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2025 CALGreen

Technical Measure Report Single Family Heat Pump Replacements

MEASURE CATEGORY: Residential HVAC Alterations

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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 developed by the California Energy Commission (CEC) for consideration and possible inclusion in the California Green Building Standards Code (also known as the CALGreen, or Title 24, Part 11). 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. Local reach codes, including those incorporating CALGreen measures, adopted by local jurisdictions must be found to be technically feasible and cost-effective as a whole.

Code Change Description

This report proposes changes to CALGreen's voluntary energy efficiency measures for single-family residential building heating, ventilation and air conditioning (HVAC) replacements. The proposed change for the 2025 CALGreen voluntary measure would include a prescriptive option for when existing building's space conditioning system in climate zones 1 through 14 and 16 is altered by the installation or replacement of an air conditioner, that a heat pump be used as the primary space conditioning source, or that if an air conditioner is installed, certain duct insulation, duct leakage, airflow, refrigerant charge verification, attic insulation, and air sealing requirements are met. Exceptions are provided for instances where an existing service panel is insufficient to service the additional electrical capacity of a heat pump relative to a new or replacement air conditioner, and when the required capacity of a heat pump is greater than or equal to 12,000 Btu/h more than the required capacity of an air conditioner. Compliance can also be met with the performance approach.

Scope of Work

The single-family heat pump replacements measure will modify the following CALGreen sections, reference appendices and supporting documents listed in Table 1.

Table 1: Code Change Scope of Work

CALGreen Section(s)	Regulation Type(s): M, Ps, Pm, or V	Reference Appendices	Modeling Tools	Forms	Other Supporting Documents
Section A4.204	V	N/A	CBECC-Res	N/A	N/A

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

Compliance and Enforcement

The proposed CALGreen measure does not include any changes to compliance and enforcement for HVAC space heating designs.

Market Assessment

Heat pump space heating is an established technology that is readily available in the market. The air conditioner option described in section 2 of this report incorporates additional measures that are already well-established in the market.

Cost-effectiveness

Table 2 summarizes the estimated benefits, costs and resulting Benefit-Cost Ratios (BCR) by climate zone for the proposed heat pump alteration measure. Evaluation of cost-effectiveness is presented in Table 2 for a 1,665 ft2 (area weighted) single family prototype. The benefit-cost ratio (BCR) is the incremental Long-term System Cost (LSC) Savings divided by the Total Incremental Costs. When the BCR 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 for all prototypes across all climate zones when applying the CEC's LSC methodology, except for climate zone 15. The CEC does not recommend the measure to replace an air conditioner with a heat pump in climate zone 15, based on the CEC's LSC cost effectiveness methodology. Local jurisdictions may use alternative methodologies to demonstrate cost-effectiveness.

Table 2: 30-Year Cost-Effectiveness Summary

Climate Zone	30-Year Total Energy LSC Savings (PV$)	Lifetime Incremental Cost	Benefit-to-Cost Ratio
1	$12,027	$3,322	3.6
2	$7,709	$1,263	6.1
3	$6,815	$759	9.0
4	$6,643	$1,263	5.3
5	$5,717	$1,008	5.7
6	$1,499	$1,008	1.5
7	$1,543	$1,008	1.5
8	$1,604	$1,519	1.1
9	$2,342	$1,519	1.5
10	$2,037	$1,519	1.3
11	$7,776	$1,848	4.2
12	$8,075	$1,519	5.3
13	$5,422	$1,848	2.9
14	$4,412	$1,519	2.9
15	$327	$2,178	0.2
16	$9,663	$2,385	4.1

Statewide Energy Impacts

This measure is voluntary and will only deliver energy and greenhouse gas emissions savings for the jurisdictions that adopt the measure. Since the CEC has no visibility into likelihood or possible timing of adoption, Table 3 and Table 4 summarize the estimated maximum statewide energy and greenhouse gas (GHG) emissions savings[1] for the first year on the assumption that the proposed measure would be adopted through an ordinance by every local government in the state, and that every air conditioner replacement would comply with the local ordinance.

[1] GHG emission savings due to net reduction in combustion of natural gas at the home and at the powerplant. A nominal increase in GHGs as a result of more refrigerants was not quantified but is discussed in greater detail in section 5.4.3.

Table 3: Estimated Maximum 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 (Million PV$)	First Year Statewide Natural Gas LSC Savings (Million PV$)
TOTAL	(230.45)	(84.19)	29.03	($2,311.89)	$3,603.05

Table 4: Estimated Maximum Statewide Greenhouse Gas Emission Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide GHG Emissions Savings (PV$)
TOTAL	128,999	$15,885,920

ACRONYMS

Acronym	Definition
ACM	Alternative 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
CPUC	California Public Utilities Commission
CZ	California Climate Zone
DEER	Database for Energy Efficient Resources
DOE	Department of Energy
DFHP	Dual Fuel Heat Pump
EUL	Effective Useful Lifetime
GHG	Greenhouse Gas
GWh	Gigawatt-Hour
GWP	Global Warming Potential
HERS	Home Energy Rating System
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, Ventilation and Air Conditioning
kWh	Kilowatt-Hour

LSC	Long-term System Cost (30-year $)
MW	Megawatt
NAICS	North American Industry Classification System
PV$	Present Value Dollars
SHGC	Solar Heat Gain Coefficient
U.S. EPA	United States Environmental Protection Agency

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 developed by the California Energy Commission (CEC) for consideration and possible inclusion in the California Green Building Standards Code (also known as CALGreen or Title 24 Part 11). 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. Local reach codes, including those incorporating CALGreen measures, adopted by local jurisdictions must be found to be technically feasible and cost-effective as a whole.

Consistent with California Law (Public Resources Code 25402(b)(3)), an energy efficiency 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 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 CALGreen. 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 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. See section 4 for cost effectiveness analysis.

2. Measure Description

This report proposes changes to CALGreen's voluntary standards for single-family residential building heating, ventilation and air conditioning (HVAC) alterations.

This code change proposal would update prescriptive options for heat pumps when an air conditioner is replaced, or space cooling is installed for the first time in existing single-family homes. Under the updated prescriptive options, heat pump heating would be the primary heat source, with backup heating allowed either provided by electric resistance or gas. In cases where the existing furnace remains, the heat pump would be installed alongside the existing furnace with integrated controls to allow for the furnace to provide backup heating only. The heat pump must be sized to satisfy the heating load at the design heating temperature without the use of backup heat.

An alternative path is also allowed that would provide for an air conditioner installation in combination with efficiency measures that improve system performance and reduce the building loads. These measures are listed below.

- R-8 duct insulation for ducts located in unconditioned space.
- No greater than 5% duct leakage.
- System airflow greater than or equal to 400 CFM per ton and fan efficacy less than or equal to 0.35 W/CFM.
- Refrigerant charge verification confirmed by a Home Energy Rating System (HERS) Rater.
- U-factor of 0.020 or R-49 or greater ceiling insulation in vented attics.
- Air sealing the ceiling plane between the attic and the conditioned space.

Exceptions are proposed for scenarios where the installation of a heat pump would necessitate an electrical panel upgrade and where the heat pump would need to be 12,000 Btu/h or greater than if an air conditioner were installed in order to meet the heating load.

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 emissions associated with space conditioning systems.

2.1 Measure Modifications to CALGreen Documents

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

2.1.1 CALGreen Change Summary

This proposal would modify the following sections of the CALGreen standards as shown below. See Section 6.1 CALGreen (Title 24, Part 11) of this report for the detailed proposed revisions to the standards language.

SECTION A4.204 –

ALTERATIONS TO EXISTING BUILDINGS

Subsection A4.204.1 The proposed regulations add the following options when an existing building's space conditioning system in climate zones 1 through 14 and 16 is altered by the installation or replacement of an air conditioner:

- The altered system shall comply with either A or B below:

  A. A heat pump shall be the primary heating source.

  B. If an air conditioner is installed, the following requirements must also be met :

    - R-8 duct insulation for ducts located in unconditioned space in accordance with the requirements of Section 150.2(b)1Di of the California Energy Code.
    - Duct system air leakage shall be less than or equal to 5 percent in accordance with the requirements of Section 150.2(b)1Diia of the California Energy Code.
    - Refrigerant charge verification must be performed in all climate zones in accordance with the requirements of Section 150.2(b)1Fiib) of the California Energy Code.
    - Vented attics shall achieve a U-factor of 0.020 or a ceiling insulation of R-49 or greater in accordance with the requirements of Section 150.2(b)1Ji) of the California Energy Code. All accessible areas of the ceiling between the attic and conditioned space shall be air sealed in accordance with the requirements of 150.2(b)1Jii of the California Energy Code.
- The altered system shall meet the installation requirements in Title 24, Part 6, Sections 150.2(b)1E and 150.2(b)1Fi.

Exceptions are provided in instances where an existing service panel is insufficient to service the additional electrical capacity of a heat pump relative to a new or replacement air conditioner, and when the required capacity of a heat pump is greater than or equal to 12,000 Btu/h more than the required capacity of an air conditioner.

The CEC does not recommend the measure for climate zone 15, where the proposed measure is found not to be cost effective when using the CEC's LSC methodology.

This standard cost-effectively increases the stringency of CALGreen, thereby minimizing the energy use of residential buildings, which in turn improves the state's economic and environmental health.

2.1.2 Reference Appendices Change Summary

The proposed code change will not modify the Energy Code Reference Appendices.

2.1.3 Compliance Manuals Change Summary

The proposed code change will not modify the Compliance Manuals.

2.1.4 Alternative Calculation Method (ACM) Reference Manuals Change Summary

The proposed code change will not modify the ACM Reference Manuals.

2.1.5 Compliance Forms Change Summary

The proposed code change will not modify the Compliance Forms.

2.2 Measure Context

2.2.1 Comparable Model Code or Standard

This topic builds on the 2022 Title 24, Part 6 Standards for newly constructed single family homes that establish a single heat pump baseline strategy wherein heat pump space conditioning systems are prescriptively required in Climate Zones 3, 4, 13, and 14. Title 10 of the Code of Federal Regulations (CFR), specifically Part 430, contains energy conservation program regulations for energy-consuming appliances and equipment, including 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. This measure proposal does not propose changes to the existing standard for the product.

2.2.2 Conflicts with Other Regulations or Certifications

There are no conflicts with other regulations, certifications, or voluntary model codes.

American Society of Heating and Refrigeration Engineers Standard 90.2 (ASHRAE 90.2) presents efficiency standards for low-rise residential buildings, including single family homes. These standards are industry consensus standards that are voluntary for state consideration.

International Energy Conservation Code (IECC) Residential Provisions sections 403.5 and 403.6 lay out mandatory and prescriptive standards for mechanical ventilation (HVAC for Title 24 Part 6) systems, respectively. IECC otherwise references federal minimum efficiency rating for equipment. These standards are industry consensus standards that are voluntary for state consideration.

ASHRAE 90.2 and IECC Residential Provisions are organized differently than Title 24 Part 6 standards. Both set HVAC requirement levels that are generally less energy efficient than Title 24 Part 6.

The proposed standards are set based on appliances that meet federal minimum efficiency requirements.

2.3 Compliance and Enforcement

Compliance and enforcement would remain the same even though the choice of standard design will be a heat pump space conditioning system in jurisdictions that adopt the proposed measure. The proposed Title 24, Part 11, prescriptive standard would prescriptively require the applicant to install heat pump systems when air conditioners (ACs) are replaced. There remains a pathway for AC-to-AC replacements with efficiency requirements specific to airflow and duct insulation that are similar to the requirements that apply for entirely new or complete replacement mechanical and duct systems found in sections 150.2(b)1C and 150.2(b)1Diia of Title 24, Part 6.

3. 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. Since this measure will only impact jurisdictions that adopt the measure, and the CEC has no visibility into likelihood or possible timing of adoption, this chapter shares data and outlines considerations for use by jurisdictions as they consider adopting the measure.

3.1 Market Structure and Availability

As California moves forward on the path of deploying 6 million heat pumps by 2030, it becomes increasingly important to provide mechanisms to promote the technology switch from air conditioner systems to heat pump technologies. An estimated 1.9 million California households have existing split system air conditioning units that are 14 years or older, according to information provided in an April 2023 filing under the 2025 Title 24, Part 6 pre-rulemaking docket (Earthjustice, Sierra Club, NRDC, RMI, et al, 2023).

Many homeowners when confronted with a failing air conditioner system will often undertake a replacement of just the air conditioner condensing unit and indoor coil, rather than a whole system replacement, since the cost of replacing both the outdoor unit and the furnace is often $5,000 or $6,000 more than just replacing the outdoor unit. A logical alternative to either of the above options is to replace the AC unit with a heat pump and retain the existing furnace. This results in conversion of the HVAC system to a mixed heat pump/gas furnace system, which can be referred to as a dual fuel system.

The mixed heat pump/gas system requires special controls to allow the heat pump to do the bulk of the heating while using the furnace as a backup system, This avoids potential cost and installation complications related to heat pump implementation that would add electrical capacity requirements for supplemental heat pump electric heating. Electrical panel upsizing due to heat pump installation is rare but can add significant cost to a heat pump retrofit (up to $5,000) in the cases where the existing electrical panel is undersized. Prescriptively requiring a heat pump replacement in the case of a failing air conditioner under all feasible scenarios is a proactive step to transition the market more quickly to heat pumps, while avoiding the scenario of installing a new AC condensing unit with an older furnace which may then require replacement in just a few years.

Jurisdictions such as the Bay Area Air Quality Management District have pursued a code provision that by 2029 only zero-NOx space heating equipment would be allowed to be sold or installed.

3.2 Impacts on Market Actors

Analysis performed form this measure demonstrated that adoption of heat pumps for space heating would result in relatively modest economic impacts.

3.2.1 Impact on Builders

This proposal impacts alterations to existing buildings. As such, there is no anticipated impact to builders.

3.2.2 Impact on Contractors, Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes is within the normal course of business for contractors and building designers. Building codes (including Title 24, Part 6 and Part 11) 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.

This proposal predominantly affects HVAC replacement contractors, while generally not impacting building designers or energy consultants. However, in certain instances where alterations utilize the performance approach, energy consultants may be affected. HVAC contractors are responsible for designing and installing HVAC systems. They are responsible for determining system types to be used in the building and ensuring the design satisfies all installation requirements such that the HVAC system can function properly. The project consultant team, including mechanical contractors, can have a strong influence on building owner/developer in decision of the type of HVAC system that go into a building. After installation, maintenance, and repairs of heat pump space heaters may require an HVAC contractor or other processional licensed to work with refrigerant-containing components. There are many contractors with extensive experience in installing heat pump systems.

Businesses that focus on residential building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 11: California Building Designer and Energy Consultant Sectors shows the number of establishments, employment, and total annual payroll for Building Architectural Services. This proposal impacts alterations to existing buildings. As such, there is no anticipated impact to firms within the Architectural Services sector.

There is not a North American Industry Classification System (NAICS) 2 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 5 provides an upper bound indication of the size of this sector in California.

Table 5 : 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: (State of California, Employment Development Department, n.d.)

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.

This measure is not anticipated to have a significant financial impact on building designers and energy consultants operating in local jurisdictions where this measure is adopted.

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, where it is adopted by a local jurisdiction, 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 Component Retailers (including manufacturers and distributors)

The proposed change would increase demand for manufacturers, distributors, and retailers of heat pump space heating equipment where adopted by a local jurisdiction. Supply chains for gas space heating equipment would experience a parallel 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 equipment.

3.2.5 Impact on Building Inspectors

Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. No impact is anticipated on employment of building inspectors or the scope of their role conducting energy efficiency inspections where this measure is adopted by local jurisdictions.

3.3 Impacts on Jobs and Businesses

No significant employment or financial impacts are anticipated to any sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.2, the proposed change in electric HVAC systems are anticipated to affect statewide employment and economic output directly and indirectly through its impact on HVAC contractors, builders, designers, and energy consultants, and building inspectors. In addition, energy savings associated with the proposed change in electric HVAC are anticipated to 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 shown in the table and discussed in the sections below.

The economic impact analysis from Table 6 shows the results from an IMPLAN model on residential construction and remodeling due to the proposed measure, assuming that the proposed measure is implemented through an ordinance by every local government in the state, and that every single-family air conditioner replacement would comply with their local ordinance Directly, these changes are estimated to create approximately 1,198 jobs and generate $90.1 million in labor income, $137.1 million in value added, and $294.2 million in output. Indirect effects include an additional 733 jobs, $54 million in labor income, $92.3 million in value added, and $156.8 million in output. Furthermore, induced effects from the spending of these incomes are projected to result in 609 jobs, $41.5 million in labor income, $74.2 million in value added, and $118.1 million in output. These findings underscore the broad economic benefits of updating HVAC systems in single-family alterations across the state.

Table 6: Residential Construction & Remodel Economic Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	1,197.5	$90,106,801	$137,139,818	$294,230,747
Indirect Effect	732.6	$54,000,552	$92,272,569	$156,761,025
Induced Effect	609.1	$41,455,120	$74,227,153	$118,142,192
Total Effect	**2,539.2**	**$185,562,473**	**$303,639,540**	**$569,133,965**

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

3.4.1 Creation or Elimination of Jobs

This proposed measure for the 2025 CALGreen code cycle are not anticipated to lead to the creation of new types of jobs or the elimination of existing types of jobs. In other words, 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.

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 replacement projects, which would not excessively burden or competitively disadvantage California businesses, nor would it necessarily lead to a competitive advantage for California businesses. Therefore, it is not anticipated that any new businesses will be created, nor will any existing businesses 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 equally to all HVAC replacement contractors doing business in the California jurisdictions where the measure is adopted. Therefore, the proposed measure for the 2025 CALGreen code cycle are not anticipated to have an adverse effect on the competitiveness of California businesses. Likewise, businesses located outside of California are not anticipated to be advantaged or disadvantaged.

3.4.4 Increase or Decrease of Investments in the State of California

The economic impacts associated with the proposed measure are not anticipated to 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 proposed code changes are not anticipated to 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 proposed code changes are not anticipated to 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 2022 Title 24, Part 6, 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 the Building Energy Efficiency Standards legislative direction in Public Resources Code 25402(b)(3), 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 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 the cost benefits realized over the estimated 30-year life of the building, Long-term System Cost (LSC) is used to determine the dollar value of measures in CALGreen. LSC hourly factors enable the CEC to account for long-term benefits associated with CALGreen. Today's energy bill rates do not adequately account for these long-term values to California's energy system. LSC hourly factors establish the long-term value of each hour, where times of peak demand are more valuable, and times of 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 for the energy models of buildings 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. The research version of CBECC-Res 2025 was used in this analysis to assess the energy savings of proposed measures. This version includes the latest updates and methodologies recommended by the California Energy Commission (CEC) for residential energy modeling. The research version of CBECC-

Res 2025 contained the necessary modeling assumptions and algorithms for evaluating the proposed measure.

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 2022 Title 24, Part 6, Energy Code.

Similarly 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.

4.1.1 Prototype

For this analysis, an existing home prototype developed by the CEC for residential ACM testing (CEC, 2022) was used with the following revisions. The original prototype includes an existing 1,440 square foot space and a 225 square foot addition. Average home size has steadily increased over time (U.S. Census Bureau, 2011), and the CEC's single family newly constructed building prototypes are larger than many existing single-family homes across California. The median size of homes built in the United States prior to the 1970s was 1,500 square feet, with size steadily increasing to a median of 2,100 square feet in the early 2000s. To better represent the existing building stock, the prototype used for this analysis was revised to reflect a 1,665 square feet existing home. Table 7 describes the basic characteristics of the single-family prototype.

Table 7: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Characteristic	Value
Existing Conditioned Floor Area	1,665 ft2
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three unique building vintages were considered: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24, Part 6 standards and selecting year ranges with distinguishing features. This analysis focuses on the 1992-2010 vintage. Staff found that the newest vintage, 1992-2010, resulted in the lowest amount of savings for the heat pump measure and therefore presents the most conservative approach to determining cost-effectiveness. Further detail on the prototypes can be found in Appendix C: Methodology and Assumptions.

CBECC-Res generates two models based on user inputs: the Standard Design and the Proposed Design. The Standard Design represents the geometry of the prototypical building and a design that uses a set of features that result in a LSC budget

The energy impacts of the proposed code change vary by climate zone and the energy impacts were simulated in every climate zone to determine where the proposed code change is cost-effective and feasible.

Table 8: Modifications Made to Standard Design to Simulate Proposed Code Change for Heat Pump Replacement Path

Climate Zone	Objects Modified	Parameter Name	Standard Design Parameter Value	Proposed Design Parameter Value
All	HVAC System	System Type	Air Conditioner with existing furnace	Heat Pump with existing furnace as backup heating
All	HVAC System	SEER2 / EER2	14.3/11.7	14.3/11.7
All	HVAC System	HSPF2	n/a	7.5
All	HVAC System	AFUE	78	78
1, 3-7, 16	HVAC System	Airflow	250 cfm/ton	300 cfm/ton
1, 3-7, 16	HVAC System	Refrigerant Charge Verification	Not Verified	Verified
2, 8-15	HVAC System	Airflow	300 cfm/ton	300 cfm/ton
2, 8-15	HVAC System	Refrigerant Charge Verification	Verified	Verified
All	Duct	Duct Leakage	10% leakage	10% leakage

Lifecycle energy impacts over the 30-year analysis period are estimated to reflect the replacement schedule presented in Table 9. The analysis used a 20-year effective useful lifetime (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). At the beginning of the analysis period, in 2026, a typical existing furnace will be halfway through its EULi. After 10 years, in 2036, when the furnace reaches the end of its life, under the Standard Design the furnace will be replaced and will be subject to new federal efficiency standards for residential gas furnaces that go into effect in 2028 requiring 95 AFUE[2]. Five years later when the air conditioner reaches the end of its life, it will be replaced with a new air conditioner.

For the Proposed Design case, in 2036 when the furnace fails it's expected that the furnace will not be replaced in its entirety since the heat pump serves as the primary heating source and was sized to provide the full design heating load. In this situation,

[2] https://www.energy.gov/articles/doe-finalizes-energy-efficiency-standards-residential-furnaces-save-americans-15-billion#:~:text=These%20furnace%20efficiency%20standards%20were,heat%20for%20the%20living%20space.

it is expected that only the fan motor would be replaced and the furnace would continue to operate another 5 years until the heat pump fails and is replaced with a new heat pump and air handler that would then provide all heating.

Table 9: Lifetime Analysis Replacement Schedule for Air Conditioner and Heat Pump

Calendar Year	Standard Design	Proposed Design
2026	AC fails, install new AC, keep existing furnace	AC fails, install new HP, keep existing furnace
2036	Furnace fails, install new 95 AFUE furnace	Furnace fails, replace fan motor
2041	AC fails, install new AC	HP fails, install new HP and air handler

4.1.2 Cost Collection

This analysis relies on current HVAC measure cost data collected in the summer of 2023 directly from HVAC contractors. The Team undertook an outreach effort to identify contractors willing to provide "typical" installed cost data for a broad range of measures with a focus on converting existing gas furnace /central air conditioner installations to either dual fuel heat pumps (DFHPs) or to a split system heat pump.

The collected cost data represent recent costs for a typical retrofit installation.

For the purposes of this study, cost data was collected for the following scenarios.

- New heat pump installation alongside the existing furnace.
- New air conditioner installation alongside the existing furnace.
- New heat pump and air handler with the existing furnace decommissioned.
- New air conditioner and furnace.

The first two scenarios were the focus of this work and applied in the cost-effectiveness results presented in Section 4 of this report. Costs were collected for both 3-ton and 4-ton capacity systems and estimates for 2-ton and 5-ton capacity systems were extrapolated from the collected data. Since DFHPs are a relatively new alternative in the California market, it was difficult to obtain a broad set of responses for this product type.

The cost estimates were obtained from contractors that work in different regions of the state, operate in different markets with (potentially) do varying amounts of work based on the size of their company, and install different brands of equipment. All of these factors will contribute to price variability. To address some of this variability, the provided costs were applied to both regional factors and "work volume" factors to try to arrive at more representative costs. The regional factors were developed based on blending costs from both the TECH program[3] and RS Means, which provides California location-based cost factors for dozens of California cities. The TECH/RS Means cost factors ranged from 0.97 to 1.15. The "work volume" factors were based on the contractor's quantification of systems installed and ranged from a low of 0.8 to a high of 1.2. The higher work volume weights were applied to the contractors doing the most work.

4.1 Energy Savings Results

Table 10 summarizes the electricity and gas LSC savings for the existing home prototype.

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

Climate Zone	30-Year Electricity LSC Savings (PV$)	30-Year Natural Gas LSC Savings (PV$)	30-Year Total Energy LSC Savings (PV$)
1	($20,269)	$32,295	$12,027
2	($15,512)	$23,221	$7,709
3	($11,305)	$18,121	$6,815
4	($13,509)	$20,152	$6,643
5	($10,606)	$16,323	$5,717
6	($1,776)	$3,275	$1,499
7	($1,127)	$2,670	$1,543
8	($2,570)	$4,174	$1,604
9	($3,941)	$6,283	$2,342
10	($3,985)	$6,022	$2,037
11	($13,453)	$21,229	$7,776
12	($13,914)	$21,989	$8,075
13	($9,746)	$15,168	$5,422
14	($14,663)	$19,075	$4,412
15	($1,104)	$1,432	$327
16	($25,536)	$35,198	$9,663

4.2 Incremental First Cost

The cost analysis based on contractor surveys described in Section 4.1.2 was used to inform the incremental first costs presented in Table 11. The survey collected cost

[3] TECH cost data for heat pump water heaters in single family homes (>500 data points) provided the clearest price signal on installed cost variability for different parts of the state including the Bay Area, Los Angeles, San Diego, Sacramento, and the Central Valley.

data for 3-ton and 4-ton systems. System costs for 2-ton, 5-ton, and ½-ton increments in between were extrapolated based on the difference between the 3-ton and 4-ton costs. Table 11 also presents the system capacities used in this analysis to determine measure costs for each climate zone. Capacities were based on load calculations using the CBECC-Res software.

Table 11: Incremental First Cost and System Sizing by Climate Zone

Climate Zone	Air Conditioner Capacity in Tons (Btu/h)	Heat Pump Capacity in tons (Btu/h)	Incremental First Cost
1	1.5 (18,000)	3.0 (36,000)	$3,660
2	3.5 (42,000)	3.5 (42,000)	$2,440
3	2.5 (30,000)	2.5 (30,000)	$2,259
4	3.5 (42,000)	3.5 (42,000)	$2,440
5	3.0 (36,000)	3.0 (36,000)	$2,349
6	3.0 (36,000)	3.0 (36,000)	$2,349
7	3.0 (36,000)	3.0 (36,000)	$2,349
8	4.0 (48,000)	4.0 (48,000)	$2,530
9	4.0 (48,000)	4.0 (48,0000)	$2,530
10	4.0 (48,000)	4.0 (48,000)	$2,530
11	4.5 (54,000)	4.5 (54,000)	$2,621
12	4.0 (48,000)	4.0 (48,000)	$2,530
13	4.5 (54,000)	4.5 (54,000)	$2,621
14	4.0 (48,000)	4.0 (48,000)	$2,530
15	5.0 (60,000)	5.0 (60,000)	$2,711
16	3.5 (42,000)	4.0 (48,000)	$2,967

4.2.1 Replacement and Maintenance Cost

Incremental replacement cost is the incremental cost of replacing the equipment or parts of the equipment over the 30-year period of analysis. Incremental maintenance cost is the incremental cost of periodic maintenance required to keep the equipment operating over the 30-year period of analysis. The present value of equipment replacement and maintenance costs (or savings) was calculated using a three percent discount rate (d), which is consistent with the discount rate used when developing the proposed 2025 LSC hourly factors. The present value of incremental costs that occurs in the n^{th} year is calculated as follows:

$$\text{Present Value of Cost} = \text{Cost} \times \left[\frac{1}{1+d}\right]^n$$

Replacement costs were applied based on the replacement schedule shown in Table 8 and Table 9 for both the Standard Design and the Proposed Design. Table 12 presents details for the lifetime cost calculation for a 3-ton system. Lifetime incremental costs for each climate zone are presented in Table 13.

Table 12: Lifetime Incremental Cost Analysis for 3-ton Air Conditioner and Heat Pump

Calendar Year	Standard Design Replacement Schedule	Standard Design Future Cost (Real)	Standard Design Present Value	Proposed Design Replacement Schedule	Proposed Design Future Cost (Real)	Proposed Design Present Value
2026	AC fails, install new AC, keep existing furnace	$9,528	$9,528	AC fails, install new HP, keep existing furnace	$11,877	$11,877
2036	Furnace fails, install new 95AFUE furnace	$8,763	$6,521	Furnace fails, replace fan motor	$1,200	$893
2041	AC fails, install new AC	$9,528	$6,116	HP fails, install new HP and air handler	$16,206	$10,402
Total	-	-	**$22,164**	-	-	**$23,172**

Table 13: Lifetime Incremental Cost by Climate Zone

Climate Zone	First Incremental Cost	Lifetime Incremental Cost
1	$3,660	$3,322
2	$2,440	$1,263
3	$2,259	$759
4	$2,440	$1,263
5	$2,349	$1,008
6	$2,349	$1,008
7	$2,349	$1,008
8	$2,530	$1,519
9	$2,530	$1,519
10	$2,530	$1,519
11	$2,621	$1,848
12	$2,530	$1,519
13	$2,621	$1,848
14	$2,530	$1,519
15	$2,711	$2,178
16	$2,967	$2,385

4.3 Cost Effectiveness

Cost-effectiveness analysis is used to determine the economic impact of proposed measures over a 30-year period of analysis. This analysis considers and includes incremental energy savings for all impacted energy sources (electricity and gas), incremental first costs, and incremental maintenance costs over a 30-year period of 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. The 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.

Evaluation of cost-effectiveness of the heat pump compliance path is presented in Table 14. The analysis demonstrates that the measure is cost effective in all climate zones, except for climate zone 15. As a result, the CEC does not recommend the proposed measure to replace an air conditioner with a heat pump in climate zone 15, based on the CEC's LSC cost effectiveness methodology. Pursuant to Public Resources Code section 25402.1(h)2, when a local jurisdiction adopts a local building energy code that requires energy savings beyond the statewide California Energy Code (local reach code), it is the responsibility of the local jurisdiction to determine cost effectiveness for that local code. Local jurisdictions in climate zone 15 may want to consider the air conditioner to heat pump replacement in their cost effectiveness determinations.

Table 14: 30-Year Cost-Effectiveness Summary

Climate Zone	30-Year Total Energy LSC Savings (PV$)	Lifetime Incremental Cost	Benefit-to-Cost Ratio
1	$12,027	$3,322	3.6
2	$7,709	$1,263	6.1
3	$6,815	$759	9.0
4	$6,643	$1,263	5.3
5	$5,717	$1,008	5.7
6	$1,499	$1,008	1.5
7	$1,543	$1,008	1.5
8	$1,604	$1,519	1.1
9	$2,342	$1,519	1.5
10	$2,037	$1,519	1.3
11	$7,776	$1,848	4.2
12	$8,075	$1,519	5.3
13	$5,422	$1,848	2.9
14	$4,412	$1,519	2.9
15	$327	$2,178	0.2
16	$9,663	$2,385	4.1

4.4 Air Conditioner Path

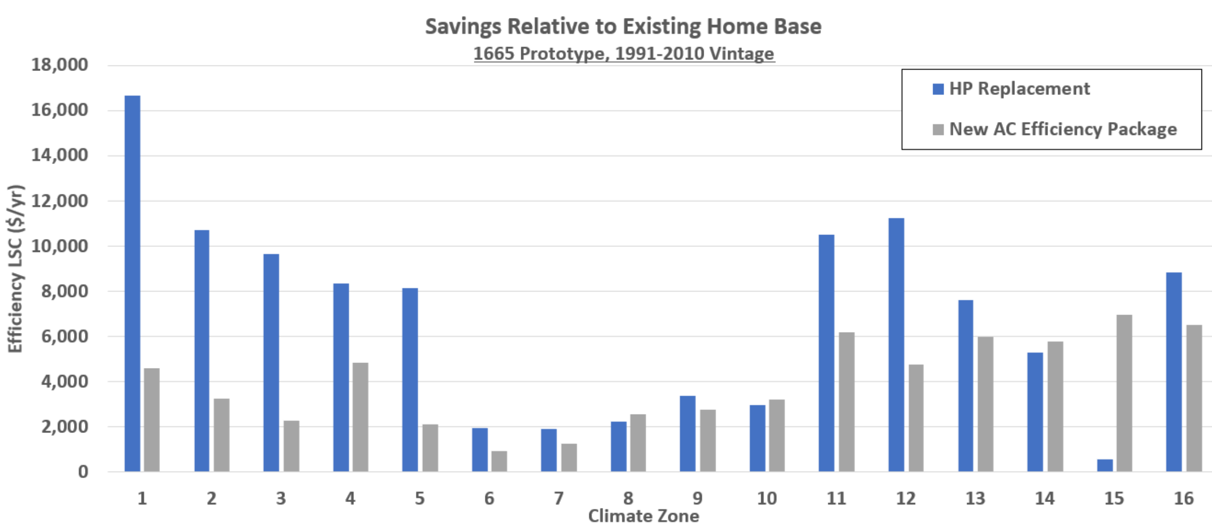
The air conditioner compliance pathway was designed to be approximately energy equivalent with the heat pump path, as simulated in CBECC-Res. Table 15 presents the parameters which were modified and what values were used in the air conditioner path simulation.

Table 15: Modifications Made to Energy Model to Simulate the Proposed Air Conditioner Path Package

Climate Zone	Objects Modified	Parameter Name	Air Conditioner Path Parameter Value
All	HVAC System	System Type	Air Conditioner with existing furnace
All	HVAC System	SEER2 / EER2	14.3/11.7
All	HVAC System	AFUE	78
All	HVAC System	Airflow	400 cfm/ton
All	HVAC Fan	Fan Efficacy	0.35 W/cfm
All	HVAC System	Refrigerant Charge Verification	Verified
All	Envelope	Attic Insulation	R-49 (from R-30)
All	Ducts	Duct insulation and leakage	R-8, 5% leakage
All	Envelope	Air Sealing	Air sealing of the ceiling from 7 to 6.5 ACH50

The alternative air conditioner path LSC savings compared to the heat pump path LSC savings is shown in Figure 1below to demonstrate approximate cost equivalency between the two pathways in many climate zones. In the performance compliance approach, the lesser of the two alternative compliance paths in each climate zone will be used to set the Standard Design.

Figure 1: Heat Pump Performance Compliance Path Compared to Air Conditioner Performance Compliance Path.



5. STATEWIDE ENERGY IMPACTS

This measure will deliver energy and greenhouse gas emissions savings for the jurisdictions that adopt the measure. Since the CEC has no visibility into the likelihood or possible timing of adoption, ￼his section provides the maximum first year statewide savings of the proposed measure, assuming that the proposed measure is implemented through an ordinance by every local government in the state, and that every air conditioner replacement would comply with their local ordinance. To assist with this analysis a statewide newly constructed building forecast for 2026 is presented in Appendix A: Maximum Statewide Savings Methodology. The maximum first year energy impacts represent the maximum first year annual savings from all single-family buildings expected to have air conditioner replacements in the state in 2026.

5.1 Maximum Statewide Energy and Energy Cost Savings

The estimated maximum statewide energy savings are presented in Table 16.

Table 16: Estimated Maximum 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 (Million PV$)	First Year Statewide Natural Gas LSC Savings (Million PV$)
TOTAL	**(230.45)**	**(84.19)**	**29.03**	**($2,311.89)**	**$3,603.05**

5.2 Maximum Statewide Greenhouse Gas Emissions Savings

Using the appropriate GHG Emissions hourly factors published by the CEC, the estimated maximum statewide greenhouse gas emissions savings, assuming that the proposed measure is implemented through an ordinance by every local government in the state, and that every air conditioner replacement complies with their local ordinance is summarized in Table 17.

Table 17: Estimated Maximum Statewide Greenhouse Gas Emissions Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide GHG Emissions Savings (PV$)
TOTAL	**128,999**	**$15,885,920**

5.3 Statewide Water Savings

The proposed code change will not result in water savings.

5.4 Other Non-Energy Impacts

Heat pump 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 combustion devices in these systems and they replace 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 systems are more likely to have less combustion equipment and less gas piping, and with them the associated risk of fire and explosion (particularly during/after an earthquake). Reducing combustion from a building through the use of heat pumps also significantly reduces sources of carbon monoxide poisoning for occupants.

5.4.2 Improved Air Quality and Resiliency

Heat pump heating systems improve air quality at the building, as well as locally and regionally by eliminating a source NOx emission. While recent years have seen California residents subject to more frequent, and longer duration electricity outages than in previous years, electric systems have the potential to be more resilient than gas systems.

All modern gas equipment requires electricity to operate. Since modern gas equipment has done away with standing pilot lights in favor of electronic ignition, power outages take both gas and electric equipment offline. Also, residential central gas heating systems use fans to circulate heat through the ducts; power outages prevent those fans from operating.

5.4.3 Increase in Refrigerant Amount

Increased adoption of heat pump space 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 global warming potential (GWP) are being phased out through efforts of the U.S. EPA and CARB and will not be allowed to be used in new products sold or installed in California. Most manufacturers are actively developing products with lower GWP refrigerants, and the impact is targeted to lessen in the future 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 will be small when compared to the overall GHG emissions originating from the building sector. While the implementation of heat pumps are projected to increase statewide greenhouse gas (GHG) emissions by an amount equivalent to 15,000 metric tons of CO2 due to refrigerant leakage, this total is relatively minimal compared to the overall net reduction of 177,000 metric tons of CO2 equivalent achieved across the whole building sector.[4] CARB refrigerant regulations will result in an important GWP reduction for cooling equipment (including heat pumps) with a January 1, 2025, effective date for most 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. However, as this requires diligent recovery by contractors when equipment is replaced, and then requires specialized 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). U.S. EPA regulations place increasingly lower caps on the use of virgin refrigerants, while allowing reclaimed refrigerants to be used instead.[5] This will increase the dollar value in the marketplace for reclaimed refrigerant and is expected to dramatically encourage increased recovery and reclamation in the future.

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[4] California Energy Commission. (2024). *Initial study and proposed negative declaration for the 2025 building energy efficiency standards*. California Energy Commission.

[5] United States Environmental Protection Agency. "Summary of Refrigerant Reclamation Trends. " https://www.epa.gov/section608/summary-refrigerant-reclamation-trends

6. PROPOSED CODE LANGUAGE

The proposed changes to the Building Energy Efficiency Title 24, Part 11 standards, Reference Appendices, and the Manuals are provided below. Changes to the 2022 Part 11 provisions are marked with black underlining (new language) and ~~strikethroughs~~ (deletions).

6.1 CALGreen (Title 24, Part 11)

SECTION A4.204 ALTERATIONS TO EXISTING BUILDINGS

A4.204.1. Air Conditioner Alterations. In climate zones 1-14 and 16, when an air conditioner is altered by the installation or replacement of refrigerant-containing system components such as the compressor, condensing coil, evaporator coil, refrigerant metering device or refrigerant piping, the altered system shall meet one of the following:

1. A heat pump as the primary heating source. Supplemental heating may be provided by a new or existing gas furnace or by electric resistance; or
2. An air conditioner that meets all the following requirements:
    a. R-8 insulation on ducts located in unconditioned space; and
    b. Duct system measured leakage shall be equal to or less than 5 percent of the system air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; and
    c. Demonstrate, in every control mode, airflow greater than or equal to 400 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.35 W/CFM. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3; and
    d. Meet the refrigerant charge verification requirements of Title 24 Part 6 Section 150.2(b)1Fi in all climate zones; and
    e. Vented attics shall have insulation installed to achieve a weighted U-factor of 0.020 or insulation installed at the ceiling level shall result in an insulated thermal resistance of R-49 or greater for the insulation alone; and
    f. Air seal all accessible areas of the ceiling plane between the attic and the conditioned space in accordance with Section 150.2(b)1Jii.

Exception 1 to Section A4.204.1.1: Where the capacity of the existing main electrical service panel is insufficient to service the additional electrical capacity of a heat pump relative to a new or replacement air conditioner, as calculated according to the requirements of California Electrical Code Article 220.83 or 220.87. Documentation of electrical load calculations in accordance with Article 220 must be submitted to the enforcement agency prior to permitting for both the heat pump and proposed air conditioner.

Exception 2 to Section A4.204.1.1: Where the required capacity of a heat pump to meet the system selection requirements of Section 150.0(h)5 is greater than or equal to 12,000 Btu/h more than the required capacity of an air conditioner to meet the design cooling load. Documentation of heating and cooling load calculations in accordance with 150.0(h) must be submitted to the enforcement agency.

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

There are no proposed changes to the ACM Reference Manuals.

6.5 Compliance Forms

There are no proposed changes to the compliance forms.

7. References

[CEC] California Energy Commission. 2022. 2022 Alternative Calculation Method Approval Manual: for the 2022 Building Energy Efficiency Standards Title 24, Part 6, and Associated Administrative Regulations in Part 1. https://www.energy.ca.gov/publications/2022/2022-alternative-calculation-method-approval-manual-2022-building-energy

[CPUC] California Public Utilities Commission. 2021. Database for Energy-Efficient resources (DEER2021 Update). Retrieved April 13, 2021, from http://www.deeresources.com/index.php/deer-versions/deer2021.

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APPENDICES

Appendix A: Maximum Statewide Savings Methodology

Estimated statewide energy savings for the first year that the Energy Code becomes in effect (2026) can be generated by multiplying the proposed measure's per unit savings by the statewide existing building forecasts provided in this appendix.

Updates to Appendix A, including updates to existing building forecast data, are located on the 2025 Title 24 Part 11 CAL Green Rulemaking Docket 24-BSTD-02, https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=24-BSTD-02.

The assessment of statewide energy savings incorporates the following data points: :

- Air conditioners are expected to be replaced every 15 years, impacting approximately 7% of homes annually.
- 66% of homes have central air conditioning, the system type that is impacted by this proposal. (DNV, 2022)
- 75% of homes in Climate Zones 1 and 16 and 25% in the other climate zones would be eligible for one of the exceptions and would not need to comply with the proposal.

Table 18 presents the statewide estimates of existing single family homes in 2026. At the rate of replacement of air conditioners identified above, Table 18 estimates the total possible single-family homes that could be impacted by the voluntary CALGreen if all local governments adopted the proposed measure.

Table 18: Statewide Residential Units (2026)

Climate Zone	Total Single-Family Units	Impacted Single Family Units
1	44,875	494
2	265,807	8,772
3	972,513	32,093
4	497,321	16,412
5	97,271	3,210
6	594,544	19,620
7	494,355	16,314
8	926,278	30,567
9	1,250,479	41,266
10	1,067,399	35,224
11	335,468	11,070
12	1,318,779	43,520
13	634,709	20,945
14	247,852	8,179
15	177,670	5,863
16	97,937	1,077
Total	**9,023,257**	**294,626**

Appendix B: Embedded Electricity in Water Methodology

There are no on-site water savings associated with the proposed code change.

Appendix C: Methodology and Assumptions

Three unique building vintages were considered for the analysis of this measure: pre-1978, 1978-1991, and 1992-2010. The vintages were defined based on review of historic Title 24, Part 6 standards and selecting year ranges with distinguishing features. Staff found that the newest vintage, 1992-2010, resulted in the lowest amount of savings for the heat pump measure and therefore presents the most conservative approach to determining cost-effectiveness.

Table 19 summarizes the baseline efficiency characteristic assumptions for the 1992-2010 vintage home used for the analysis. The building characteristics were determined based on the prescriptive requirement from the Energy Code that were in effect during the building's time period. Additionally, the analysis used the following when modeling the baseline prototype buildings:

- Individual space conditioning and water heating systems, one per single family building.
- Split-system air conditioner with gas furnace. Efficiency defined by year of the most recent equipment replacement (based on standard equipment lifetime).
- Small storage gas water heater. Efficiency defined by year of most recent equipment replacement (based on standard equipment lifetime).
- Gas cooktop, oven, and clothes dryer.

Table 19: Baseline Efficiency Characteristics for the Prototype

Building Component Efficiency Feature	Specification 1992-2010 Home
Envelope	
Exterior Walls	2x4 16inch on center wood frame, R-13
Foundation Type & Insulation	Uninsulated slab (CZ 2-15) Raised floor, R-19 (CZ 1 & 16)
Ceiling Insulation & Attic Type	Vented attic, R-30 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)
Radiant Barrier	No
Window Type: U-factor/SHGC	Vinyl, dual pane Low-E: 0.55/0.40
House Infiltration	7 ACH50
HVAC Equipment	
Heating Efficiency	78 AFUE
Cooling Efficiency	13 SEER, 11 EER
Duct Location & Details	Attic, R-4.2, 15% leakage
Whole Building Mechanical Ventilation	None
Water Heating Equipment	
Water Heater Efficiency	0.575 Energy Factor
Water Heater Tank	40-gallon uninsulated tank
Pipe Insulation	None
Hot Water Fixtures	Standard, non-low flow