807
Climate Zone 2	$640	$11,307
Climate Zone 3	$4,780	$6,079
Climate Zone 4	$3,870	$5,954
Climate Zone 5	$25	$4,844
Climate Zone 6	$0	$2,293
Climate Zone 7	$0	$2,108
Climate Zone 8	$0	$1,769
Climate Zone 9	($5)	$2,691
Climate Zone 10	$0	$2,555
Climate Zone 11	$515	$10,054
Climate Zone 12	$555	$10,574
Climate Zone 13	$3,990	$6,400
Climate Zone 14	$3,460	$5,601
Climate Zone 15	$0	$384
Climate Zone 16	$1,105	$14,804

Table 11 summarizes the total LSC savings and a breakdown of electricity and natural gas LSC savings for the 500 ft² prototype. Table 12 summarizes the total LSC savings and a breakdown of electricity and natural gas LSC savings for the weighted 2,100 and 2,700 ft² prototypes.

Table 11: LSC Savings Over 30-Year Period of Analysis (500 ft^2 prototype)

Climate Zone	30-Year Electricity LSC Savings (PV$)	30-Year Natural Gas LSC Savings (PV$)	30-Year Total Energy LSC Savings (PV$)
1	($2,380)	$3,630	$1,250
2	($1,310)	$1,950	$640
3	($5,585)	$10,365	$4,780
4	($6,165)	$10,035	$3,870
5	($155)	$180	$25
6	$0	$0	$0
7	$0	$0	$0
8	$0	$0	$0
9	($25)	$20	($5)
10	($10)	$10	$0
11	($1,035)	$1,550	$515
12	($1,165)	$1,720	$555
13	($5,155)	$9,145	$3,990
14	($6,005)	$9,465	$3,460
15	$0	$0	$0
16	($2,795)	$3,900	$1,105

Table 12: LSC Savings Over 30-Year Period of Analysis (2100/2700 ft² weighted prototype)

Climate Zone	30-Year Electricity LSC Savings (PV$)	30-Year Natural Gas LSC Savings (PV$)	30-Year Total Energy LSC Savings (PV$)
1	($24,390)	$43,197	$18,807
2	($16,985)	$28,292	$11,307
3	($9,318)	$15,397	$6,079
4	($8,920)	$14,874	$5,954
5	($7,922)	$12,766	$4,844
6	($2,279)	$4,572	$2,293
7	($1,609)	$3,717	$2,108
8	($2,352)	$4,121	$1,769
9	($3,765)	$6,456	$2,691
10	($3,989)	$6,543	$2,555
11	($13,889)	$23,943	$10,054
12	($14,179)	$24,753	$10,574
13	($7,056)	$13,457	$6,400
14	($8,376)	$13,977	$5,601
15	($1,187)	$1,570	$384
16	($25,880)	$40,684	$14,804

4.3 Incremental First Cost and Replacement/Maintenance Costs

The authors estimated incremental first costs and replacement and maintenance costs of the proposed measure compared to the current requirements of the Energy Code. For both the baseline and proposed systems, the authors gathered costs for the new HVAC and DHW systems. The difference between the baseline and proposed system costs is the incremental costs.

Cost data was gathered by outreach to contractors, leveraging past research, online cost data, and by performing a literature review.

Note that the authors have not included any cost savings from eliminating natural gas infrastructure to the home in the analysis presented in this report. However, costs do include cost savings by eliminating gas pipelines from the meter to appliances within the home.

The incremental replacement cost is the incremental cost of replacing the equipment over the period of analysis of 30 years. There are no incremental maintenance costs for the heat pump space heater measures in this analysis. The water heating measure includes maintenance costs over the analysis period for a tankless water heater baseline system and heat pump water heater proposed system derived from DOE’s recent water heater rulemaking (DOE, 2022). The present value of replacement costs or savings is calculated using the following equation:

$$\text{Present Value of Replacement Cost} = \text{Replacement Cost} \times \left\lfloor \frac{1}{1+\text{d}} \right\rfloor^{\text{n}}$$

Where:
d = the discount rate of 3%
n = the year of replacement

4.3.1 Heat Pump Space Heating

Heat pump space heating was the focus of cost effectiveness analysis in Climate Zones 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 15, and 16. Cost analysis was performed for both cooling-dominated and heating-dominated climate zones. In cooling-dominated climate zones, heat pump sizes are driven by their peak cooling loads whereas in heating-dominated climate zones, the sizes are driven by peak heating loads.

Load sizing results from CBECC-Res were evaluated to determine which climates were cooling dominated and which were heating dominated. The cooling-dominated climate zones included 2, 5, 6, 7, 8, 9, 10, 11, 12, and 15; the heating-dominated climate zones included 1 and 16.

Table 13 presents the nominal capacities determined from the load sizing results. Air conditioner nominal capacity was calculated as the CBECC-Res cooling load, rounded up to the nearest half ton. Heat pump nominal capacity was calculated as the maximum of either the CBECC-Res heating or cooling load, rounded up to the nearest half ton. In both cases a minimum capacity of 1.5-ton was applied as this represents the typical smallest available split system heat pump equipment. In cooling-dominated climate zones, the heat pump system capacity is equivalent to the baseline AC system. In heating-dominated climate zones, the heat pump capacities are larger (in terms of tons capacity) compared to the baseline AC system.

Table 13: Nominal Capacities

	500 ft² Prototype	500 ft² Prototype	2100/2700 ft² Weighted Prototype	2100/2700 ft² Weighted Prototype
Climate Zone	**AC Nominal Capacity (tons)**	**Heat Pump Nominal Capacity (tons)**	**AC Nominal Capacity (tons)**	**Heat Pump Nominal Capacity (tons)**
1	1.5	1.5	1.5	2.5
2	1.5	1.5	3	3
3	-	-	-	-
4	-	-	-	-
5	1.5	1.5	3	3
6	1.5	1.5	3	3
7	1.5	1.5	3	3
8	1.5	1.5	2.5	2.5
9	1.5	1.5	2.5	2.5
10	1.5	1.5	2.5	2.5
11	1.5	1.5	3	3
12	1.5	1.5	2.5	2.5
13	-	-	-	-
14	-	-	-	-
15	1.5	1.5	4	4
16	1.5	1.5	2	3.5

First cost data for the heat pump water heating analysis was gathered from the reach code report 2022 Cost-Effectiveness Study: Single Family New Construction (Statewide Reach Code Team 2023) and refined based on more recent feedback from a contractor and online cost data (ACWholesalers.com). Gas furnace system costs include $580 for the gas pipeline from the meter to the furnace within the home. Electric wiring costs are also included and derived from the RSMeans cost database (RSMeans 2022). Replacement costs were estimated based on a contractor survey conducted by the Statewide Reach Codes Team in 2023 (Statewide Reach Code Team February 2024), less any gas and electric infrastructure costs.

The analysis assumed a 20-year effective useful life (EUL) for a furnace, a 15-year EUL for an air conditioner and a 15-year EUL for a heat pump. Lifetimes are based on the Database for Energy Efficient Resources (DEER) (CPUC, 2021). For HVAC system costing, air-conditioning is included in all cases in both the base case and proposed models.

Error! Not a valid bookmark self-reference. and Table 15 summarize the first cost and replacement costs for the heat pump system for each climate zone and prototype. The present values of these costs are used to determine the Lifetime Cost.

Table 14: Cooling-Dominated Climates – Heat Pump Space Heating System Costs Compared to Gas-Fired Furnace/AC

		All CZ 500 ft²	**CZ 8-10,12 2100/2700 ft²**	**CZ 2,5-7,11 2100/2700 ft²**	**CZ 15 2100/2700 ft²**
Gas/AC System	**Capacity (Tons)**	1.5	2.5	3	4.5
	First Cost	$9,383	$11,049	$11,692	$15,207
	Replacement Cost (Future Value)	$15,252	$16,329	$16,766	$18,306
	Replacement Cost (Present Value)	$9,170	$9,843	$10,123	$11,092
	Residual Value (Present Value)	($1,449)	($1,491)	($1,491)	($1,538)
HP (No Strip Heat)	**Capacity (Tons)**	1.5	2.5	3	4.5
	First Cost	$7,263	$9,604	$10,648	$12,309
	Replacement Cost (Future Value)	$12,776	$14,396	$15,206	$16,825
	Replacement Cost (Present Value)	$8,201	$9,240	$9,760	$10,800
	Residual Value (Present Value)	$0	$0	$0	$0
Incremental Costs	**First Cost**	($2,120)	($1,445)	($1,044)	($1,032)
	Lifetime (Present Value)	**($1,640)**	**($557)**	**$84**	**$495**

Table 15: Heating-Dominated Climates – Heat Pump Space Heating System Costs Compared to Gas-Fired Furnace/AC

		CZ 1	CZ 16
Gas/AC System	**Capacity (Tons)**	1.5	2
	First Cost	$9,383	$10,182
	Replacement Cost (Future Value)	$15,252	$15,689
	Replacement Cost (Present Value)	$9,170	$9,450
	Residual Value (Present Value)	($1,449)	($1,449)
HP (with Strip Heat)	**Capacity (Tons)**	2.5	3.5
	First Cost	$10,187	$12,513
	Replacement Cost (Future Value)	$14,551	$16,178
	Replacement Cost (Present Value)	$9,340	$10,384
	Residual Value (Present Value)	$0	$0
Incremental Costs	**First Cost**	$803	$2,331
	Lifetime (Present Value)	**$2,423**	**$4,714**

4.3.2 Heat Pump Water Heating

First cost data for the heat pump water heating analysis was gathered from the reach code report 2022 Cost-Effectiveness Study: Single Family New Construction (Statewide Reach Code Team 2023) and refined based on more recent feedback from surveyed contractors. The Statewide Reach Code Team conducted surveys from contractors and made modifications to reflect the market. These modifications were based on a range of factors, including market trends, installation cost adjustments, and changes in material costs. This careful refinement ensures that our heat pump cost data accurately reflects the current economic and industry realities. Gas tankless system costs include $580 for the gas pipeline from the meter to the water heater within the home. Electric wiring costs are also included and derived from the RSMeans cost database (RSMeans 2022). Gas tankless system costs assume meeting the electric ready requirement in the 2022 Energy Code. Replacement costs assume no change in cost from the first cost estimates before accounting for inflation, less any gas and electric infrastructure costs. First costs are representative of costs to a production builder. Replacement costs are representative of one-off contractor installations. Cost data used in this report was presented at the July 27th 2025 Pre-Rulemaking Staff Workshop on Heat Pump Baselines and Photovoltaic System Requirements [1].

All costs are for equipment at the minimum federal efficiency standards. The HPWH is a 65-gal storage water heater. The analysis used a 20-year lifespan for an instantaneous water heater and a 15-year lifespan for a HPWH based on DOE's recent water heater rulemaking (DOE 2022). For the 2,100 / 2,700 ft² prototype, the HPWH was modeled with the system located in the garage. For the 500 ft² prototype, the HPWH was modeled located inside the conditioned space with the air intake ducted from the outside and air exhaust ducted to the outside.

Table 16 summarizes the cost difference of the gas instantaneous water and HPWH for the 500 ft² and 2100/2700 ft² prototypes. The present values of these costs are used to determine the Lifetime Cost.

[1] See TN #251405 (https://efiling.energy.ca.gov/GetDocument.aspx?tn=251405&DocumentContentId=86256).

Table 16: HPWH Compared to Instantaneous Gas Water Heater

		500 ft²	2100/2700 ft²
Gas Tankless System	First Cost	$4,000	$4,000
	Replacement Cost (Future Value)	$3,215	$3,215
	Replacement Cost (Present Value)	$1,780	$1,780
	Maintenance Cost (Present Value)	$1,583	$1,583
	Residual Value (Present Value)	($662)	($662)
Heat Pump Water Heater	First Cost	$5,708	$4,765
	Replacement Cost (Future Value)	$5,458	$4,515
	Replacement Cost (Present Value)	$3,503	$2,898
	Maintenance Cost (Present Value)	$609	$609
	Residual Value (Present Value)	$0	$0
Incremental Costs	First Cost	$1,708	$765
	Lifetime (Present Value)	**$3,120**	**$1,572**

4.3.3 **Low SHGC Windows**

Based on research conducted by the Statewide CASE Team for the Single Family High-Performance Windows and Walls CASE report (CASE Team 2023), there is a negligible cost impact going from a 0.23 to 0.20 SHGC window and no incremental cost is assigned to this measure change for Climate Zone 15. In a 2023 report by the Northwest Efficiency Energy Alliance (NEEA 2023), it was found that "SHGC of almost all windows can be "tweaked" higher or lower by making relatively simple glass or glass coating substitutions that generally do not involve window design changes and generally have modest, well-defined manufacturing cost differentials… …As a result, the authors do not expect to see significant design changes that increase window costs in order to change SHGC."

4.4 Cost Effectiveness

Cost-effectiveness analysis is required 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 value of the energy savings exceeds the life-cycle cost of the measure. This occurs when the life-cycle Benefit-Cost Ratio (BCR) is equal to or greater than 1.0. BCR is calculated by dividing the total present value cost benefits by the total present value costs. In the case where there are cost savings, the BCR is reported as "Infinite".

Cost-effectiveness analyses results are presented in Table 17 and Table 18 for the 500 ft^2 and 2,100 / 2,700 ft^2 (area weighted) single family prototypes respectively. The analysis demonstrates that the measure is cost effective in all climate zones for both prototypes.

Table 17: Cost-effectiveness Summary (500 ft^2 Prototype)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Replacement Costs (PV$)	Benefit-Cost Ratio (BCR)
Climate Zone 1	$1,250	-$1,640	Infinite
Climate Zone 2	$640	-$1,640	Infinite
Climate Zone 3	$4,780	$3,120	1.5
Climate Zone 4	$3,870	$3,120	1.2
Climate Zone 5	$25	-$1,640	Infinite
Climate Zone 6	$0	-$1,640	Infinite
Climate Zone 7	$0	-$1,640	Infinite
Climate Zone 8	$0	-$1,640	Infinite
Climate Zone 9	-$5	-$1,640	328.0
Climate Zone 10	$0	-$1,640	Infinite
Climate Zone 11	$515	-$1,640	Infinite
Climate Zone 12	$555	-$1,640	Infinite
Climate Zone 13	$3,990	$3,120	1.3
Climate Zone 14	$3,460	$3,120	1.1
Climate Zone 15	$270	-$1,640	Infinite
Climate Zone 16	$1,105	-$1,640	Infinite

Table 18: Cost-effectiveness Summary (2,100/2,700 ft^2 Prototypes)

Climate Zone	Benefit: Total Incremental LSC Savings and Other Savings (PV$)	Cost: Total Incremental First Costs and Replacement Costs (PV$)	Benefit-Cost Ratio (BCR)
Climate Zone 1	$18,807	$2,423	7.8
Climate Zone 2	$11,307	$84	134.9
Climate Zone 3	$6,079	$1,572	3.9
Climate Zone 4	$5,954	$1,572	3.8
Climate Zone 5	$4,844	$84	57.8
Climate Zone 6	$2,293	$84	27.3
Climate Zone 7	$2,108	$84	25.1
Climate Zone 8	$1,769	-$557	infinite
Climate Zone 9	$2,691	-$557	infinite
Climate Zone 10	$2,555	-$557	infinite
Climate Zone 11	$10,054	$84	119.9
Climate Zone 12	$10,574	-$557	infinite
Climate Zone 13	$6,400	$1,572	4.1
Climate Zone 14	$5,601	$1,572	3.6
Climate Zone 15	$1,232	$495	2.5
Climate Zone 16	$14,804	$4,714	3.1

5. STATEWIDE ENERGY 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 newly constructed building forecast was developed by the CEC for 2026, 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 2026.

5.1 Statewide Energy and Energy Cost Savings

The estimated statewide energy savings are presented in Table 19.

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$ Millions)	First Year Statewide Natural Gas LSC Savings (PV$ Millions)
Heat Pump Space Heating	(53.05)	(18.68)	5.94	356.55	$314.45
Heat Pump Water Heating	(19.72)	(2.05)	1.95	140.38	$100.10
TOTAL	**(72.77)**	**(20.74)**	**7.88**	**496.93**	**$414.56**

5.2 Statewide Greenhouse Gas Emissions Savings

Using the appropriate hourly GHG Emissions hourly factors published by the CEC as part of the LSC development analysis, the estimated statewide greenhouse gas emissions savings are summarized in Table 20.

Table 20: Estimated Statewide Greenhouse Gas Emissions Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide GHG Emissions Savings (PV$)
Heat Pump Space Heating	16,226	$1,998,185
Heat Pump Water Heating	7,594	$935,128
TOTAL	**23,820**	**$2,933,313**

5.3 Statewide Water Savings

The proposed code change will not result in water savings.

5.4 Other Non-Energy Impacts

Electric heat pump water and space heating systems save on-site and systemwide emissions as captured in Section 5.2. Additionally, use of the heat pump technologies provides improved indoor air quality due to the lack of any combustion devices in these systems and they replace natural gas or propane systems that produce harmful pollutants in the space. These air quality improvements in turn provide health benefits to occupants, especially those with respiratory illnesses such as asthma.

5.4.1 Improved Safety

Buildings with heat pump space heating and DHW systems have less combustion equipment and less gas piping. All-electric building designs that voluntarily go further than the heat pump baselines would eliminate gas piping and combustion from the property, and with them the associated risk of fire and explosion (particularly during/after an earthquake). Eliminating combustion from a building via all-electric design also significantly reduces sources of carbon monoxide poisoning for occupants.

Since there is no combustion in electric heat pump water heating systems, projects would have no combustion safety testing requirements for water heating equipment. Depending on local fire inspector requirements, eliminating combustion equipment from a building may also eliminate some other requirements under the California Fire Code.

5.4.2 Improved Air Quality and Resiliency

Heat pump HVAC and DHW systems improve air quality at the building, as well as locally and regionally by eliminating source NOx emissions. While recent years have seen California residents subject to more frequent, and longer duration electricity outages than in previous years, electric HPWH systems are likely to be more resilient than gas water heating systems for a number of reasons.

Most modern gas equipment requires electricity to operate. Since modern gas equipment has done away with standing pilot lights in favor of electronic ignition, they rely on both electricity and natural gas to operate, so power outages would take both gas and electric equipment offline.

Additionally, the Energy Code's requirements for rooftop solar and battery storage allow for electricity resilience in the case of electrical grid outages. Homes with HPWH systems can continue to generate hot water using stored electricity.

5.4.3 Increase in Refrigerant Amount

Increased adoption of heat pump space heating and water heating will increase the amount of refrigerant usage. Refrigerants are very potent greenhouse gas emitters when released into the environment and regulatory bodies are working to encourage use of less potent refrigerants to curb this environmental issue. Refrigerants with very high GWP are getting phased out and will not be allowed to be used in new products including a halt of production and import. Most manufacturers are actively developing products with lower GWP refrigerants, and the impact will likely lessen as lower GWP products become available.

Refrigerant GHG emissions constitute only a minimal portion of the total GHG emissions associated with the building sector. Any potential increase in GHG emissions resulting from increased adoption of heat pump space heating and water heating will be negligible when compared to the overall GHG emissions originating from the building sector. The analysis does assume that California Air Resources Board (CARB) would require R-32 effective in 2025. The most recent CARB regulations have a January 1, 2023 effective date for room/window and wall units and January 1, 2025 effective date for other equipment, except for new variable refrigerant flow equipment, which has an effective date of January 1, 2026.

Heat pump systems have used a variety of refrigerants; recently, manufacturers have begun the transition from R-410A to refrigerants with lower global warming potential, such as R-454B and R-32. At the end of the heat pump useful life, the used refrigerant can be reclaimed. As this requires equipment for removing impurities and waste products and testing the composition for purity, currently, less than 2% of refrigerant is reclaimed (U.S. EPA, 2022). The ongoing transition to products using low-GWP refrigerants will further reduce heat pump emissions.

6. PROPOSED CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2022 documents are marked with underlining (new language) and strikethroughs (deletions).

6.1 Energy Code (Title 24, Part 6)

Water Heating: Section 150.1(c)8

8. **Domestic water-heating systems.** Water-heating systems shall meet the requirements of A, B, C, or shall meet the performance compliance requirements of Section 150.1(b)1. For recirculation distribution systems, only demand recirculation systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used:

   A. A single 240 volt heat pump water heater (HPWH). The storage tank shall be located in the garage or conditioned space. In addition, meet the following:

      i. A compact hot water distribution system as specified in the Reference Appendix RA4.4.6 in climate zone 1 and 16; and

      ii. A drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9 in climate zone 16.

   B. A single 240 volt HPWH **that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. In addition, f**or Climate Zone 16, a drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9 and the storage tank shall be located in the garage or conditioned space.

   C. A solar water-heating system with electric backup meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum annual solar savings fraction of 0.7.

   ~~**Exception 1 to Section 150.1(c)8:** For Climate Zones 3, 4, 10, 13 and 14, a gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank may be installed.~~

   ~~**NOTE:** The space conditioning system shall be a heat pump as specified in Section 150.1(c)7.~~

   Exception ~~2~~1 to Section 150.1(c)8: An ~~instantaneous~~ electric water heater with point of use distribution as specified in RA4.4.5 may be installed for new dwelling units with a conditioned floor area of 500 square feet or less.

   Exception ~~3~~2 to Section 150.1(c)8A and B: A 120V HPWH may be installed in place of a 240V HPWH for new dwelling unit with one bedroom or less.

Space Heating: Section 150.1(c)6 & Table 150.1-A.

6. **Heating system type.** Heating system types shall be installed as required in Table 150.1-A. ~~For climate zones 3, 4, 13, and 14, t~~ The space conditioning system shall be a heat pump, or shall meet the performance compliance requirements of Section 150.1(b)1.

   Exception to Section 150.1(c)6: A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kW or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

TABLE 150.1-A COMPONENT PACKAGE – Single-~~–~~Family Standard Building Design (continued)

			Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone	Climate Zone
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
HVAC System	**Space Heating [10]**	Electric-Resistance Allowed	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
HVAC System	**Space Heating [10]**	If gas, AFUE[2]	NA ~~Min~~	NA~~Min~~	NA	NA	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~	NA~~Min~~
HVAC System	**Space Heating [10]**	If Heat Pump, HSPF2[8]	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
HVAC System	**Space Cooling**	SEER2	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
HVAC System	**Space Cooling**	Whole-house fan[9]	NR	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR	NR

Water Heating Additions: Section 150.2(a)1D

D. **Water heater**. When a ~~second~~ additional water heater is installed as part of the addition, one of the following types of water heaters shall be installed:

i. A single heat pump water heater. The storage tank shall not be located outdoors and shall be placed on an incompressible, rigid insulated surface with a minimum thermal resistance of R-10. The water heater shall be installed with a communication interface that meets either the requirements of 110.12(a) or has a ANSI/CTA-2045-B communication port; or

ii. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher; or

~~iii. A gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank; or~~

iii~~iv~~. For additions that are 500 square feet or less, an ~~instantaneous~~ electric water heater with point of use distribution as specified in RA4.4.5; or

iv. A water-heating system determined by the Executive Director to use no more energy than the one specified in Item i, ii, or iii, ~~or iv~~.

Space Heating Additions: Exception 7 to Section 150.2(a)

(a) **Additions.** Additions to existing single-family residential buildings shall meet the requirements of Sections 110.0 through 110.9, Sections 150.0(a) through (n), (p), (q), and either Section 150.2(a)1 or 2.

~~**Exception 7 to Section 150.2(a): Space heating system.** New or replacement space heating system serving an addition may be a heat pump or gas heating system.~~

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

6.3 Compliance Manuals

There are no proposed changes to the Compliance Manuals.

6.4 ACM Reference Manuals

This measure results in changes to sections 2.4.1 (Heating Subsystems) and 2.9.2 (Domestic Water Heating Systems) of the *Single-Family Residential Alternative Calculation Method Reference Manual*. Changes to the language are marked up below using strikethrough for deleted text and underline for new text.

2.4.1 Heating Subsystems

The heating subsystem describes the equipment that supplies heat to a space-conditioning system…

PROPOSED DESIGN

The user selects the type and supplies required inputs for the heating subsystem, including the appropriately rated heating efficiency…

STANDARD DESIGN

The standard design heating subsystem is a heat pump in all climate zones. ~~if the proposed water heating system is gas-fired in climate zones 3, 4, 13, and 14. Otherwise, the heating system is a gas-heating system.~~

~~When the standard design is a heat pump, t~~The equipment used in the standard design building is an electric split-system heat pump with default ducts in the attic and a heating seasonal performance factor (HSPF) meeting the current Appliance Efficiency Regulations minimum efficiency for heat pumps. The standard design heat-pump compressor size is determined by the software as the larger of the compressor size calculated for air-conditioning load, or the compressor with a 47°F rating that is 75 percent of the heating load (at the heating design temperature).

~~When the standard design is a gas heating system, the equipment used in the standard design building is a gas furnace (or propane if natural gas is not available) with default ducts in the attic and an annual fuel utilization efficiency (AFUE) meeting the Appliance Efficiency Regulations minimum efficiency for central systems.~~

2.9.2 Domestic Water Heating Systems

The standard design for all climate zones is a single heat pump water heater with a 2.0 UEF. If the Proposed Design in Climate Zones 1 or 16 uses a minimally compliant HPWH, the standard design will additionally include the ~~with~~ compact distribution basic credit. ~~in Climate Zones 1 and 16, and~~, If the Proposed Design in Climate Zone 1 uses a minimally compliant HPWH, the standard design will additionally include a drain water heat recovery system. ~~in Climate Zone 16. In Climate Zone 16, the standard design DWHR has an exchanger efficiency of 0.65, serving 100 percent of showers, with an equal shower configuration.~~

If the proposed building has an attached garage, then the standard design HPWH location is the garage. If the proposed building does not have an attached garage, then the standard design HPWH location is in the conditioned space with the air inlet and outlet ducted to the outside.

~~In Climate Zones 3, 4, 13, and 14, if the proposed design is gas, then the standard design is a single gas or propane consumer instantaneous water heater for each dwelling unit. The single consumer instantaneous water heater is modeled with an input of 200,000 Btu/h, a tank volume of zero gallons, a high draw pattern, and a UEF meeting the minimum federal standards. The current minimum federal standard for a high draw pattern instantaneous water heater is 0.81 UEF. For buildings that are 500 square feet or less, if the proposed design is an instantaneous electric water heater, or an electric consumer storage water heater that is less than or equal to 20 gallons with point of use distribution, the standard design is the same.~~

6.5 Compliance Forms

There are no proposed changes to the compliance forms.

7. References

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APPENDICES

Appendix A: Statewide Savings Methodology

Statewide impacts are estimated for the first year by multiplying per unit savings estimates by statewide construction forecasts that the CEC provided on March 27, 2023, at the Staff Workshop on Triennial California Energy Code Measure Proposal Template (California Energy Commission, 2022).

Statewide energy savings assume a statewide weighting of 2% for the 500 ft^2 prototype, 42% for the 2,100 ft^2 prototype, and 56% for the 2,700 ft^2prototype. In Section 4, results are presented for a weighted average of the 2,100 ft^2 and 2,700 ft^2 newly constructed building prototypes since results for each of the prototypes are similar. After excluding the 500 ft^2 prototype, results for the 2100/2700 weighted prototype are calculated as 43% for the 2100 ft^2 prototype and 57% for the 2700 ft^2 prototype.

Table 21 presents the statewide construction forecasts for newly constructed single family homes in 2026. All new homes would be impacted by the proposed code change.

Table 21: Statewide Residential Newly Constructed Single Family Buildings (2026)

Climate Zone	Single-Family Units
1	359
2	1,861
3	3,035
4	2,689
5	616
6	1,719
7	1,869
8	4,163
9	4,286
10	7,950
11	5,840
12	14,542
13	7,257
14	3,739
15	3,160
16	1,937
Total	65,022

Appendix B: CBECC Software Specification

The following changes will be made to the 2025 CBECC-Res software:

Revised Standard Design:

The following three new simulations support calculating the 2025 Standard Design budgets in CBECC-Res:

1. Prescriptive base case with HPWH & HPSH
    a. Dryer and cooking fuel same as Proposed
    b. Require the input of the EER for all space heating heat pumps. If Proposed EER<11.7, set the corresponding Standard EER = Proposed EER. If proposed EER >= 11.7, Standard EER = 11.7.
2. Same as Run #1, except assign minimum efficiency gas appliances where gas appliances exist in the Proposed Design. This applies to space heating, water heating, dryer and stove.
3. Same as Run #1, except with a prescriptive gas tankless water heater.

Set the 2025 Standard Design budget as follows:

- The Standard Design Efficiency LSC budget is the annual Efficiency LSC from run #1.
- The Standard Design Total LSC budget is the total annual LSC from run #1 for all end-uses except PV. The annual PV LSC result from run #2 is inserted for PV.
- The annual Source Energy budget is the total annual Source energy from run #3.

Other Software Updates:

- Update the prescriptive PV requirement and integrate it into the software to size the Standard Design PV using a revised prescriptive equation.
    - Develop the PV calculation to offset total kWh for a mixed fuel home.
        - A set of simulations will be used to re-define the prescriptive equation that will cover 16 zone, 3 Prototype (500, 2100, 2700 ft^2), and 2 EER2 values (11.7 and 7). Simulations will reflect a home that meets the 2022 prescriptive requirements except with a gas furnace, water heater, dryer, and stove.
    - Include additional PV to offset the impact of reduced EER in the Proposed
- Calculated the Self Utilization Credit (SUC) for the Proposed Design using the 2022 approach, but substitute the following revised table of maximum SUC credits. These values were calculated based on the current rules in the 2022 Single Family ACM using the 2025 metrics and the budget from case #1. After analysis and review, this table may be expanded to include more SUC scenarios.

Climate Zone	SUC
1	10%
2	7%
3	10%
4	9%
5	11%
6	4%
7	4%
8	10%
9	10%
10	10%
11	10%
12	10%
13	10%
14	10%
15	9%
16	12%