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STAFF REPORT

Low-Income Residential Energy Bill Impact Analysis

**Modeling the Impact of Decarbonization
Activities on Energy Bills in California**

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ABSTRACT

California Energy Commission staff completed modeling bill impact analysis to estimate the energy and cost impacts to residents with low-income qualified energy utility rates of retrofitting existing homes in California. This report describes the method and results of using California Building Energy Code Compliance software. This analysis seeks to estimate, comparatively, where in California certain decarbonization measures will provide energy bill benefits to residents and where greenhouse gas emission reduction benefits can be maximized.

The baseline existing home prototypes are modeled with gas end uses for domestic hot water, space heating, cooking, and clothes drying. The decarbonization measures included in this analysis are heat pump water heaters, heat pumps for space conditioning, electric cooking, and electric clothes drying. The weatherization measures include, in a subset of the residential building prototypes, attic insulation, floor insulation, duct sealing, air sealing, and solar window films.

Bill impacts are calculated by comparing the energy bill of each retrofit to the energy bill of the baseline, in each of the 16 climate zones. Utility rates, up to December 2024, for Pacific Gas and Electric, Southern California Edison, San Diego Gas & Electric, Southern California Gas Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District are included in this analysis.

Results show that each climate zone has decarbonization retrofit measure combinations and rates that lead to energy bill savings. High energy bill savings are achieved with space-cooling efficiencies in high-cooling-load climate zones. Low energy bill savings and, in some cases, bill increases occur in climate zones with low cooling load and high heating load. Results also show that electricity rates with low volumetric charges are most electrification-friendly, leading to higher energy bill savings. Additionally, while replacing any gas fired appliance with an electric appliance will reduce greenhouse gas emissions, the most impactful decarbonization measures across all climate zones is changing from a gas water heater or furnace to electric heat pump technology. As a next step, staff plans to use interval meter data to calibrate the modeled results of energy consumption and utility bills to improve accuracy and better identify appropriate retrofit measures.

Keywords: Building decarbonization, low-income, energy bill impact analysis, heat pump, existing homes, retrofit

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EXECUTIVE SUMMARY

California Energy Commission (CEC) staff completed this energy bill impact analysis to estimate the energy and cost impacts to California residents on income-qualified rate discounts who are retrofitting their homes. This analysis was completed to support the implementation of the Equitable Building Decarbonization Program (as directed by Assembly Bill 209 (Committee on Budget, Chapter 251, Statutes of 2022)).

The Equitable Building Decarbonization Program includes both a direct install program and an incentive program. The Direct Install program's primary goals are to reduce greenhouse gas emissions in homes and advance energy equity through decarbonization retrofits to low- and moderate-income households and tribal-owned or managed homes. Decarbonization retrofits include replacing fossil fuel appliances with clean heating technologies, such as replacing a gas water heater with an electric heat pump water heater.

This bill impact analysis seeks to estimate, comparatively, where in California certain decarbonization measures will provide energy bill benefits to residents and where greenhouse gas emission reductions can be maximized. It is important to understand the energy and bill impacts of installing equipment in homes to enable building decarbonization program developers and administrators to optimize program implementation and positive outcomes, utilize funding judiciously, and improve the accuracy of education and outreach materials discussing the program and impacts. This analysis is intended to aid EBD program administrators to tailor measures for specific communities and home vintages to help reduce the chances of negative bill impacts.

This analysis describes the method and results of using California Building Energy Code Compliance software to estimate the energy bill effect of decarbonization retrofits in existing homes. These results are based on computer modeling, which uses assumptions about energy use and has limitations when considering specific homes. This modeling cannot account for all the variations in weather, building characteristics, existing building systems, and occupant behavior.

The baseline existing home prototype is modeled with gas end uses for domestic hot water, space heating, cooking, and clothes drying. The replacement decarbonization measures and packages modeled in this analysis are heat pump water heater, heat pump for space conditioning, electric cooking, and electric clothes drying. Other decarbonization and weatherization measures considered were attic insulation, floor insulation, duct sealing, air sealing, and solar window films. These home retrofit measures were modeled in all 16 California building climate zones established by the CEC and in all possible combinations that included at least a heat pump water heater or heat pump for space conditioning, resulting in hundreds of thousands of modeling files.

This analysis looks specifically at the low-income-qualified energy utility rates for residents over a calendar year. CEC staff calculated energy bills by applying hourly electricity and gas rates to California Building Energy Code Compliance hourly energy outputs. Staff also included

fixed charges in calculating the energy bills. Staff calculated bill impacts by comparing the energy bill of each retrofit to the energy bill of the baseline, in each climate zone, for each home prototype. December 2024 utility rates for Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), San Diego Gas & Electric Company (SDG&E), Southern California Gas Company (SoCalGas), Los Angeles Department of Water and Power (LADWP), and Sacramento Municipal Utility District (SMUD) are included in this analysis. Utility rates are applied to climate zones located in each utility territory. Both the baseline and retrofit hourly results have the same utility rates applied, with the exception of electrification-friendly rates, which are applied only to retrofit hourly results. Electrification-friendly rates are highly differentiated time-of-use rates that encourage electrification with lower volumetric rates for electricity during off peak hours, and homes with electric heat pump for space or water heating or both can qualify. The analysis does not include future rate projections.

Staff would like to point out that this is a modeling effort, representing specific scenarios rather than a probabilistic forecast for the housing population in California. Scenarios are based on these factors: home type, size, vintage, retrofit measure combination, and utility rate. The results show general trends based on modeled home energy for different scenarios in all California climate zones and are not meant to predict the bill impact of individual homes based only on location. Results show that in each climate zone, there are decarbonization retrofit measure combinations and rates that lead to energy bill savings. High energy bill savings are achieved with space-cooling efficiencies in high-cooling-load climate zones, such as the Central Valley and desert climate zones. Low energy bill savings and, in some cases, bill increases occur in climate zones with low cooling load and high heating load, such as San Luis Obispo area and mountain areas. Results also show that electricity rates with low volumetric hourly charges are the most electrification-friendly, leading to higher energy bill savings. With the rates used in this analysis, Sacramento Municipal Utility District (SMUD) and San Diego Gas & Electric Company's (SDG&E's) TOU-ELEC rate resulted in the highest energy bill savings for residential decarbonization measures.

CHAPTER 1:

Equitable Building Decarbonization Program Background

The State of California is committed to a just and equitable transition to carbon neutrality by 2045.¹ Homes and businesses account for about 25 percent of California’s greenhouse gas emissions,² so the decarbonization³ of buildings and engagement of all communities are essential to achieving the state’s carbon neutrality goal. As stated in the *2022 Integrated Energy Policy Report Update*, building decarbonization must prioritize low-income, disadvantaged, and tribal communities, who bear the highest energy burden and have suffered the most from historical environmental injustices, economic disparities, and the current climate crisis.⁴

The California Energy Commission (CEC) advances building decarbonization through numerous programs, including:

- Developing building energy efficiency standards, energy and water efficiency appliance standards, flexible demand appliance standards, and load management standards.
- Advancing innovation and research that supports building decarbonization.
- Designing and implementing incentive programs.
- Gathering and analyzing data to allow for data-informed policy and program decision-making.

Based on the findings of the *2021 California Building Decarbonization Assessment*, the *2022 Integrated Energy Policy Report* recommended the state adopt a goal of 6 million heat pump installations by 2030 and direct funding toward building decarbonization retrofits in low-income and disadvantaged communities.⁵ Governor Gavin Newsom endorsed the goal of 6

¹ [Executive Order B-55-18 To Achieve Carbon Neutrality](https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf), signed by Governor Edmund G. Brown Jr. on September 10, 2018, <https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf>.

² Kenney, Michael, Nicholas Janusch, Ingrid Neumann, and Mike Jaske. 2021. [California Building Decarbonization Assessment. California Energy Commission](https://www.energy.ca.gov/data-reports/reports/building-decarbonization-assessment). Publication Number: CEC-400-2021-006-CMF, <https://www.energy.ca.gov/data-reports/reports/building-decarbonization-assessment>.

³ Decarbonization: activities that reduce or eliminate greenhouse gas emissions, such as by replacing the use of fossil fuels (in buildings, vehicles, industry, and electric power generation) with clean and renewable technologies.

⁴ Bailey, Stephanie, Jane Berner, David Erne, Noemí Gallardo, Quentin Gee, Akruiti Gupta, Heidi Javanbakht, Hilary Poore, John Reid, and Kristen Widdifield. 2023. [Final 2022 Integrated Energy Policy Report Update](https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report-iepr/2022-integrated-energy-policy-report). California Energy Commission. Publication Number: CEC-100-2022-01-CMF, <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report-iepr/2022-integrated-energy-policy-report>.

⁵ Kenney, Michael, Jacob Wahlgren, Kristina Dulonglo, Tiffany Mateo, Danuta Drozdowicz, and Stephanie Bailey. 2022. [Final 2021 Integrated Energy Policy Report, Volume I: Building Decarbonization](https://www.energy.ca.gov/publications/2021/2021-integrated-energy-policy-report). California Energy Commission. Publication Number: CEC-100-2021-001-V1, <https://www.energy.ca.gov/publications/2021/2021-integrated-energy-policy-report>.

million heat pumps by 2030 in July 2022.⁶ Further, in September 2022, Governor Newsom signed Assembly Bill 209 (Committee on Budget, Chapter 251, Statutes of 2022), which directed the CEC to develop and implement an Equitable Building Decarbonization (EBD) Program with the primary goals to reduce greenhouse gas (GHG) emissions from existing residential buildings and advance energy equity. CEC is also directed in statute to encourage resiliency to extreme heat, indoor air quality improvements, energy affordability, grid reliability, and local workforce opportunities for the direct install program.

The EBD Program has two primary statewide components –direct install and incentive. The direct install includes Statewide Direct Install and Tribal Direct Install subprograms while the incentive program is being implemented through the GoGreen program. The guidelines for Tribal Direct Install program was approved in January 2026⁷. While the resulting findings can be used for both programs, the scenarios are based on the requirements of the Statewide Direct Install program.

To support implementation of the EBD Statewide Direct Install Program and understand potential for participants’ bill impacts, CEC modeled potential bill impacts from energy retrofits for income-qualified ratepayers on discounted rates. This analysis modeled the three eligible home types (single-family, multifamily, and manufactured) across multiple vintages and all California climate zones. Future iterations will utilize interval meter data from EBD Statewide Direct Install retrofitted homes to improve the analysis and inform program direction or changes.

Statewide Direct Install Program

The CEC adopted guidelines for the EBD Statewide Direct Install Program in October 2023, following extensive public input and engagement.⁸ In November 2024, the CEC approved grant agreements with three regional administrators to implement the program in Northern, Central, and Southern California, respectively.⁹ The regional administrators are the Association for Energy Affordability in Northern California, the Center for Sustainable Energy in Central California, and the County of Los Angeles in Southern California. Regional administrators are required to partner with community-based organizations for culturally appropriate outreach, education, and support for participating households and communities. The program is expected to begin retrofitting homes in February 2026.

⁶ [Letter From Governor Newsom to Chair Liane Randolph](https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf), California Air Resources Board. July 22, 2022, <https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf>.

⁷ Steele, Monica, Katie Webster, and Diana Maneta. 2026. [Equitable Building Decarbonization Tribal Direct Install Program Guidelines](https://www.energy.ca.gov/publications/2025/equitable-building-decarbonization-tribal-direct-install-program-guidelines). California Energy Commission. Publication Number: CEC-300-2025-001. <https://www.energy.ca.gov/publications/2025/equitable-building-decarbonization-tribal-direct-install-program-guidelines>

⁸ Maneta, Diana. 2023. [Equitable Building Decarbonization Direct Install Program Guidelines](https://www.energy.ca.gov/publications/2023/equitable-building-decarbonization-direct-install-program-guidelines). California Energy Commission. Publication Number: CEC-400-2023-003-CMF, <https://www.energy.ca.gov/publications/2023/equitable-building-decarbonization-direct-install-program-guidelines>.

⁹ [“Grant Funding Opportunity 23-404 — Equitable Building Decarbonization Program Direct Install,”](https://www.energy.ca.gov/solicitations/2024-04/gfo-23-404-equitable-building-decarbonization-program-direct-install) <https://www.energy.ca.gov/solicitations/2024-04/gfo-23-404-equitable-building-decarbonization-program-direct-install>.

The Statewide Direct Install Program will provide decarbonization retrofits to low-income households in underresourced communities at no cost to the building owner or occupant. Single-family homes, multifamily buildings, and manufactured homes are eligible to participate.

All building retrofits conducted by the EBD Direct Install Program will, at a minimum, include the following elements:

- Replace existing gas-fired heating equipment with a heat pump for space heating and cooling or replace an existing gas-fired water heater with a heat pump water heater (HPWH).
 - At the conclusion of the retrofit, at least two of the following four end uses in the building must be electric: space heating, water heating, cooking, and clothes drying. Full building electrification is encouraged but not required.

The full list of measures that are eligible to be installed through the program is below. The program guidelines¹⁰ provide more details about the eligible measures, including efficiency requirements.

- Heat pump for space heating and cooling
- Duct testing, sealing, or new ducts, returns, and registers or a combination
- Smart thermostat
- Ceiling fan or whole-house fan
- Air sealing
- Insulation
- Solar window film
- HPWH, unitary or central
- Low-flow showerheads and faucets
- Induction range or cooktop
- Electric clothes dryer, heat pump or electric resistance
- Light-emitting diode (LED) bulbs and fixtures
- Air filtration
- Electric wiring and panel upsizing
- Automatic circuit sharing devices
- Remediation and safety measures

Not all eligible measures will be installed in every participating home. Specific measures to be installed in each home will be determined based on factors such as the building type and

¹⁰ Maneta, *op. cit.*, pp. 14-17.

condition, climate zone, expected energy savings and bill impacts, and homeowner/occupant preferences.

All work funded by the program requires a California contractors' license (as applicable) and must comply with applicable permitting, standards, and manufacturers' installation requirements and instructions.

CHAPTER 2:

Method

This chapter describes the method, assumptions, and calculations used for this bill impact analysis.

Existing Home Prototypes

The bill impact analysis uses California Building Energy Code Compliance software (CBECC) to model the hourly energy use of existing buildings¹¹ for a calendar year and model home prototypes that represent different vintage categories. Table 1 below lists the home prototypes, floor area, and number of bedrooms modeled in this analysis. Table 2 shows the vintage categories and the prototype models that were built in each category. The single-family and multifamily existing building baseline prototype assumptions were developed by NORESKO¹² using data from the 2019 Residential Appliance Saturation Study¹³ (RASS), ResStock¹⁴ — modeling of the U.S. housing stock — hosted by the National Renewable Energy Laboratory (NREL) and the U.S. Census Bureau. For manufactured homes, the baselines were based off the U.S. Department of Housing and Urban Development (HUD) standards¹⁵.

In CBECC, conditioned floor area and number of bedrooms are large factors in determining space-conditioning and water-heating energy demand in single-family, multifamily, and manufactured homes. Home types are defined as:

- Single-family is a residential building with two or less dwelling units, including townhouses.
- Multifamily is a residential building with three or more dwelling units, excluding townhouses.
- Manufactured home is a home completely constructed in a factory and delivered to the site.

¹¹ CBECC-Res 2022.3.0 was used for the single-family and manufactured home prototypes. CBECC 2022.3.0 was used for the multifamily prototypes.

¹² NORESKO is a consulting company for energy services and is part of the technical advisory group for the CEC.

¹³ California Energy Commission. "[2019 Residential Appliance Saturation Study webpage](https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study)," <https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study>.

¹⁴ National Renewable Energy Laboratory. "[ResStock webpage](https://resstock.nrel.gov/)," <https://resstock.nrel.gov/>.

¹⁵ [HUD Standards, 24 CFR Part 3280](https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280), <https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280>.

Table 1: Existing Building Prototypes

Residential Type	Floor Area (sqft)	Number of Stories	Number of Bedrooms
Single-Family	1,250	1	2
Single-Family	1,750	1	3
Single-Family	2,250	2	4
Low-Rise Multifamily	6,960	2	8 units (four 2-bedroom; four 1-bedroom)
Mid-Rise Multifamily	95,028	6	88 units (128 bedrooms; studio, 1, 2, & 3 bedroom units)
Single-Wide Manufactured Home	910	1	2
Double-Wide Manufactured Home	1,512	1	3

Source: California Energy Commission staff

Table 2: Existing Building Prototype Vintage Categories

Vintage Category	Applicable Prototypes
Pre-1975	Single-family; low-rise multifamily; mid-rise multifamily
1975–1983	Single-family; low-rise multifamily; mid-rise multifamily
1984–2005	Single-family; low-rise multifamily; mid-rise multifamily
Pre-1976	Single-wide manufactured home; double-wide manufactured home
1976–1993	Single-wide manufactured home; double-wide manufactured home
1994–present	Single-wide manufactured home; double-wide manufactured home

Source: California Energy Commission staff

Home vintage category determines the baseline modeling assumptions for building envelope and mechanical systems. The vintage categories are different for single-family and multifamily homes versus manufactured homes because manufactured homes are not subject to California’s Title 24, Part 6 Energy Code (Energy Code).¹⁶ Manufactured homes are subject to U.S. Department of Housing and Urban Development (HUD) standards, which have a different

¹⁶ California Energy Commission. “[Building Energy Efficiency Standards](https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards),” <https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards>.

schedule for energy efficiency standards.¹⁷ The home vintage category determines the baseline modeling assumptions for building envelope and mechanical system.

Baseline Existing Home Prototypes

The baseline home prototypes models have a gas-fired 50-gallon water heater, gas-fired furnace and electric air conditioner, gas cooking, and gas clothes drying. In these models, the fuel type used is pipeline gas and does not include other fossil fuels such as propane. The baseline home prototypes for the envelope, mechanical system, and water heating, are based on the NORESKO¹⁸ prototype assumptions, which are meant to represent the typical home for each building type and vintage in California.

The mechanical system efficiency is consistent for all vintage categories with the assumption that the water heater and heating, ventilation, and air conditioning (HVAC) system were replaced within the last 15 years with efficiencies that met Energy Code requirements at that time. For example, for a home built in 1985, it is assumed the water heater was replaced in 2000, with an efficiency of 0.58 energy factor¹⁹. A 0.58 energy factor was the standard efficiency for a gas water heater in 2000.

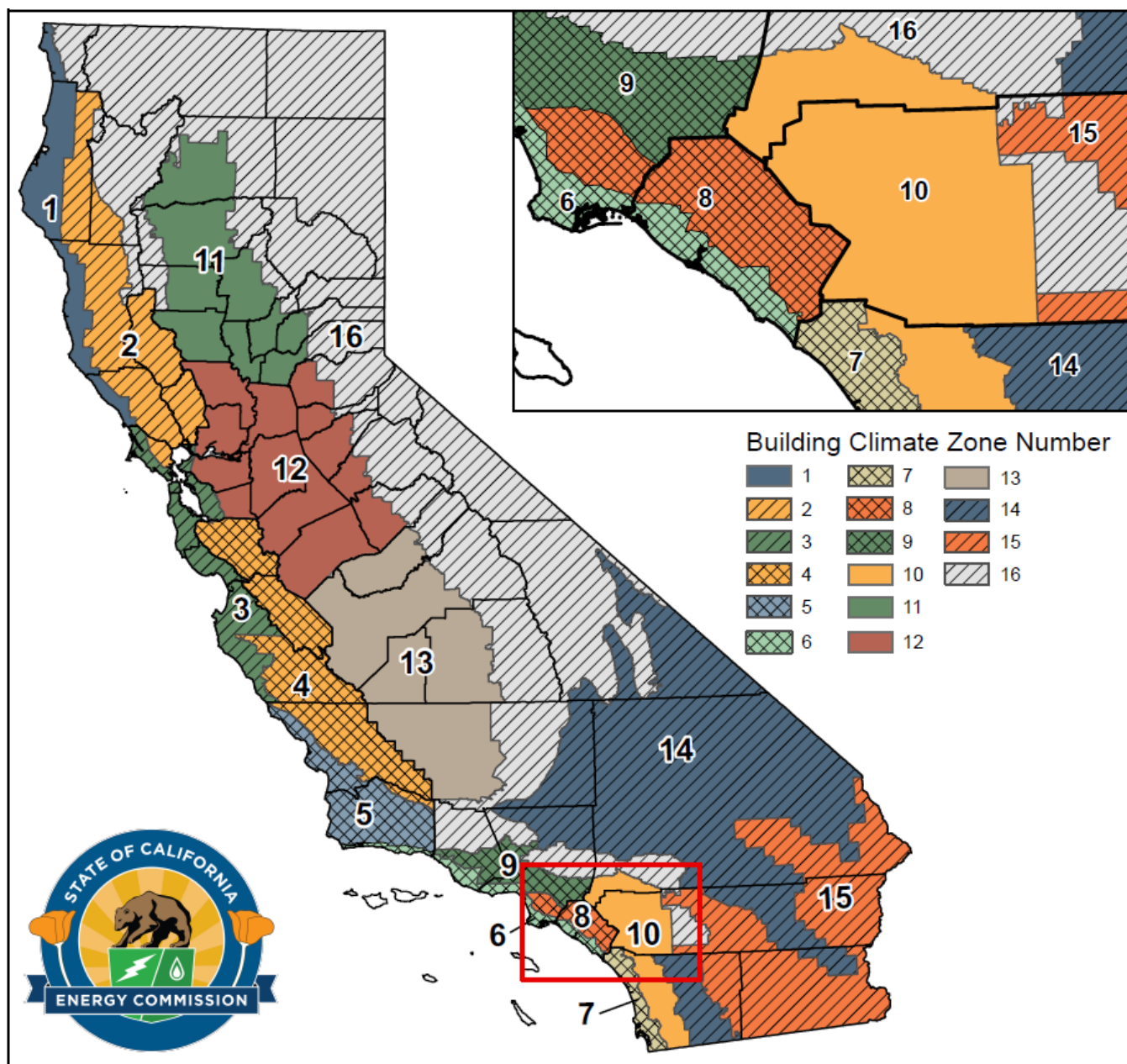
The assumptions of home envelopes are based on RASS data, historical code requirements, and common home construction practices at the time. Generally, homes built before 1975 have less insulation and less efficient windows. CBECC includes weather assumptions, which determines the heating and cooling load of the HVAC system, with different climate zones having different heating and cooling load demands. This analysis applied the 16 climate zones in California, according to the California Energy Code. For this analysis, CEC staff created baseline models in the applicable home type and vintage category prototypes and ran an energy analysis on them in all 16 climate zones. Figure 1 shows the California building climate zones. This led to hundreds of baseline prototypes and sets of baseline hourly results.

¹⁷ 24 CFR Part 3280.

¹⁸ NORESKO is an energy consulting company.

¹⁹ The energy factor (EF) of a water heater is a metric that measures the overall efficiency of the water heater, defined as the ratio of useful hot water produced to the total energy consumed.

Figure 1: Building Climate Zones



Source: California Energy Commission

Values shown in Table 3 and Table 4 demonstrate CBECC modeling assumption values that are different in the baseline versus the retrofit models. The list below describes the modeling assumptions. The single-family and multifamily existing building baseline prototype assumptions were developed by NORESO using data from RASS, Restock, and the U.S. Census Bureau. For manufactured homes, the baselines were based off the federal HUD standards. These sources were chosen as they are publicly available and are meant to represent a typical Californian home for each vintage and building type. All assumptions across building types are the same, unless stated otherwise.

- Attic/floor insulation — Attic and floor insulation are represented by an “R-value,” which is the resistance to heat flow. Higher R-values represent stronger insulation and better efficiency. Floor insulation is not modeled for single- and multifamily homes because most homes are built on concrete slab-on-grade. In contrast, most manufactured homes have raised floors. Therefore, the manufactured homes are modeled with raised floors and include floor insulation in the modeled retrofits.
- Air/envelope seal — The envelope tightness, or openness to the outside, is represented by an air changes per hour (ACH) value. In this case, it is the number of times all the volume of air in the homes escapes to the outside under 50 pascals of air pressure (50 pascals is roughly equivalent to the pressure generated by a 20 mile per hour wind). A lower ACH value represents a tighter home with a stronger envelope seal and fewer air gaps.
- Duct leakage — For a central heating and air-conditioning (HVAC) system, conditioned air travels through ducts into living spaces. Duct leakage occurs through gaps, cracks, and seams of the ducts and lost into the attic. A higher duct leakage of 15 percent was modeled to represent less efficient existing ducts based on CBECC defaults.
- Window U-factor – The window U-Factor represents how well the window insulates. Windows with a lower U-Factor are more insulative and are better at maintaining internal temperatures.
- Window solar heat gain coefficient (SHGC) — The solar heat gain coefficient represents how well a window blocks heat from the sun. Windows with a lower SHGC allows less heat from the sun to enter the home.
- Furnace annual fuel utilization efficiency (AFUE) — The annual fuel utilization efficiency rates the efficiency of a gas-fired furnace. It is represented as a fraction or percentage. A higher AFUE represents a furnace that is more efficient at heating.
- Air conditioner seasonal energy efficiency ratio (SEER) — The seasonal energy efficiency ratio, or rating, is a measure of the energy-efficiency of an air-conditioning system. The higher the rating, the more efficient the system. Based on RASS data, single-family, multifamily, and manufactured home baseline prototypes in Climate Zones 1 and 5 do not have an existing air conditioner for all vintage categories. In Climate Zone 3, pre-1975 vintage category homes do not have an existing air conditioner. Therefore, air conditioning energy is not modeled in the baseline, but it is modeled in the retrofit.
- Water heater energy factor (EF) — The energy factor is a measure of energy efficiency, with higher values for higher efficiency.

Table 3: Baseline Prototype CBECC Model Assumptions – Single-Family and Multifamily

Vintage Category	Attic Insulation	Envelope Seal (ACH50)	Duct Leakage	Window U-Factor	Window SHGC	Furnace AFUE	AC SEER*	Water Heater EF
Pre-1975	R-17	16	15%	0.78	0.70	0.78	13.0	0.58
1975-1983	R-19	13	15%	0.82	0.70	0.78	13.0	0.58
1984-2005	R-27	8	15%	0.74	0.67	0.78	13.0	0.58

Source: California Energy Commission staff

*There is no existing air conditioner modeled in Climate Zones 1 and 5. There is no existing air conditioner modeled for pre-1975 prototypes in Climate Zone 3.

Table 4: Baseline Prototype CBECC Model Assumptions – Manufactured Home

Vintage Category	Attic Insulation	Floor Insulation	Envelope Seal (ACH50)	Duct Leakage	Window U-Factor	Window SHGC	Furnace AFUE	AC SEER	Water Heater EF
Pre-1976	R-7	R-0	16	15%	1.19	0.83	0.78	13.0	0.58
1976-1994	R-11	R-7	13	15%	1.19	0.83	0.78	13.0	0.58
Post-1994	R-19 single wide R-22 double wide	R-19	11.5	15%	0.71	0.73	0.78	13.0	0.58

Source: California Energy Commission staff

Retrofit Existing Home Prototypes

This analysis includes retrofit measures that are eligible measures in the EBD Direct Install Program but does not include all the eligible measures. Those that are included were because they could be modeled in CBECC while others could not. Assumptions are applicable to all eligible housing types unless otherwise noted.

- Heat pump water heater — A Northwest Energy Efficiency Alliance²⁰ (NEEA) Tier 3-rated tank HPWH is modeled to replace the tank gas-fired water heater. EBD Direct Install

²⁰ "NEEA's Water Heating Specification," <https://neea.org/our-work/advanced-water-heating-specification>.

requires NEEA Tier 3 for 240-volt (V) HPWH and NEEA Tier 2 for 120V HPWH. Staff modeled minimally compliant HPWHs as required by the EBD Direct Install Program Guidelines²¹; however, more efficient HPWHs are available on the marketplace.

- Heat pump HVAC, with duct sealing — A HP HVAC unit is modeled to replace the gas-fired furnace and existing air conditioner. Instead of an AFUE rating, HP HVAC units have a heating seasonal performance factor (HSPF). The higher the factor, or rating, the more efficient the heat pump. HP HVAC units with two levels of efficiency were modeled separately in the single-family and manufactured home retrofits. The standard unit meets the 2022 Energy Code minimal efficiency requirements with an HSPF of 8.8 and SEER of 15.0.²² The higher-efficiency unit has an HSPF of 10.0 and a SEER of 16.0, which meets the EBD requirements for air-source heat pumps. Retrofits with an HP HVAC also have duct sealing, as duct sealing and testing are required with HVAC retrofits per the 2022 Energy Code²³. Duct leakage is reduced from 15 percent to 10 percent in the retrofit prototypes.
- Electric cooking — In CBECC, cooking is a binary input as either gas or electric. The baseline models have gas cooking and the retrofit models have electric resistance cooking. While EBD Statewide Direct Install requires induction cooking, CBECC can model only electric resistance at this time. Induction cooking is more efficient than electric resistance²⁴. The electric cooking assumptions are therefore conservative estimates when compared to induction cooking.
- Electric clothes drying — Similar to cooking, in CBECC, clothes drying is a binary input as either gas or electric. The baseline models have gas clothes drying. The retrofit models have electric resistance clothes drying. CBECC can model only electric resistance clothes drying. Similar to cooking, heat pump clothes drying is more efficient than electric resistance²⁵. The electric clothes drying assumptions are conservative estimates when compared to heat pump drying.
- Attic/floor insulation — Attic insulation is included only in single-family and double-wide manufactured home retrofits. Because of the modeled design of the roof and accessibility of the attic, attic insulation is not included in multifamily or single-wide manufactured home retrofits.

²¹ [EBD Direct Install Program Guidelines](https://www.energy.ca.gov/publications/2023/equitable-building-decarbonization-direct-install-program-guidelines), <https://www.energy.ca.gov/publications/2023/equitable-building-decarbonization-direct-install-program-guidelines>

²² Title 24, Part 6 Section 110.2(a).

²³ Title 24, Part 6 Section 150.2(b)1E.

²⁴ Bui, Vivien. 2023. [Making the Switch to Induction Stoves or Cooktops](https://www.energy.gov/articles/making-switch-induction-stoves-or-cooktops). Department of Energy. <https://www.energy.gov/articles/making-switch-induction-stoves-or-cooktops>

²⁵ Energy Star. [Heat Pump Dryer](https://www.energystar.gov/products/clothes_dryers/heat-pump-dryer). https://www.energystar.gov/products/clothes_dryers/heat-pump-dryer

Floor insulation is included only in the manufactured home retrofits. The manufactured home prototypes are modeled with a raised floor and would practically have accessibility for installing floor insulation. The single-family and multifamily prototypes are modeled on concrete-slab foundation. The insulation assumptions are based on conservative industry practices.

- Air/envelope sealing — Air/envelope sealing reduces the ACH value. Data shared by Lawrence Berkeley National Laboratory (LBNL) showed that homes with air sealing applied as a retrofit measure had an ACH value reduction of about 30 percent²⁶. This reduction was applied to the baseline models. The air/envelope sealing assumptions are industry standard values for single- and multi-family homes, following the NORESKO prototype models. For manufactured homes, a lower limit of 8 ACH is assumed.
- Solar window films —Solar window films reduce the heat gain from sunlight. Retrofits with solar window films affect the overall window assembly and results in lower SHGC values and U-Factors than in the baseline. The solar window films assumptions are moderate efficiency values.

When comparing the modeling assumptions for the retrofit home prototypes versus the baseline home prototypes, the retrofit home prototype assumptions represent a more efficient home mechanical system and envelope.

The retrofit home prototypes modeled to have an HP HVAC provide space cooling, including in the climate zones and prototypes that do not have existing air conditioning in the baseline.

Table 5: Retrofit Prototype CBECC Model Assumptions — Single-Family and Multifamily

Vintage Category	Attic Insulation*	Envelope Seal (ACH50)	Duct Leakage**	Window U-Factor	Window SHGC	HP HSPF	AC SEER	Water Heater
Pre-1975	R-38	11.2	10%	0.50	0.35	8.8 10.0	15.0 16.0	NEEA Tier 3
1975-1983	R-38	9.1	10%	0.50	0.35	8.8 10.0	15.0 16.0	NEEA Tier 3
1984-2005	R-38	5.6	10%	0.50	0.35	8.8 10.0	15.0 16.0	NEEA Tier 3

Source: California Energy Commission

²⁶ Less, Brennan D., Iain S. Walker, Nuria Casquero-Modrego, Leo I. Rainer. 2021. *The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes*, https://eta-publications.lbl.gov/sites/default/files/final_walker_-_the_cost_of_decarbonization_and_energy.pdf

*Attic insulation is only applied to single-family prototypes.

**In multifamily prototypes, duct leakage is 0%, as ducts are modeled in conditioned space.

Table 6: Retrofit Prototype CBECC Model Assumptions — Manufactured Home

Vintage Category	Attic Insulation*	Floor Insulation	Envelope Seal (ACH50)	Duct Leakage	Furnace AFUE	AC SEER	Water Heater
Pre-1976	R-30	R-19	11.2	10%	8.8 10.0	15.0 16.0	NEEA Tier 3
1976-1994	R-30	R-19	9.1	10%	8.8 10.0	15.0 16.0	NEEA Tier 3
Post-1994	R-30	R-19	8	10%	8.8 10.0	15.0 16.0	NEEA Tier 3

Source: California Energy Commission staff

*Attic insulation is only applied to the double-wide manufactured home prototypes.

Energy Utility Rates

To estimate energy bill cost to the resident after an EBD Direct Install energy retrofit, staff applied electricity and gas residential rates with low-income discounts applied, from six of the state’s largest utilities to the CBECC hourly energy outputs. The goal was to estimate the total energy bill as accurately as possible and is a combination of the gas bill and electric bill with monthly minimum or fixed costs. Table 7 lists the rates included in this analysis, by utility.

Time-of-use (TOU) and electrification-friendly rates vary during “peak” periods, typically summer afternoons, evenings, or both. Because the rate varies by the time of day, it is important to track when energy is consumed, not just how much. Thus, hourly energy usage is used in this analysis. In contrast, tiered rates are based on total monthly energy use, regardless of the time of day.

Table 7: Utility Rates Included in This Analysis (Low-Income Discounts Applied)

Utility	Gas Rate	Tiered Rate	TOU Rate	Electrification-Friendly Rate
Pacific Gas & Electric (PG&E)	G-1	E1	TOU-C	E-ELEC
Southern California Gas Company (SoCalGas)	GR	NA	NA	NA
Southern California Edison (SCE)	NA	D	TOU 4-9	Prime
San Diego Gas & Electric (SDG&E)	GR	DR	DR1	TOU-ELEC
Los Angeles Department of Water and Power (LADWP)	NA	R-1A	NA	NA
Sacramento Municipal Utility District (SMUD)	NA	R (fixed rate)	TOD	NA

Source: California Energy Commission staff

This analysis uses gas and electricity rates that represent a year of rate data. Staff sourced the rate data from utility tariffs between January 2024 and December 2024. (See Appendix A for the rates used in this analysis.) The baseline prototypes do not have electrification-friendly rates applied, as they are assumed to use gas for space and water heating. To qualify for an electrification-friendly rate, the customer must have either an HPWH, HP HVAC, battery storage, or an electric vehicle charger installed. Energy and bill impacts from solar PV and electric vehicles are outside the scope of this analysis.

CEC staff applied an electrification-friendly rate to the retrofit prototypes of an HPWH or HP HVAC and to the scenarios that include said equipment. This rate is applied to all energy use of the home, not just the added electricity use of the new measure. Electrification-friendly rates have a lower volumetric rate than TOU and tiered rates for most hours of the year. And though electrification-friendly rates have a higher monthly fixed charge, for homes that use more electricity, there are often savings just by switching to an electrification-friendly rate.

Because of the income eligibility requirement of the EBD Statewide Direct Install Program,²⁷ staff used low-income or California Alternative Rates for Energy²⁸ (CARE) rates to calculate the energy bill. For investor-owned utility (IOU) customers, those who qualify for CARE receive a 20 percent discount on their gas bill and a 30–35 percent discount on their electricity bill.

²⁷ The maximum household income for the EBD Direct Install Program is 80 percent of the area median income (AMI), whereas the maximum household income for CARE rates is 200 percent of the federal poverty limit (FPL), which is lower than 80 percent AMI in many parts of California. Therefore, not all households served by the EBD Direct Install Program will be eligible for CARE rates.

²⁸ “CPUC’s California Alternative Rates for Energy,” <https://www.cpuc.ca.gov/consumer-support/financial-assistance-savings-and-discounts/california-alternate-rates-for-energy>.

For public owned utilities (POU) customers in LADWP and SMUD territories, qualified low-income customers receive a fixed discount on their monthly electricity bill. LADWP's EZ-Save Program²⁹ offers a subsidy of \$16.34 every two months, while SMUD's Energy Assistance Program Rate³⁰ (EAPR) offers different amounts of discounts depending on the customer's income level, varying from \$10 to \$105 per month. In this analysis, staff used the smallest discount offered to SMUD low-income customers. For additional information, see Appendix A.

Rate Baseline Allowance

Utility rates not only vary by season and time of day, but customers can also be charged a higher rate depending on how much energy they use above an established baseline, or tier, during a billing period. In this bill impact analysis for qualified customers on CARE or FERA rates, staff used each calendar month as a separate billing period. Baseline usage limits are set by each utility and can vary by climate region within the utility territory and by season. Both gas and electricity usage are subject to baseline allowances, set as a therm amount per month and a kilowatt-hour (kWh) per month usage limit. If a customer exceeds this energy usage limit in a month, all the energy usage above the baseline usage is charged at a higher rate. In contrast, some rate structures – such as SMUD rates and IOU electrification-friendly rates – remain constant regardless of monthly usage. These are flat (non-tiered) rates.

Typically, baseline allowances are related to the energy needs of the local climate. For example, the gas baseline allowance in the winter in a cold mountain climate is higher than in a mild coastal climate. A customer in a mountain climate would need more heating and, therefore, more gas in the winter than a customer in a coastal climate. Likewise, the electricity baseline allowance in the summer in the hot Central Valley is higher than in a mild coastal climate. A customer in the Central Valley would need more cooling and, therefore, more electricity in the summer than a customer in a coastal climate.

The electric IOUs have two baseline allowances for customers, one for all-electric and one for gas and electricity (mixed fuel). To qualify for an all-electric baseline, the customer must have either an HPWH or an HP HVAC. Since the EBD Direct Install Program requires the installation of either an HPWH or an HP HVAC, in this analysis the retrofit energy outputs are subject to the all-electric baseline allowances and associated rate charges. On the other hand, the baseline prototype energy outputs are subject to the basic (not the all-electric) baseline allowance since they have neither an HPWH nor an HP HVAC.

Similarly to the rates, this analysis uses baseline allowances updated as of December 2024, sourced from utility tariffs or websites. The calculation of the energy bill includes accounting for baseline allowances and any higher rate charges for above-baseline usage. The baseline energy usage thresholds used in this analysis are in Appendix A.

²⁹ "LADWP's EZ-Save Program," <https://www.ladwp.com/account/customer-service/electric-rates/residential-rates#ez-save>.

³⁰ "SMUD's Income-Eligible Assistance," <https://www.smud.org/en/Rate-Information/Low-income-and-nonprofits>.

Energy Bill Calculation

CEC staff calculated the energy bill per meter. In this analysis, staff assumed there is one electricity meter and one gas meter per single-family home, per multifamily unit, and per manufactured home. Staff estimated the resident energy bill by applying hourly rates to the CBECC hourly energy outputs. There are several elements to calculating the total energy bill estimate. The energy bill calculation for gas requires monthly therm usage and includes minimum or fixed charges. The calculation also accounts for any higher rate charges for above-baseline usage. Similarly, for a tiered electricity rate, the energy bill calculation for electricity requires monthly kWh usage, includes fixed charges, and accounts for any higher rate charges for above-baseline usage.

For a time-of-use rate, the calculation requires hourly kWh usage, includes minimum or fixed charges, and accounts for higher rate charges for above-baseline usage. To calculate the monthly energy bill, staff gathered information from utility rate tariffs to determine the energy minimum or fixed charges, dollar per unit of energy charges, baseline allowances, and the applicable low-income discounts.

Monthly Gas Bill

In each gas bill, there is a minimum transportation charge, usually a dollar amount per meter per day.

$$\text{Minimum Charge}_{gas} = \frac{\$minimum\ charge}{day} \times no.\ days\ in\ billing\ period$$

A minimum charge is included only if the volumetric charge is less than the minimum charge. Low-income or CARE discounts were applied, when applicable.

As described earlier in this report, the volumetric charge depends on the total therms used in the billing period, i.e., each month in this analysis. For volumetric gas use, staff charged the therms below the baseline allowance at the basic rate and charged therms above the baseline allowance at the excess rate. Staff determined the baseline allowance by season and location. In this analysis, staff had to cross-reference the utility, month of the year, and climate zone or region to determine the appropriate baseline allowance to apply.

If usage is below the baseline allowance:

$$\text{Volumetric Charge}_{gas} = \text{Monthly Therms} \times \frac{\$basic\ charge}{therm}$$

If usage is above the baseline allowance:

$$\text{Volumetric Charge}_{gas} = \left[(\text{Monthly Therms} - \text{Baseline Allowance}) \times \frac{\$excess\ charge}{therm} \right] + (\text{Baseline Allowance} \times \frac{\$basic\ charge}{therm})$$

Low-income or CARE customers receive a 20 percent discount on their total gas bill. Staff calculated this by subtracting 20 percent of the total gas bill.

$$Total\ Bill_{gas} = (1 - 0.20) \times (Minimum\ Charge + Volumetric\ Charge)$$

Staff calculated the total gas bill for each month of the year and summed all the months to calculate the annual gas bill.

$$Annual\ Bill_{gas} = \sum_{i=1}^{12} Total\ Bill_{gas,i}, \text{ where } i \text{ is the month of the year}$$

Monthly Electricity Bill

The calculation for the monthly electric bill differs depending on which type of rate the customer is on. In this analysis, there are three types of rates included: tiered rates, default time-of-use rates, and electrification-friendly rates. Low-income or CARE discounts were applied, when applicable. The calculation for each is described in this subsection.

Tiered Rates

The electric bill for tiered rates is calculated similarly to the gas bill. There can be a minimum charge or a fixed charge. Fixed charges are included regardless of the volumetric charge.

If the fixed charge is per day:

$$Fixed\ Charge_{elec} = \frac{\$fixed\ charge}{day} \times \text{no. days in billing period}$$

If the fixed charge is per month:

$$Fixed\ Charge_{elec} = \frac{\$fixed\ charge}{month}$$

A minimum charge is included only if the volumetric charge is less than the minimum charge. Usually, the volumetric charge exceeds the minimum charge.

If the minimum charge is per day:

$$Minimum\ Charge_{elec} = \frac{\$minimum\ charge}{day} \times \text{no. days in billing period}$$

If the minimum charge is per month:

$$Minimum\ Charge_{elec} = \frac{\$minimum\ charge}{month}$$

In the electric bill for tiered rates, the volumetric charge depends on the total kWh used in the billing period. For volumetric electricity use, staff charged the kWh below the baseline allowance at the Tier 1 usage rate. Staff charged electricity usage above the baseline allowance at the Tier 2 usage rate. Some utilities may charge a high usage rate, which

happens if the customer uses 400 percent of the baseline allowance, or a high usage threshold. In this case, staff charged the kWh in high usage at the high usage rate.

Again, like for gas, staff determined the electricity baseline allowance by season and location. It is also different for basic versus all-electric usage. In this analysis, staff had to cross-reference the utility, month of the year, and climate zone or region to determine the appropriate baseline allowance to apply. Staff applied the basic baseline allowance to the baseline prototype outputs and the all-electric baseline allowance to the retrofit prototype outputs.

If usage is below baseline allowance:

$$Volumetric\ Charge_{elec} = Monthly\ kWh \times \frac{\$Tier\ 1\ rate}{kWh}$$

If usage is above baseline allowance:

$$Volumetric\ Charge_{elec} = \left[(Monthly\ kWh - Baseline\ Allowance) \times \frac{\$Tier\ 2\ rate}{kWh} \right] + (Baseline\ Allowance \times \frac{\$Tier\ 1\ rate}{kWh})$$

If utility charges for high usage and usage is high usage:

$$Volumetric\ Charge_{elec} = \left[(Monthly\ kWh - High\ Usage\ Threshold) \times \frac{\$high\ usage\ rate}{kWh} \right] + \left[(High\ Usage\ Threshold - Baseline\ Allowance) \times \frac{\$Tier\ 2\ rate}{kWh} \right] + (Baseline\ Allowance \times \frac{\$Tier\ 1\ rate}{kWh})$$

For electricity, IOU customers with a CARE discount receive a 50 percent discount on minimum and fixed charges and a 30–35 percent discount on volumetric charges. For simplicity, in the equation here, the volumetric CARE discount will be represented by 30 percent. Alternatively, for LADWP and SMUD who offer a dollar amount subsidy, the analysis considered a discount of \$8.17 per month for LADWP and \$10 per month for SMUD on their fixed charge.

$$\begin{aligned} Total\ Bill_{IOU,elec} &= (0.50 \times Fixed\ Charge) \\ &+ The\ Maximum\ of: [(1 - 0.30) \times Volumetric\ Charge] OR (0.50 \\ &\times Minimum\ Charge) \end{aligned}$$

$$\begin{aligned} Total\ Bill_{POU,elec} &= Fixed\ Charge - Subsidy \\ &+ The\ Maximum\ of: Volumetric\ Charge OR Minimum\ Charge \end{aligned}$$

Mirroring the annual gas bill calculation, staff calculated the total electricity bill for each month of the year and summed all the months to calculate the annual electricity bill.

$$Annual\ Bill_{elec} = \sum_{i=1}^{12} Total\ Bill_{elec,i}, \text{ where } i \text{ is the month of the year}$$

Default TOU Rates

The electricity bill calculation for customers on default TOU rates is similar to the calculation for customers on a tiered rate. The fixed and minimum charges are applied the same, as are the low-income or CARE discounts.

If the fixed charge is per day:

$$Fixed\ Charge_{elec} = \frac{\$fixed\ charge}{day} \times no.\ days\ in\ billing\ period$$

If the fixed charge is per month:

$$Fixed\ Charge_{elec} = \frac{\$fixed\ charge}{month}$$

If the minimum charge is per day:

$$Minimum\ Charge_{elec} = \frac{\$minimum\ charge}{day} \times no.\ days\ in\ billing\ period$$

If the minimum charge is per month:

$$Minimum\ Charge_{elec} = \frac{\$minimum\ charge}{month}$$

The volumetric charge for TOU rates is calculated differently and needs to track monthly usage against the baseline allowance, as well as the time of day, type of day, and season. These are all factors in determining which rate to apply for each hour of the year. For below-baseline allowance, the customer receives a baseline credit on the applicable TOU rate. When usage in a billing period exceeds the baseline allowance, the customer does not receive a baseline credit and is charged the full TOU rate for each hour in the billing period after the baseline allowance was passed. At the beginning of each billing period, the monthly usage is reset and compared against the applicable baseline allowance. For this calculation, staff cross-referenced the utility, month, day, and time to determine which baseline allowance threshold to apply and which hourly rate to charge for each hour of the year.

If usage for the month is below baseline allowance:

$$Volumetric\ Charge_{elec} = \sum_{i=1} \left[kWh_i \times (TOU\ rate_i - Baseline\ Credit) \frac{\$}{kWh} \right],$$

where i is the hour of the month

If usage for the month is above-baseline allowance:

$$\text{Charge}_{\text{elec}} = \sum_{i=1}^k \left[\text{kWh}_i \times (\text{TOU rate}_i - \text{Baseline Credit}) \frac{\$}{\text{kWh}} \right] + \sum_{i=k} \left(\text{kWh}_k \times \text{TOU rate}_k \frac{\$}{\text{kWh}} \right),$$

where i is the hour of the mos and

k is the hour when the monthly usage exceeds baseline allowance

The volumetric CARE discount will be represented by 30 percent and the POU low-income customers received a dollar amount subsidy as stated above..

$$\begin{aligned} \text{Total Bill}_{\text{IOU,elec}} &= (0.50 \times \text{Fixed Charge}) \\ &+ \text{The Maximum of: } [(1 - 0.30) \times \text{Volumetric Charge}] \text{ OR } (0.50 \\ &\times \text{Minimum Charge}) \end{aligned}$$

$$\begin{aligned} \text{Total Bill}_{\text{POU,elec}} &= \text{Fixed Charge} - \text{Subsidy} \\ &+ \text{The Maximum of: Volumetric Charge OR Minimum Charge} \end{aligned}$$

The annual electric bill calculation for default TOU rates is also consistent with the annual electric bill calculation for tiered rates. Staff calculated the total electricity bill for each month of the year and summed all the months to calculate the annual electricity bill.

$$\text{Annual Bill}_{\text{elec}} = \sum_{i=1}^{12} \text{Total Bill}_{\text{elec},i}, \text{ where } i \text{ is the month of the year}$$

Electrification-Friendly Rates

The calculation of the monthly electric bill for a customer on an electrification-friendly rate is similar to the calculation of the monthly electric bill for a customer on a default TOU rate, since electrification-friendly rates also vary by time of use. The main difference is that electrification-friendly rates are not subject to baseline allowances and there is no minimum charge, though there is a fixed charge. The absence of these factors makes the calculation simpler. This is true for the POU time-of-use rates, so the bill for customers on these rates is calculated like the IOU electrification-friendly rates.

If the fixed charge is per day:

$$\text{Fixed Charge}_{\text{elec}} = \frac{\$ \text{fixed charge}}{\text{day}} \times \text{no. days in billing period}$$

If the fixed charge is per month:

$$\text{Fixed Charge}_{\text{elec}} = \frac{\$ \text{fixed charge}}{\text{month}}$$

The volumetric charge for electrification-friendly rates depends on the time of day and season of electricity use. The applicable time-of-day rate may also vary for weekdays versus weekends. In this calculation, staff cross-referenced the utility, month, day, and time to determine which rate is the correct rate to charge for each hour of the year.

$$Volumetric\ Charge_{elec} = \sum_i \left(kWh_i \times TOU\ rate_i \frac{\$}{kWh} \right),$$

where i is the hour of the year

Again, the volumetric CARE discount for IOU customers will be represented by 30 percent and POU eligible low-income customers received a dollar amount subsidy, not a percentage discount, on their fixed charge.

$$Total\ Bill_{IOU,elec} = (1 - 0.30) \times (Fixed\ Charge + Volumetric\ Charge)$$

$$Total\ Bill_{POU,elec} = Fixed\ Charge - Subsidy + Volumetric\ Charge$$

Again, staff calculated the total electricity bill for each month of the year and summed all the months to calculate the annual electricity bill.

$$Annual\ Bill_{elec} = \sum_{i=1}^{12} Total\ Bill_{elec,i}, \text{ where } i \text{ is the month of the year}$$

Energy Bill Savings Calculation

Staff calculated the annual gas and electricity bill for each of the baseline and retrofit prototypes. The energy bill savings calculation is a percentage and is calculated by comparing the annual gas and electric bill of the retrofit to the baseline.

Energy Bill Savings

$$= \frac{\left[(Annual\ Bill_{gas} + Annual\ Bill_{elec})_{bsln} - (Annual\ Bill_{gas} + Annual\ Bill_{elec})_{retro} \right]}{(Annual\ Bill_{gas} + Annual\ Bill_{elec})_{bsln}} \times 100$$

A positive energy savings represents a lower annual energy bill after the retrofit. A negative energy savings represents a higher annual energy bill after the retrofit.

See Chapter 3 for the results of the energy bill savings calculation.

Energy Efficiency Calculation

To calculate energy efficiency, staff converted both gas use and electricity use to British thermal units (BTUs) for an equivalent unit comparison. The total annual BTUs of each retrofit is compared to the total annual BTUs of the associated baseline to determine energy efficiency.

$$MMBTU = [(kWh \times 3,412) + (Therm \times 99,976)]/1,000,000$$

$$Energy\ Savings = MMBTU_{bsln} - MMBTU_{retro}$$

$$Energy\ Efficiency = \frac{MMBTU_{bsln} - MMBTU_{retro}}{MMBTU_{bsln}} \times 100\%$$

See Chapter 3 for the results of the energy efficiency calculations.

Avoided GHG Emission Calculation

This analysis calculates avoided GHG emissions by comparing the GHG emissions of the baseline prototype to a retrofit prototype.

$$\text{Avoided GHG Emissions} = \text{GHG Emissions}_{\text{bsln}} - \text{GHG Emissions}_{\text{retro}}$$

CEC staff calculated annual GHG emissions by applying the GHG emission factors to the CBECC hourly energy usage outputs. This analysis uses a constant emission factor for the combustion of methane gas to calculate the GHG emission associated with gas use. The emission factor for electricity use varies by climate zone and hour of day. This analysis uses the long-run marginal emission factors³¹ developed for the *2022 Building Energy Efficiency Standards*.³² The sum of the GHG emissions associated with annual gas use and annual electricity use is the total GHG emissions.

$$\text{GHG Emissions}_{\text{therm}} = \sum_{i=1}^{8760} \text{Therms}_i \times 0.005847542 \frac{\text{MTCO}_2\text{e}}{\text{Therm}}, \text{ where } i \text{ is the hour of the year}$$

$$\text{GHG Emissions}_{\text{kWh}} = \sum_{i=1}^{8760} \left(\text{kWh}_i \times \text{Electricity Emission Factor}_i \frac{\text{MTCO}_2\text{e}}{\text{kWh}} \right), \text{ where } i \text{ is the hour of the year}$$

$$\text{GHG Emissions} = \text{GHG Emissions}_{\text{therm}} + \text{GHG Emissions}_{\text{kWh}}$$

Because the emission factor for gas is higher than the emission factor for electricity, all the retrofits have lower associated GHG emissions than the baseline. Lowering GHG emissions is a goal of the state and calculating avoided GHG emissions is a performance metric of the program.

See Chapter 3 for the results of the avoided GHG emission calculation.

³¹ “[TN233260, Long Run Marginal Emission Factors](https://efiling.energy.ca.gov/GetDocument.aspx?tn=233260&DocumentContentId=65748),” <https://efiling.energy.ca.gov/GetDocument.aspx?tn=233260&DocumentContentId=65748>.

³² California Energy Commission. [2022 Building Energy Efficiency Standards](https://www.energy.ca.gov/publications/2022/2022-building-energy-efficiency-standards-residential-and-nonresidential), <https://www.energy.ca.gov/publications/2022/2022-building-energy-efficiency-standards-residential-and-nonresidential>.

CHAPTER 3:

Results

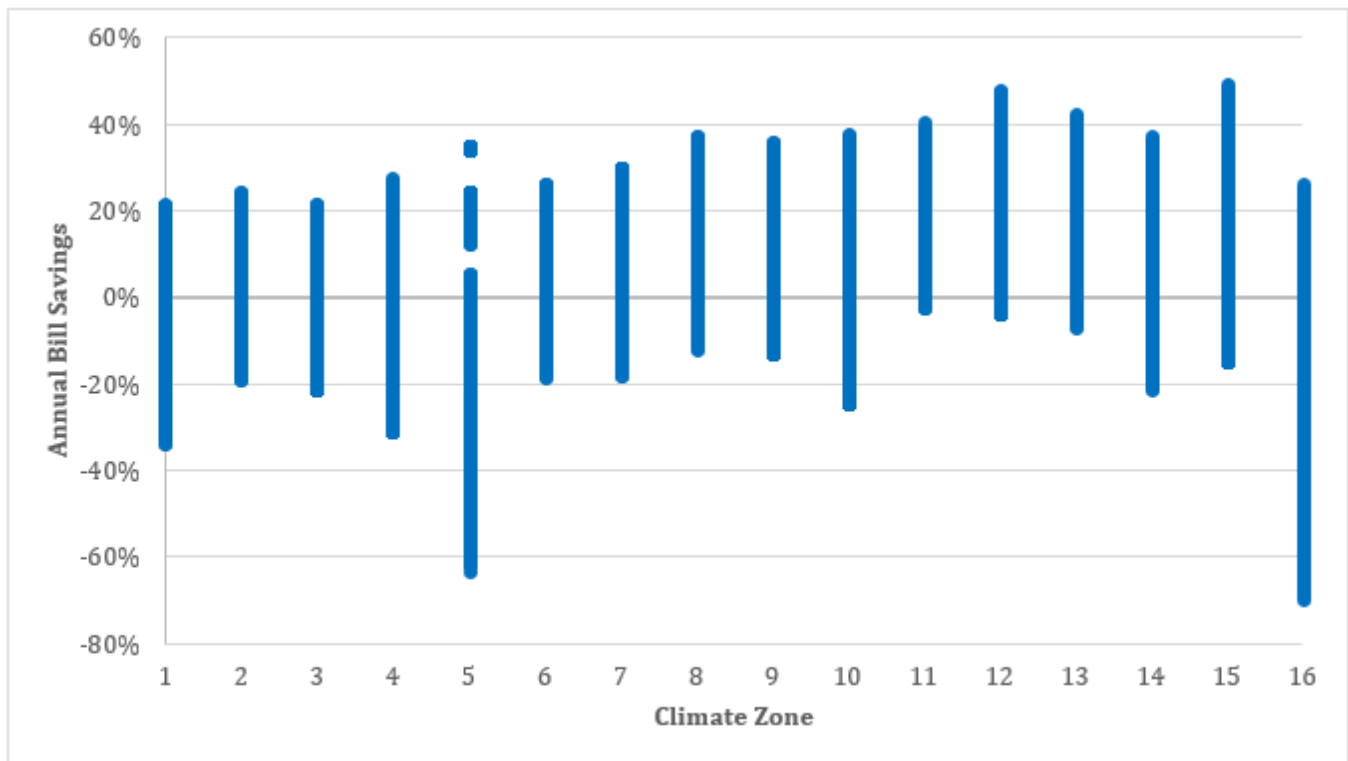
The goal of this analysis is to estimate, comparatively, where in California certain decarbonization measures will provide energy and cost benefits to residents and GHG emission reduction benefits to the state. This analysis informs CEC staff and building decarbonization program implementers, where installing heat pumps in homes would be beneficial and other beneficial efficiency measures and helps to inform residents participating in the EBD Direct Install program on what to expect with heat pump equipment in their homes, including how their energy bill may change throughout the year and which utility rate will minimize their energy bill.

This chapter summarizes the results of the bill impact analysis. To reiterate, these results are a technical evaluation based on modeling, which uses assumptions about energy use and has limitations when considering specific homes. This modeling cannot account for all the variations in weather, building characteristics, existing building systems, and occupant behavior. The appendices to this report include additional result data.

Energy Bill Impact

The results for the energy bill impact by climate zone include every vintage home prototype for single-family, multifamily, and manufactured homes, and each of the applicable utility rates with low-income qualified discounts. Figure 2 is a scatter plot of the annual bill savings for home decarbonization retrofit scenarios that include at least a HPWH or HP HVAC. They may include other measures as mentioned in Chapter 1.

Figure 2: Annual Bill Savings of Heat Pump Retrofit Prototypes by Climate Zone



Source: California Energy Commission staff

In Figure 2, the data above zero percent annual bill savings represent a lower energy bill post-retrofit combination compared to the baseline. Conversely, data below zero percent annual bill savings represent a higher energy bill post-retrofit combination compared to the baseline. Staff emphasizes that this modeling effort represents a scenario analysis rather than a probabilistic forecast. Figure 2 presents estimated bill savings for various retrofit scenarios or combinations across different climate zones. These results should not be interpreted as the expected energy savings for a randomly selected household within each climate zone. Rather, they illustrate that certain climate zones offer a greater number of retrofit scenarios that yield positive bill savings.

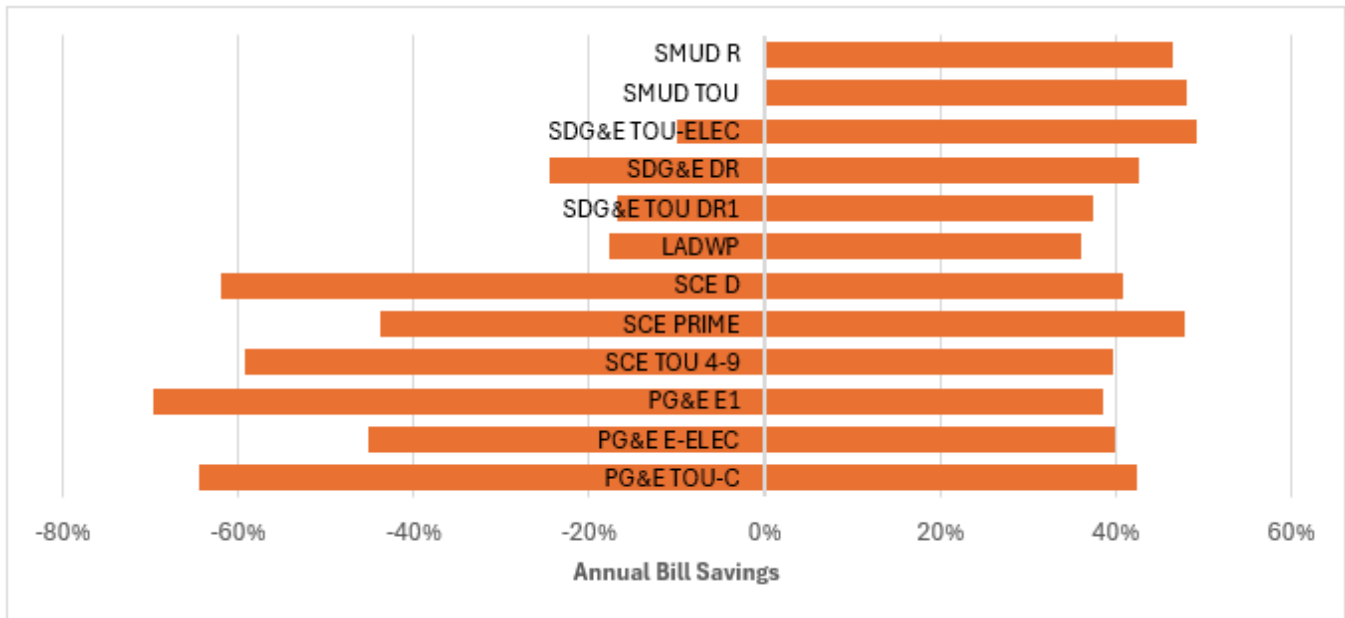
Figure 2 shows Climate Zones 2–4, 6–11, and 13–15 result in bill saving, with the highest savings in the Central Valley, Climate Zones 11–13. Staff estimate the high annual bill savings are mostly due to HVAC decarbonization retrofits in high cooling load climates combined with electrification-friendly rates. For homes that use more energy, switching to an electrification-friendly rate lowers the energy bill since each kWh is charged at a lower rate. There are also energy savings post-retrofit from using more efficient electric equipment.

The data further provides that most modeled decarbonization retrofit combinations in Climate Zones 1 (North Coast), 5 (Central Coast), and 16 (mountain region) result in higher energy bills. Staff contributes this finding to the very low cooling load and higher heating load in

Climate Zones 1, 5, and 16. These modeled retrofits are not gaining savings from cooling efficiencies, and a relatively large amount of gas space heating is switched to electric heating.

Figure 3 is a bar chart of the annual bill savings results by utility rate. The data in Figure 3 are the same as that represented in Figure 2 but grouped by utility rate as opposed to Climate Zone.

Figure 3: Annual Bill Savings of Heat Pump Retrofit Prototypes by Utility Rate



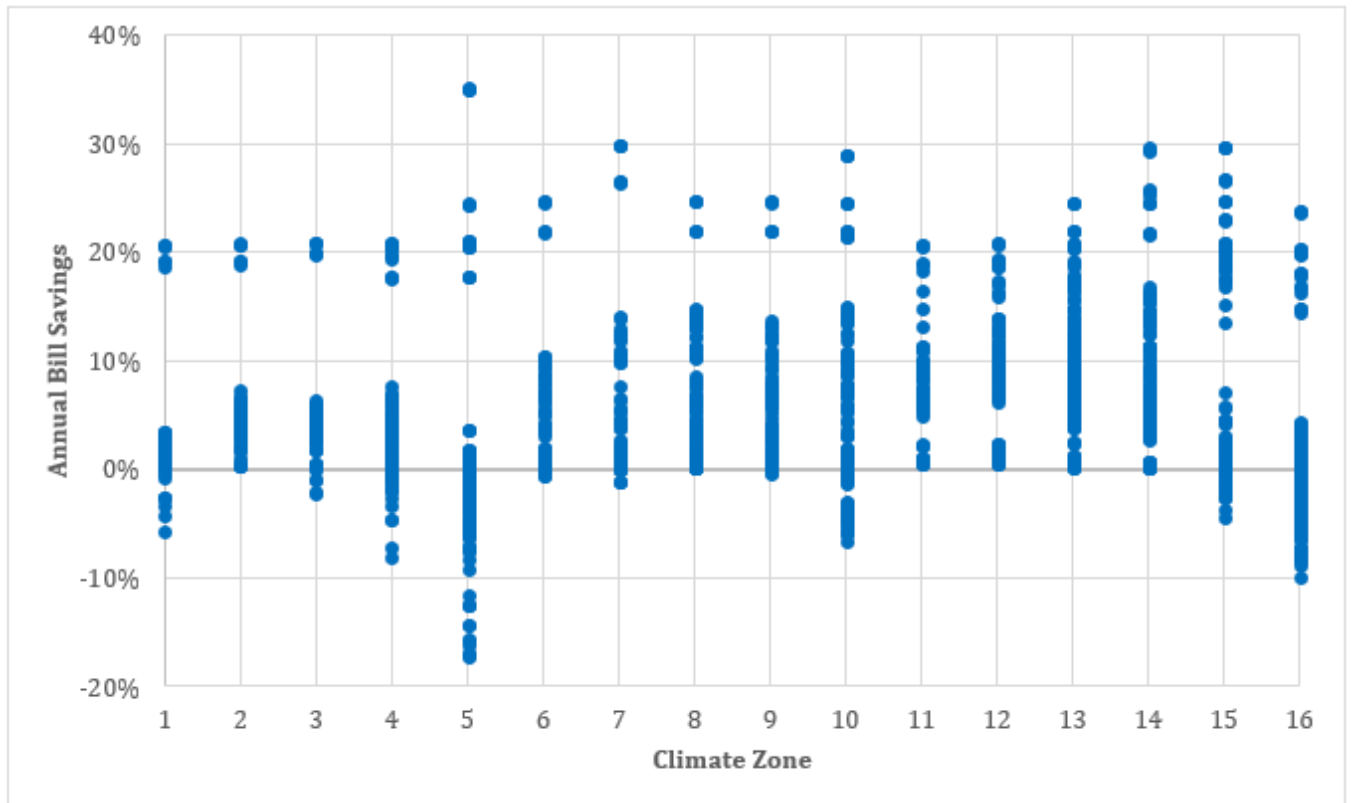
Source: California Energy Commission staff

Figure 3 shows homes on the SDG&E TOU-ELEC and SMUD TOU or R rates with the low-income discount applied result in the highest annual bill savings, with most modeled retrofit combinations achieving bill savings. For other rates, the bars are both below and above zero. This shows that there are many modeled retrofit scenarios where there are bill savings on the other rates, but also several retrofit scenarios where results show bills increasing.

From this modeling analysis, staff found climate zone and rate were the major factors determining bill savings. Bill savings did not vary significantly by home type or vintage. The charts by home type and vintage are included in Appendix B.

Figure 4 shows the modeled bill impact results from replacing a gas water heater with an electric HPWH by climate zone.

Figure 4: Annual Bill Savings Heat Pump Water Heater Retrofit by Climate Zone

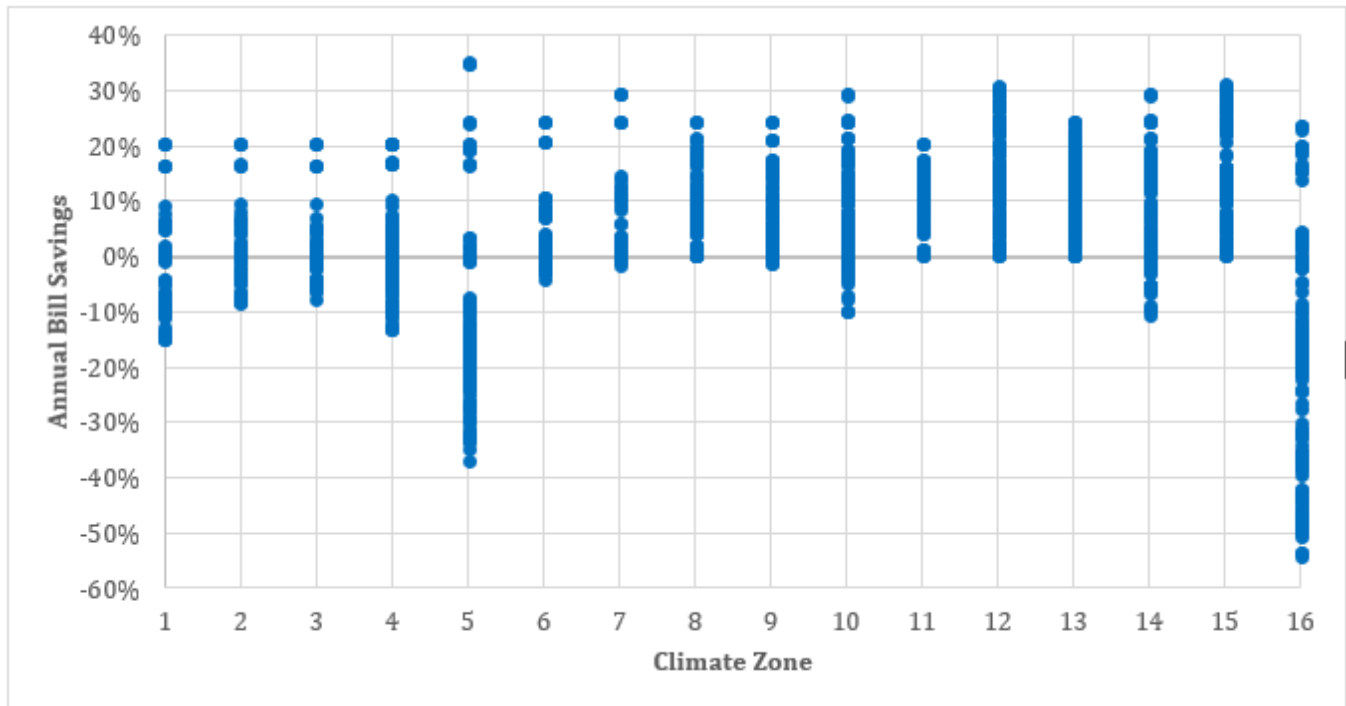


Source: California Energy Commission staff

Figure 4 shows that a modeled HPWH retrofit results in bill savings in nearly all climate zones as evident by most of the data being above the zero percent line. Modeled results show that a HPWH retrofit will most likely result in bill savings in Climate Zones 2 and 11–14. In Climate Zones 5 and 16, an HPWH may result in an energy bill increase. Staff attributes this finding to heat pump water heaters operating more efficiently in warmer climates because they can draw heat from the surrounding air with less electrical effort. In colder climates, the heat pump must work harder and may rely more often on electric resistance backup, reducing efficiency and sometimes increasing energy bills.

Figure 5 shows the modeled bill impact results from replacing a gas furnace and air conditioner with an electric HP HVAC plus duct-sealing by climate zone.

Figure 5: Annual Bill Savings Heat Pump Space Conditioning Retrofit by Climate Zone



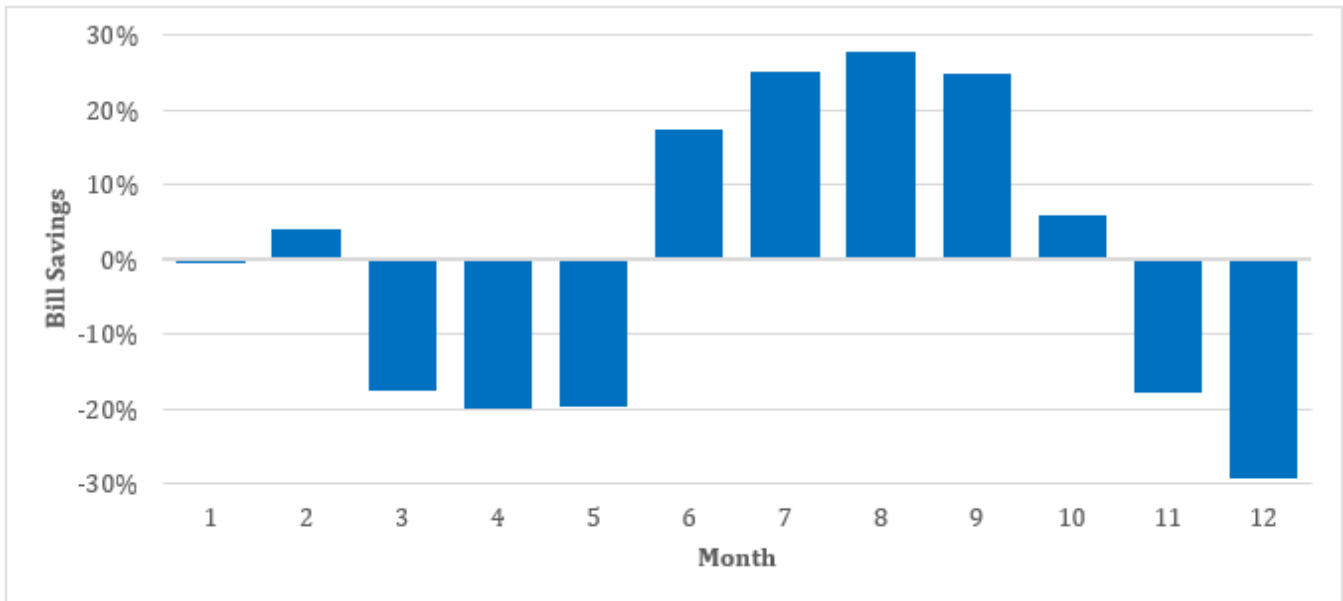
Source: California Energy Commission staff

Figure 5 shows a modeled HP HVAC retrofit with code-required duct sealing will likely result in bill savings in most of the simulated scenarios. Staff found that higher-efficiency HVAC equipment results in more energy and bill savings in hotter climates with high cooling load, as seen in Climate Zones 11–13 (Central Valley) and 15 (desert).

Alternatively, staff found that in colder climates with low cooling load and high heating load, the electrification of gas heating would result in higher electricity use and resulting electricity bills. This is the case for Climate Zones 1 (North Coast) and 16 (mountain region). Furthermore, with mild winters and warm summers, Climate Zone 5 (Central Coast) also had lower bill savings.

The modeled bill impact shown above are annual bill impact results. Figure 6 looks at the modeled bill impact for each month of a year. This figure represents a sample prototype: a single-family, three-bedroom home built before 1975 with an HP HVAC retrofit, in Climate Zone 6 (South Coast) using the SCE Prime rate with a CARE discount. The SCE Prime rate is for customers with an electric vehicle or plug-in hybrid, residential battery, or electric heat pump system for water or space heating. This prototype represents the most common building type and vintage in California, and Climate Zone 6 was chosen as an example to show the seasonal variation of energy bills. Modeled results show that HP HVAC retrofit had an annual bill savings of 5 percent because of increased efficiency of summer cooling.

Figure 6: Monthly Bill Savings Heat Pump Space Conditioning Retrofit in Climate Zone 6



Source: California Energy Commission staff

Calculating bill impact for a whole year resulted in bill savings; however, there is not consistent savings each month of the year. Figure 6 shows that there are bill savings in the summer months, and there are bill increases in the spring and winter months. Utility bills are typically paid each month and the utilities offer programs to their customers, such as level pay and budget billing, to even out their energy bill throughout the year, making it more predictable. In implementing building decarbonization programs, it will be important to educate residents about potential seasonal impacts to their energy bill and utility programs that can help alleviate large fluctuations in utility bills each month. Appendix B contains additional modeled annual bill savings results for other retrofit packages.

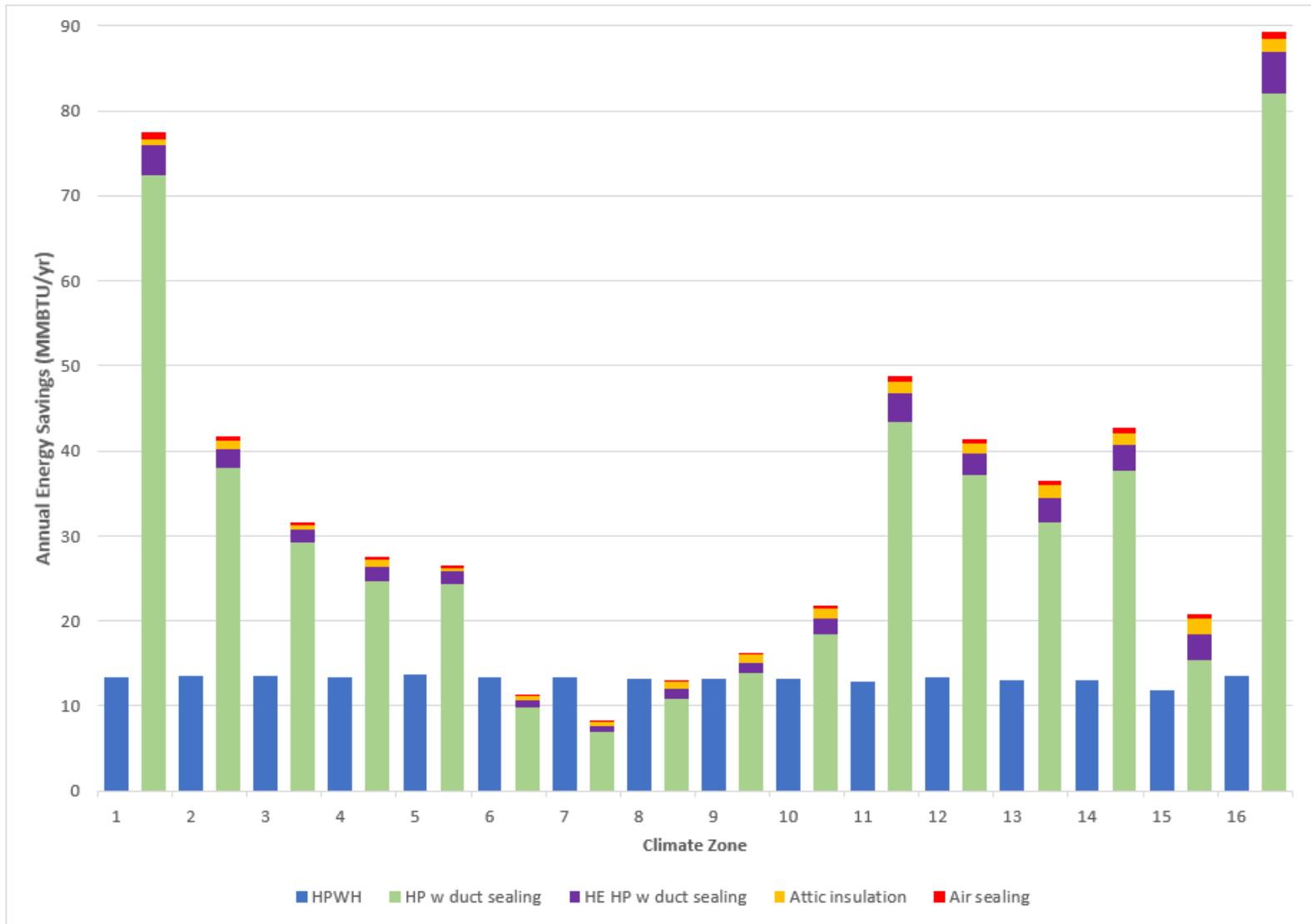
Energy Efficiency

This section shows the energy saving and efficiency results due to switching from gas to electricity. Because this analysis focuses on efficient electric measures, the retrofit prototypes use more electricity, but less gas, than the baseline counterparts. However, there are total energy savings because the amount of gas saved usually outweighs the additional electricity use.

This section shows the results of the decarbonization retrofit of a 1,750-sqft, three-bedroom single-family, vintage category 1975–1983 prototype. This prototype was randomly selected to show the quantified energy savings for a single home with multiple retrofit scenarios. Results of the other prototypes are different, potentially less savings for smaller and newer prototypes, and potentially more savings for larger and older prototypes.

Figure 7 shows energy savings, in million BTUs per year, by climate zone. The blue bars show the HPWH retrofit savings, and the gold bars show HP HVAC retrofit energy savings. The dark orange, red, and purple bars show the incremental energy savings from high-efficiency HP HVACs, attic insulation, and air sealing, respectively.

Figure 7: Energy Savings of Heat Pump Retrofits



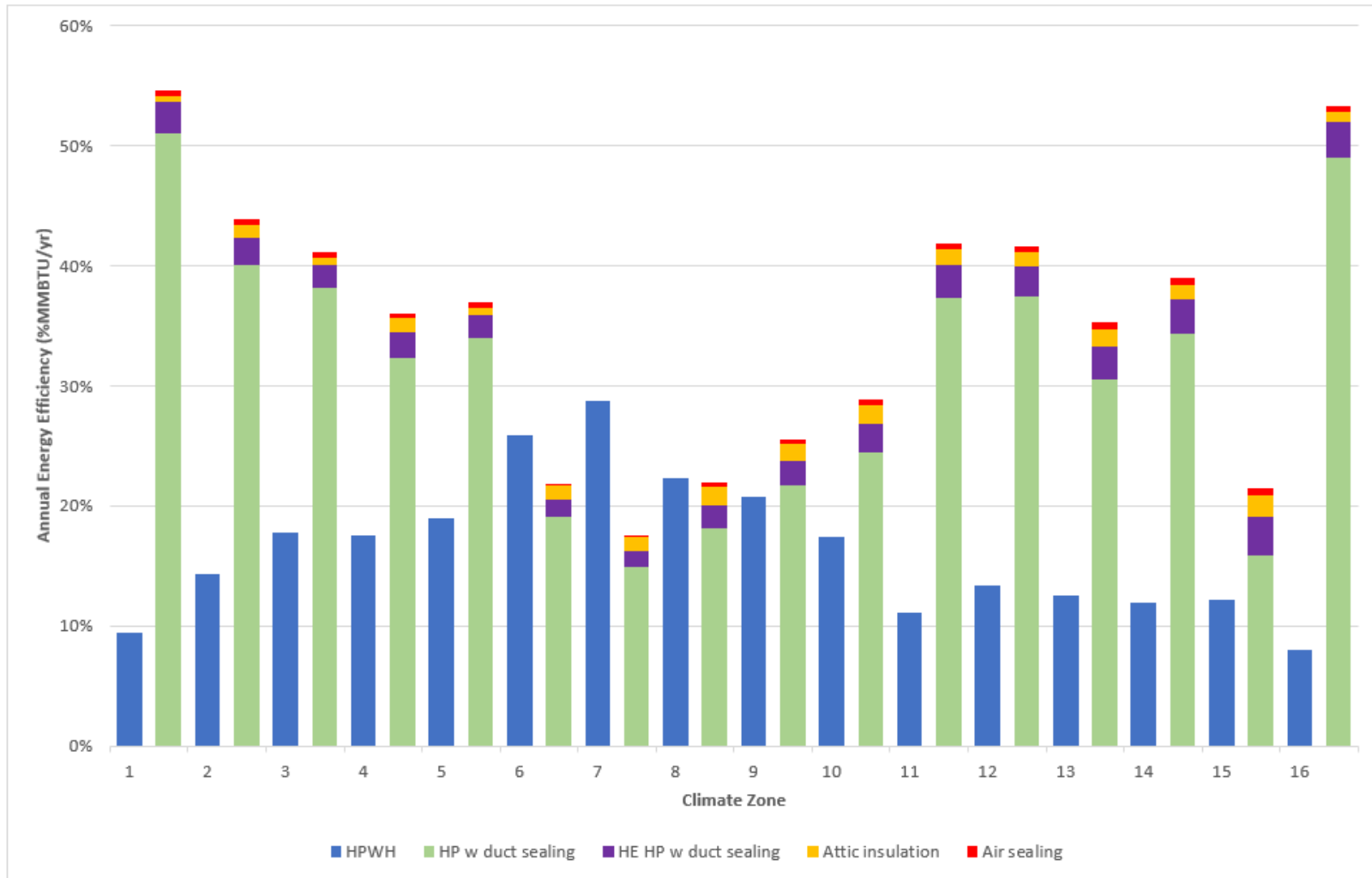
Source: California Energy Commission staff

As Figure 7 shows, the HPWH retrofit shows consistent energy savings for each climate zone, about 13 MMBTU/year. This consistency is likely due to the fairly uniform use of hot water by residents, regardless of the climate zone in which the home is located, and the fact that occupant hot water use behavior did not change in the modeled analysis. Figure 7 also shows the different situation for HP HVAC retrofits where energy savings are more dependent on climate zone than HPWH. This variation makes sense because use of the HVAC system in a home depends highly on the climate. The highest energy savings, more than 70 MMBTU/year, are achieved in Climate Zones 1 and 16, the North Coast and Sierra Nevada mountain areas. These areas have high heating loads, so there are high energy savings in avoiding gas use for space heating load. Although these two areas have the highest energy savings, staff found that in colder climates with low cooling load and high heating load, the electrification of gas heating would result in higher electricity use and higher electricity bills (see Figure 5 Annual Bill Savings Heat Pump Space Conditioning Retrofit by Climate Zone). There are also high energy savings in Climate Zones 11–15, the Central Valley and desert areas. Though there are some savings from avoiding gas use for space heating, these climates have a high cooling load, and there are energy savings from a more efficient HP HVAC system for cooling.

In addition to straight energy savings, this analysis also calculated energy efficiency. The CEC plans to fund the EBD Direct Install Program with a combination of state funding and federal funding available to California through the Inflation Reduction Act Home Efficiency Rebates (HOMES) Program. For retrofit projects that receive federal HOMES funding, energy savings must be estimated or modeled before the retrofit to equal or exceed 20 percent. While the required modeling will consider the individual characteristics of each home, the results shown below provide CEC and program administrators estimated energy savings associated with heat pump retrofits for representative homes in each climate zone.

Figure 8 shows the energy efficiency of an HPWH and an HP HVAC retrofit in the 1,750-sqft, three-bedroom single-family, vintage category 1975–1983 prototype. As mentioned above, this prototype was randomly selected, and different prototype sizes and vintages may show different results. However, since energy efficiency is calculated as a percentage, staff expects the relative energy efficiency between the climate zones would not vary significantly.

Figure 8: Energy Efficiency of Heat Pump Retrofits



Source: California Energy Commission staff

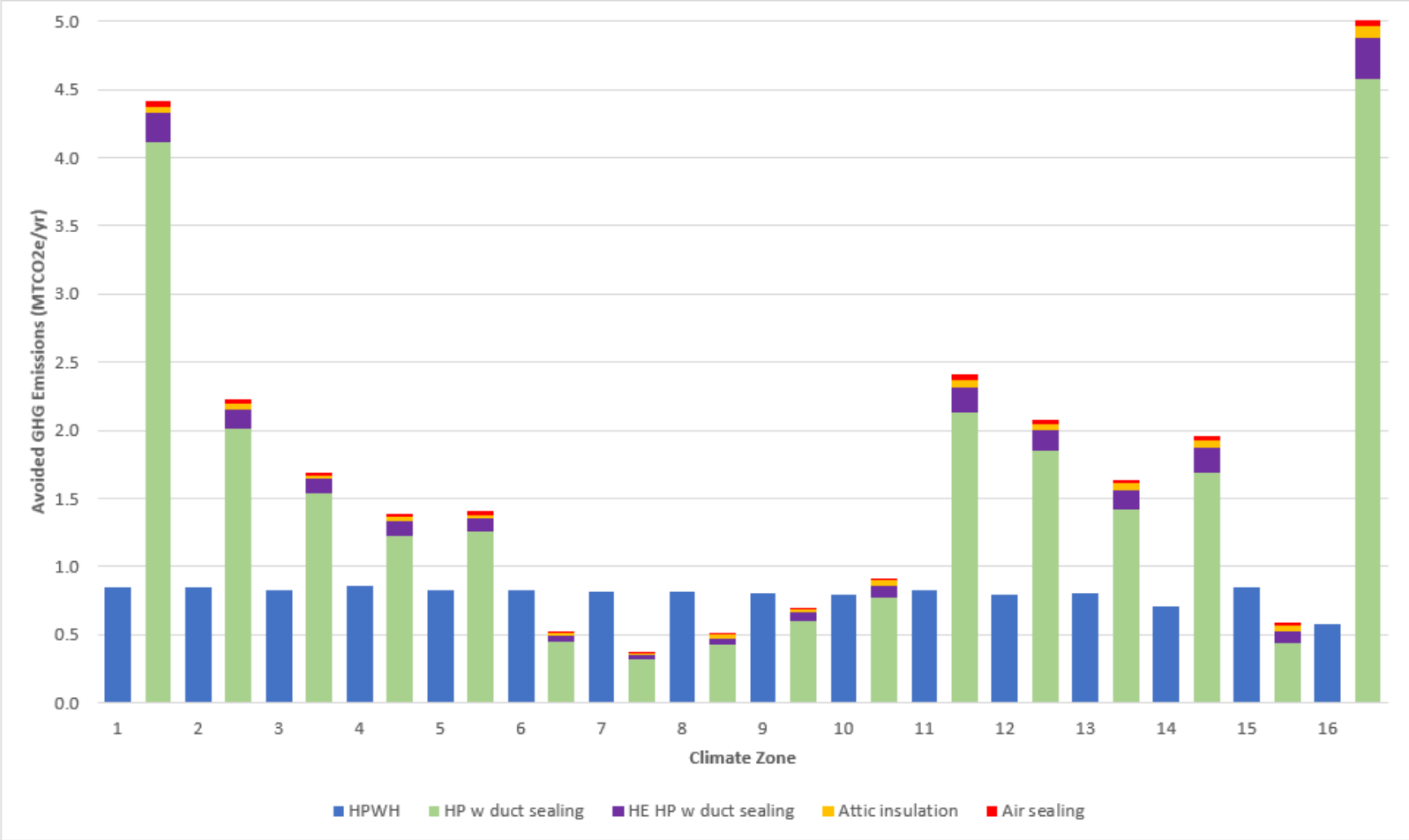
Figure 8 shows that HPWH-only retrofit projects (blue bars) in Climate Zones 6–9 would likely meet the HOMES 20 percent modeled savings threshold. HPWH projects installed in other climate zones may need additional efficiency improvements to meet the threshold. Also, HP HVAC (gold bars) retrofit projects would likely meet the HOMES modeled 20 percent savings threshold in all climate zones, except Climate Zones 6–8. A higher-efficiency heat pump or envelope measures, such as attic insulation or air sealing, or a combination could allow HP HVAC retrofit projects in Climate Zones 6 and 8 to meet the HOMES threshold, shown at the top of the bars in darker orange, red, and purple in Figure 8.

GHG Impact

A central statutory goal of EBD is to reduce GHG emissions from homes. Reducing both electricity and fossil fuels usage will reduce GHG emissions from homes; however, as the state’s electricity supply shifts to more renewable generation, the GHG impact from reduced electricity usage in a home will decrease.

Figure 9 shows the modeled avoided GHG emission results from the 1,750-sqft, three-bedroom single-family, vintage category 1975–1983 prototype. As mentioned above, this prototype was randomly selected, and different prototype sizes and vintages may show different results. There may be potentially less savings for smaller and newer home prototypes, and potentially more savings for larger and older home prototypes.

Figure 9: Avoided GHG Emissions of Heat Pump Retrofits



Source: California Energy Commission staff

The blue bars in Figure 9 show that switching from a gas water heater to an HPWH saves GHG emissions fairly consistently across all climate zones, a little less than 1 metric ton of CO₂ equivalent per year. Replacing a gas HVAC with a HP HVAC shows greater GHG emission savings in extreme cold climate zones than milder climate zones, as shown by the gold bars in Figure 8. There are high GHG savings, more than 4 metric tons of CO₂ equivalent, with an HP HVAC retrofit in Climate Zones 1 and 16, which are the North Coast and mountain areas. Mirroring energy savings shown in Figure 7, switching from gas to electricity for space heating saves significant GHG emissions in high-heating-load climate zones. While replacing any gas fired appliance with an electric appliance will reduce greenhouse gas emissions, Figure 9 shows the most impactful decarbonization measures across all climate zones is changing from a gas water heater or furnace to electric heat pump technology.

CHAPTER 4:

Next Steps and Analysis Updates

CEC staff plans to expand this bill impact analysis in the future by incorporating several updates over the next 12 months. These analysis updates are described below.

Solar PV and Battery

In this analysis, the bill impact calculation does not include the capability to account for electricity export. A customer can export electricity if their home has a solar photovoltaic (PV) or battery storage system installed. In the update, the bill impact calculation will include utility export rates according to the net billing tariff (NBT)³³ for the IOUs and the applicable net billing structure for the POUs. This inclusion will allow for the calculation of bill impact on retrofit prototypes that include solar PV or battery systems.

Gas and Electricity Rates

As stated in Chapter 2, this analysis uses energy utility rates that are updated as of December 2024. Changes in rates or billing structures can alter bill impacts. This includes the CPUC's decision to move existing fixed costs into a "flat rate" that went into effect late 2025 and early 2026.³⁴ This decision reduces the price IOU customers pay for each unit of electricity. Updates to the analysis may include these new rates and billing structure changes.

Non-CARE Rates

As the EBD Statewide Direct Install Program eligibility includes only low-income residents, this initial analysis focused on low-income utility customers and discounted rates. In the analysis update, staff will include standard rates or non-CARE rates and thus capture bill impacts to all incomes of Californians. This analysis could inform the potential energy and bill impacts of other building decarbonization programs.

³³ [Decision 22-12-056, Decision Revising Net Energy Metering Tariff and Subtariffs](https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K043/500043682.PDF),
<https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K043/500043682.PDF>.

³⁴ [CPUC Decision Cuts Price of Electricity Under New Billing Structure and Accelerates California's Clean Energy Transition](https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-flexibility-oir/ab205_factsheet_050824.pdf),
https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-flexibility-oir/ab205_factsheet_050824.pdf.

Interval Meter Data

Complementary to this analysis, staff plans to measure bill and energy impacts using interval meter data (IMD) from EBD Statewide Direct Install retrofitted homes. Using IMD will inform EBD and future building decarbonization programs beyond what modeling can achieve. A phased timeline will be needed for this process: data collection for the first year before and after retrofit, and then preliminary analysis completed afterwards in approximately 12 months. Additionally, given this analysis is a model-based approach, staff also plans to use IMD to calibrate the modeled results of energy consumption and utility bills to improve accuracy and better identify appropriate retrofit measures.

GLOSSARY

Term	Definition
Area median income (AMI)	Median household income based on household size of a geographic area of the state, as annually updated by the California Department of Housing and Community Development.
California Alternative Rates for Energy (CARE)	Program that offers a discount on electric bills and gas bills for income-qualified households.
California Building Energy Code Compliance (CBECC)	A free software developed by the CEC for demonstrating compliance with the Energy Code. This software is available on the CEC website (https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency-1).
California Energy Commission (CEC)	California’s primary energy policy and planning agency.
Carbon neutrality	A state of net-zero greenhouse gas emissions, in which greenhouse gases emitted into the atmosphere are balanced in equal measure by greenhouse gases removed from the atmosphere.
Decarbonization	Activities that reduce or eliminate greenhouse gas emissions, such as replacing the use of fossil fuel burning equipment and appliances (in buildings, vehicles, industry, and electric power generation) with renewable or efficient electric technologies.
Disadvantaged community	An area identified as disadvantaged by the California Environmental Protection Agency per Senate Bill 535 (Chapter 830, Statutes of 2012) based on geographic, socioeconomic, public health, and environmental hazard criteria. A map of disadvantaged communities is available at the CalEPA web page (https://calepa.ca.gov/EnvJustice/GHGInvest/).
Energy burden	The percentage of household income spent on energy costs.
Greenhouse gas (GHG)	Gases that trap heat in the atmosphere, such as carbon dioxide (CO ₂), methane (CH ₄), and nitrous oxide (N ₂ O).
Heat pump	An appliance or system that uses electricity to transfer heat rather than generate it. In summer, transfer heat from a cool space to a warm space, and reverse in winter, for providing an energy-efficient way to heat and cool buildings or to heat water.

Low-income household	A household earning 80 percent or less of the area median income. Low-income thresholds by county and household size are available from the Housing and Community Development web page at hcd.ca.gov/grants-and-funding/income-limits/state-and-federal-income-rent-and-loan-value-limits .
Manufactured home	A home completely constructed in a factory and delivered to the site.
Multifamily building	A residential building with three or more dwelling units, excluding townhouses.
Single-family building	A residential building with two or less dwelling units, including townhouses.
Time of Use (TOU) Rates	Time-of-use rates fall within a broader category of innovative utility rate structures that adjust the rate you pay for electricity over the course of the day and between seasons.
Underresourced community	A disadvantaged community or a low-income community, or both.

APPENDIX A:

Utility Rates Used and Discounts Applied

Gas and electricity rates are important variables in an energy bill impact analysis. There are global socioeconomic factors that affect gas and electricity rates. This appendix is composed of tables with the utility rates used in this calculation. These tables allow readers to understand the actual rates used for the bill impact analysis. This appendix also includes the baseline allowance thresholds used in this calculation to determine rate tiers.

As shown in Chapter 2, Table A-1 lists the utilities and rates used in the bill impact analysis. Additional tables below show details of each rate.

Table A-1: Utility Rates Included in This Analysis (Low-Income Discounts Applied)

Utility	Gas Rate	Tiered Rate	TOU Rate	Electrification-Friendly Rate
Pacific Gas and Electric (PG&E)	G-1	E1	TOU-C	E-ELEC
Southern California Gas Company (SoCalGas)	GR	NA	NA	NA
Southern California Edison (SCE)	NA	D	TOU 4-9	Prime
San Diego Gas and Electric (SDG&E)	GR	DR	DR1	TOU-ELEC
Los Angeles Department of Water and Power (LADWP)	NA	R-1A	NA	NA
Sacramento Municipal Utility District (SMUD)	NA	R	TOD	NA

Source: California Energy Commission staff

Gas Rates Used

Table A-2: PG&E G-1 Rate (2024)

Month	G-1 Baseline (\$/therm)	G-1 Excess (\$/therm)	Minimum Charge (\$/day)	CARE Discount (volumetric / minimum charge)
1	2.43888	2.86665	0.13151	20% / no charge
2	2.39475	2.83177	0.13151	20% / no charge
3	2.16783	2.60485	0.13151	20% / no charge
4	1.86657	2.31002	0.13151	20% / no charge
5	1.88593	2.32938	0.13151	20% / no charge
6	1.97292	2.41637	0.13151	20% / no charge
7	2.16291	2.60636	0.13151	20% / no charge
8	2.29904	2.74249	0.13151	20% / no charge
9	2.39227	2.88603	0.13151	20% / no charge
10	2.30397	2.79773	0.13151	20% / no charge
11	2.40329	2.89705	0.13151	20% / no charge
12	2.47848	2.97224	0.13151	20% / no charge

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-3: SoCalGas GR Rate (2024)

Month	GR Baseline (\$/therm)	GR Non-Baseline (\$/therm)	Minimum Charge (\$/day)	CARE Discount
1	1.4197	1.84631	0.16438	20%
2	1.46941	1.89602	0.16438	20%
3	1.37281	1.79942	0.16438	20%
4	1.18545	1.61206	0.16438	20%
5	1.15032	1.57693	0.16438	20%
6	1.16584	1.59245	0.16438	20%
7	1.21124	1.6419	0.16438	20%
8	1.21451	1.64517	0.16438	20%
9	1.21213	1.64279	0.16438	20%
10	1.28327	1.71392	0.16438	20%
11	1.33404	1.76469	0.16438	20%
12	1.35614	1.78679	0.16438	20%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-4: SDG&E GR Rate (2024)

Month	GR Baseline (\$/therm)	GR Non-Baseline (\$/therm)	Minimum Charge (\$/day)	CARE Discount
1	2.04178	2.34113	0.13151	20%
2	2.09156	2.39091	0.13151	20%
3	1.99483	2.29418	0.13151	20%
4	1.80719	2.10654	0.13151	20%
5	1.77202	2.07137	0.13151	20%
6	1.78756	2.08691	0.13151	20%
7	1.83236	2.13566	0.13151	20%
8	1.83563	2.13893	0.13151	20%
9	1.83325	2.13655	0.13151	20%
10	1.91691	2.22207	0.13151	20%
11	1.96776	2.27292	0.13151	20%
12	1.98989	2.29505	0.13151	20%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Electricity Rates Used

Electricity Tiered Rates

Table A-5: PG&E E1 Rate (2024)

Month	Baseline Usage (\$/kWh)	101%-400% of Baseline Usage (\$/kWh)	Over 400% Usage (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	\$0.42009	\$0.52566	\$0.52566	\$0.37612	34.986%
2	\$0.42009	\$0.52566	\$0.52566	\$0.37612	34.986%
3	\$0.42101	\$0.52708	\$0.52708	\$0.39167	34.985%
4	\$0.42676	\$0.53406	\$0.53406	\$0.39167	34.986%
5	\$0.42676	\$0.53406	\$0.53406	\$0.39167	34.986%
6	\$0.42676	\$0.53406	\$0.53406	\$0.39167	34.986%
7	\$0.38828	\$0.48617	\$0.48617	\$0.39167	34.985%
8	\$0.38828	\$0.48617	\$0.48617	\$0.39167	34.985%
9	\$0.39033	\$0.48870	\$0.48870	\$0.39167	34.985%
10	\$0.40206	\$0.50323	\$0.50323	\$0.39167	34.985%
11	\$0.40206	\$0.50323	\$0.50323	\$0.39167	34.985%
12	\$0.40206	\$0.50323	\$0.50323	\$0.39167	34.985%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-6: SCE D Rate (2024)

Month	Baseline Usage (\$/kWh)	101%-400% of Baseline Usage (\$/kWh)	Over 400% Usage (\$/kWh)	Single-Family Basic Charge (\$/day)	Multifamily Basic Charge (\$/day)	Fixed Recovery Charge (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	0.33558	0.43195	0.43195	0.031	0.02400	0.00188	0.346	29.0%
2	0.33558	0.43195	0.43195	0.031	0.02400	0.00188	0.346	29.0%
3	0.33950	0.43698	0.43698	0.031	0.02400	0.00188	0.346	29.1%
4	0.33950	0.43698	0.43698	0.031	0.02400	0.00188	0.346	29.1%
5	0.33950	0.43698	0.43698	0.031	0.02400	0.00188	0.346	29.1%
6	0.33398	0.42990	0.42990	0.031	0.02400	0.00188	0.346	29.0%
7	0.33398	0.42990	0.42990	0.031	0.02400	0.00188	0.346	29.0%
8	0.33398	0.42990	0.42990	0.031	0.02400	0.00188	0.346	29.0%
9	0.33398	0.42990	0.42990	0.031	0.02400	0.00188	0.346	29.0%
10	0.32652	0.42032	0.42032	0.031	0.02400	0.00188	0.346	29.0%
11	0.32652	0.42032	0.42032	0.031	0.02400	0.00188	0.346	29.0%
12	0.32652	0.42032	0.42032	0.031	0.02400	0.00188	0.346	29.0%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-7: SDG&E DR Rate (2024)

Month	Up to 130% of Baseline Usage (\$/kWh)	Above 130% of Baseline Usage (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	0.38385	0.48331	0.392	31.548%
2	0.38385	0.48331	0.392	31.548%
3	0.40437	0.50915	0.392	31.73%
4	0.40437	0.50915	0.392	31.73%
5	0.40437	0.50915	0.392	31.73%
6	0.40437	0.50915	0.392	31.733%
7	0.40437	0.50915	0.392	31.733%
8	0.40437	0.50915	0.392	31.733%
9	0.40437	0.50915	0.392	31.733%
10	0.40685	0.51228	0.392	31.754%
11	0.40685	0.51228	0.392	31.754%
12	0.40685	0.51228	0.392	31.754%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-8: LADWP R-1A Rate (2024)

Month	Tier 1 Consumption Charge (\$/kWh)	Tier 2 Consumption Charge (\$/kWh)	Tier 3 Consumption Charge (\$/kWh)	Tier 1 Power Access Charge (\$/month)	Tier 2 Power Access Charge (\$/month)	Tier 3 Power Access Charge (\$/month)	Low-Income Subsidy (\$/month)
1	0.20042	0.25901	0.25901	2.30	7.90	22.70	8.17
2	0.20042	0.25901	0.25901	2.30	7.90	22.70	8.17
3	0.20042	0.25901	0.25901	2.30	7.90	22.70	8.17
4	0.19645	0.25504	0.25504	2.30	7.90	22.70	8.17
5	0.19645	0.25504	0.25504	2.30	7.90	22.70	8.17
6	0.19645	0.25504	0.34205	2.30	7.90	22.70	8.17
7	0.21169	0.27028	0.35729	2.30	7.90	22.70	8.17
8	0.21169	0.27028	0.35729	2.30	7.90	22.70	8.17
9	0.21169	0.27028	0.35729	2.30	7.90	22.70	8.17
10	0.21408	0.27267	0.27267	2.30	7.90	22.70	8.17
11	0.21408	0.27267	0.27267	2.30	7.90	22.70	8.17
12	0.21408	0.27267	0.27267	2.30	7.90	22.70	8.17

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Table A-9: SMUD R Rate (2024)

Month	Usage Charge (\$/kWh)	Fixed Charge (\$/month)	Low-Income Discount (\$/month)
1	0.12270	24.15	10
2	0.12270	24.15	10
3	0.12270	24.15	10
4	0.12270	24.15	10
5	0.12610	24.80	10
6	0.20130	24.80	10
7	0.20130	24.80	10
8	0.20130	24.80	10
9	0.20130	24.80	10
10	0.12610	24.80	10
11	0.12610	24.80	10
12	0.12610	24.80	10

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

Electricity Default Time-of-Use Rates

Table A-10: PG&E TOU-C Rate (2024)

Month	Peak Rate* (\$/kWh)	Off-Peak Rate (\$/kWh)	Baseline Credit (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	0.51536	0.48701	0.10556	0.37612	34.986%
2	0.51536	0.48701	0.10556	0.37612	34.986%
3	0.51678	0.48843	0.10607	0.39167	34.985%
4	0.52376	0.49541	0.10730	0.39167	34.986%
5	0.52376	0.49541	0.10730	0.39167	34.986%
6	0.63879	0.53579	0.10730	0.39167	34.986%
7	0.59089	0.48789	0.09788	0.39167	34.985%
8	0.59089	0.48789	0.09788	0.39167	34.985%
9	0.59342	0.49042	0.09837	0.39167	34.985%
10	0.49378	0.46378	0.10117	0.39167	34.985%
11	0.49378	0.46378	0.10117	0.39167	34.985%
12	0.49378	0.46378	0.10117	0.39167	34.985%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*PG&E TOU-C Peak: 4 p.m.–9 p.m. everyday

Table A-11: SCE TOU 4-9 (2024)

Month	On-Peak Rate* (\$/kWh)	Mid-Peak Rate** (\$/kWh)	Off Peak Rate*** (\$/kWh)	Super Off Peak Rate**** (\$/kWh)	Baseline Credit (\$/kWh)	Single-Family Basic Charge (\$/day)	Multifamily Basic Charge (\$/day)	Fixed Recovery Charge (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	NA	0.53481	0.40508	0.36776	0.09637	0.031	0.024	0.00188	0.346	29.0%
2	NA	0.53481	0.40508	0.36776	0.09637	0.031	0.024	0.00188	0.346	29.0%
3	NA	0.54109	0.40984	0.37209	0.09749	0.031	0.024	0.00188	0.346	29.1%
4	NA	0.54109	0.40984	0.37209	0.09749	0.031	0.024	0.00188	0.346	29.1%
5	NA	0.54109	0.40984	0.37209	0.09749	0.031	0.024	0.00188	0.346	29.1%
6	0.60296	0.48890	0.37658	NA	0.09591	0.031	0.024	0.00188	0.346	29.0%
7	0.60296	0.48890	0.37658	NA	0.09591	0.031	0.024	0.00188	0.346	29.0%
8	0.60296	0.48890	0.37658	NA	0.09591	0.031	0.024	0.00188	0.346	29.0%
9	0.60296	0.48890	0.37658	NA	0.09591	0.031	0.024	0.00188	0.346	29.0%
10	NA	0.52028	0.39406	0.35776	0.09379	0.031	0.024	0.00188	0.346	29.0%
11	NA	0.52028	0.39406	0.35776	0.09379	0.031	0.024	0.00188	0.346	29.0%
12	NA	0.52028	0.39406	0.35776	0.09379	0.031	0.024	0.00188	0.346	29.0%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*SCE TOU 4-9 On-Peak: Summer (June – September), 4pm-9pm weekdays

**SCE TOU 4-9 Mid-Peak: Summer (June – September), 4pm-9pm weekends; Winter (October – May), 4pm-9pm everyday

***SCE TOU 4-9 Off Peak: Summer (June – September), 9pm-4pm every day; Winter (October – May), 9pm-8am everyday

****SCE TOU 4-9 Super Off Peak Winter (October – May), 8am-4pm everyday

Table A-12: SDG&E TOU DR1 (2024)

Month	On Peak Rate (\$/kWh)*	Off Peak Rate (\$/kWh)**	Super Off Peak (\$/kWh)***	Baseline Credit (\$/kWh)	Minimum Charge (\$/meter/day)	CARE Discount
1	0.53209	0.47034	0.45242	0.09946	0.392	31.548%
2	0.53209	0.47034	0.45242	0.09946	0.392	31.548%
3	0.55802	0.49615	0.47820	0.10478	0.392	31.733%
4	0.55802	0.49615	0.47820	0.10478	0.392	31.733%
5	0.55802	0.49615	0.47820	0.10478	0.392	31.733%
6	0.70206	0.47262	0.35211	0.10478	0.392	31.733%
7	0.70206	0.47262	0.35211	0.10478	0.392	31.733%
8	0.70206	0.47262	0.35211	0.10478	0.392	31.733%
9	0.70206	0.47262	0.35211	0.10478	0.392	31.733%
10	0.70519	0.47575	0.35524	0.10543	0.392	31.754%
11	0.56115	0.49928	0.48133	0.10543	0.392	31.754%
12	0.56115	0.49928	0.48133	0.10543	0.392	31.754%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*SDG&E TOU DR1 On Peak: 4pm-9pm everyday

**SDG&E TOU DR1 Off Peak: 6am-4pm weekday (excluding 10am-2pm in March - April), 2pm-4pm weekend, and 9pm – 12am everyday

***SDG&E TOU DR1 Super Off Peak: 12am-6am weekdays, March – April 10am-2pm weekdays, 12am-2pm weekends

Table A-13: SMUD TOD (2024)

Month	Peak Rate* (\$/kWh)	Mid-Peak Rate** (\$/kWh)	Off-Peak Rate*** (\$/kWh)	Fixed Charge (\$/month)	Low-Income Discount (\$/month)
1	0.15900	NA	0.11510	\$24.15	10
2	0.15900	NA	0.11510	\$24.15	10
3	0.15900	NA	0.11510	\$24.15	10
4	0.15900	NA	0.11510	\$24.15	10
5	0.16330	NA	0.11830	\$24.80	10
6	0.34620	0.19670	0.14250	\$24.80	10
7	0.34620	0.19670	0.14250	\$24.80	10
8	0.34620	0.19670	0.14250	\$24.80	10
9	0.34620	0.19670	0.14250	\$24.80	10
10	0.16330	NA	0.11830	\$24.80	10
11	0.16330	NA	0.11830	\$24.80	10
12	0.16330	NA	0.11830	\$24.80	10

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*SMUD TOD Peak: 5pm-8pm weekdays

**SMUD TOD Mid-Peak: Summer (June – September), 12pm-5pm and 8pm-12am weekdays

***SMUD TOD Off-Peak: Summer (June – September), 12am-12pm weekday, all day weekends; Winter (October – May), 12am-5pm weekday, all day weekends

Electricity Electrification-Friendly Rates

Table A-14: PG&E E-ELEC (2024)

Month	Peak Rate* (\$/kWh)	Part Peak** Rate (\$/kWh)	Off-Peak Rate*** (\$/kWh)	Fixed Charge (\$/meter/day)	CARE Discount
1	0.40429	0.38220	0.36834	0.49281	35%
2	0.40429	0.38220	0.36834	0.49281	35%
3	0.40551	0.38342	0.36956	0.49281	35%
4	0.41177	0.38968	0.37582	0.49281	35%
5	0.41177	0.38968	0.37582	0.49281	35%
6	0.64328	0.48140	0.42472	0.49281	35%
7	0.60054	0.43866	0.38198	0.49281	35%
8	0.60054	0.43866	0.38198	0.49281	35%
9	0.60280	0.44092	0.38424	0.49281	35%
10	0.38426	0.36217	0.34831	0.49281	35%
11	0.38426	0.36217	0.34831	0.49281	35%
12	0.38426	0.36217	0.34831	0.49281	35%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*PG&E E-ELEC Peak :4pm-9pm everyday

**PG&E E-ELEC Part Peak :3pm-4pm and 9pm-12am everyday

***PG&E E-ELEC Off-Peak :12am-3pm everyday

Table A-15: SCE Prime (2024)

Month	On-Peak Rate* (\$/kWh)	Mid-Peak Rate** (\$/kWh)	Off Peak Rate*** (\$/kWh)	Super Off Peak Rate**** (\$/kWh)	Basic Charge (\$/day)	Fixed Recovery Charge (\$/kWh)	CARE Discount
1	NA	0.59689	0.23823	0.23823	0.503	0.00188	29.0%
2	NA	0.59689	0.23823	0.23823	0.503	0.00188	29.0%
3	NA	0.60166	0.24126	0.33206	0.515	0.00188	29.0%
4	NA	0.60166	0.24126	0.33206	0.515	0.00188	29.0%
5	NA	0.60166	0.24126	0.33206	0.515	0.00188	29.0%
6	0.52396	0.38637	0.20744	NA	0.52	0.00188	29.0%
7	0.52396	0.38637	0.20744	NA	0.52	0.00188	29.0%
8	0.52396	0.38637	0.20744	NA	0.52	0.00188	29.0%
9	0.52396	0.55432	0.20744	NA	0.52	0.00188	29.0%
10	NA	0.55432	0.34994	0.23690	0.545	0.00188	29.0%
11	NA	0.55432	0.34994	0.23690	0.545	0.00188	29.0%
12	NA	0.55432	0.34994	0.23690	0.545	0.00188	29.0%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*SCE Prime On-Peak: Summer (June – September), 4pm-9pm weekdays

**SCE Prime Mid-Peak: Summer (June – September), 4pm-9pm weekends; Winter (October – May), 4pm-9pm everyday

***SCE Prime Off Peak: Summer (June – September), 9pm-4pm every day; Winter (October – May), 9pm-8am everyday

****SCE Prime Super Off Peak Winter (October – May), 8am-4pm everyday

Table A-16: SDG&E TOU-ELEC (2024)

Month	On Peak Rate* (\$/kWh)	Off Peak Rate** (\$/kWh)	Super Off Peak*** (\$/kWh)	Service Fee (\$/month)	CARE Discount
1	0.40898	0.30569	0.27341	16	31.548%
2	0.40898	0.30569	0.27341	16	31.548%
3	0.42448	0.321	0.28866	16	31.733%
4	0.42448	0.321	0.28866	16	31.733%
5	0.42448	0.321	0.28866	16	31.733%
6	0.60094	0.33067	0.2951	16	31.733%
7	0.60094	0.33067	0.2951	16	31.733%
8	0.60094	0.33067	0.2951	16	31.733%
9	0.60094	0.33067	0.2951	16	31.733%
10	0.60289	0.33262	0.29705	16	31.733%
11	0.42643	0.32295	0.29061	16	31.754%
12	0.42643	0.32295	0.29061	16	31.754%

Source: Rates published by utilities (i.e., tariffs) and compiled by California Energy Commission staff

*SDG&E TOU-ELEC On Peak: 4pm-9pm everyday

**SDG&E TOU-ELEC Off Peak: 6am-4pm weekday (excluding 10am-2pm in March - April), 2pm-4pm weekend, and 9pm – 12am everyday

***SDG&E TOU-ELEC Super Off Peak: 12am-6am weekdays, March – April 10am-2pm weekdays, 12am-2pm weekends

Baseline Allowances Used

Gas Baseline Allowances

Table A-17: SoCalGas (Tier 2) Gas Baseline Allowance

Month	Zone 1 CZ 6, 8-10, 15 (therms)	Zone 2 CZ 4, 5, 13, 14 (therms)	Zone 3 CZ 16 (therms)
1	49.6	57.9	80.6
2	44.8	52.3	72.8
3	27.1	28.6	53.1
4	26.2	27.7	51.4
5	13.1	13.1	13.1
6	12.7	12.7	12.7
7	13.1	13.1	13.1
8	13.1	13.1	13.1
9	12.7	12.7	12.7
10	13.1	13.1	13.1
11	26.2	27.7	53.1
12	49.6	57.9	80.6

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-18: PG&E (Tier 2) Gas Baseline Allowance

Month	R CZ 11, 13 (therms)	S CZ 12 (therms)	T CZ 1-3, 5 (therms)	X CZ 4 (therms)	Y CZ 16 (therms)
1	56.1	60.1	52.1	62.0	80.0
2	34.7	38.6	36.7	41.4	62.2
3	38.4	42.8	40.6	45.9	68.8
4	10.8	11.7	16.8	14.7	21.6
5	11.2	12.1	17.4	15.2	22.3
6	10.8	11.7	16.8	14.7	21.6
7	11.2	12.1	17.4	15.2	22.3
8	11.2	12.1	17.4	15.2	22.3
9	10.8	11.7	16.8	14.7	21.6
10	11.2	12.1	17.4	15.2	22.3
11	37.2	41.4	39.3	45.9	68.8
12	56.1	60.1	52.1	62.0	80.0

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-19: SDG&E (Tier 2) Gas Baseline Allowance

Month	All Territories (therms)
1	38.2
2	34.5
3	21.5
4	20.8
5	11.1
6	10.8
7	11.1
8	11.1
9	10.8
10	11.1
11	20.8
12	38.2

Source: Data published by utilities and compiled by California Energy Commission staff

Electric Baseline Allowances

Table A-20: PG&E Basic Electric (Tier 2) Baseline Allowance

Month	R CZ 13 (kWh)	S CZ 11, 12 (kWh)	T CZ 1-3, 5 (kWh)	X CZ 4 (kWh)	Y CZ 16 (kWh)
1	322.4	316.2	232.5	300.7	344.1
2	291.2	285.6	210.0	271.6	310.8
3	322.4	316.2	232.5	300.7	344.1
4	312.0	306.0	225.0	291.0	333.0
5	322.4	465.0	201.5	300.7	344.1
6	531.0	450.0	195.0	294.0	315.0
7	548.7	465.0	201.5	303.8	325.5
8	548.7	465.0	201.5	303.8	325.5
9	531.0	465.0	201.5	294.0	315.0
10	322.4	316.2	232.5	300.7	344.1
11	312.0	306.0	225.0	291.0	333.0
12	322.4	316.2	232.5	300.7	344.1

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-21: PG&E All-Electric (Tier 2) Baseline Allowance

Month	R CZ 13 (kWh)	S CZ 11, 12 (kWh)	T CZ 1-3, 5 (kWh)	X CZ 4 (kWh)	Y CZ 16 (kWh)
1	827.7	734.7	399.9	452.6	744.0
2	747.6	663.6	361.2	408.8	672.0
3	827.7	734.7	399.9	452.6	744.0
4	801.0	711.0	387.0	438.0	720.0
5	616.9	551.8	220.1	452.6	744.0
6	597.0	534.0	213.0	255.0	360.0
7	616.9	551.8	220.1	263.5	372.0
8	616.9	551.8	220.1	263.5	372.0
9	597.0	534.0	213.0	255.0	360.0
10	827.7	734.7	399.9	452.6	744.0
11	801.0	711.0	387.0	438.0	720.0
12	827.7	734.7	399.9	452.6	744.0

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-22: PG&E Basic Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	R CZ 13 (kWh)	S CZ 11, 12 (kWh)	T CZ 1-3, 5 (kWh)	X CZ 4 (kWh)	Y CZ 16 (kWh)
1	1,289.6	1,264.8	930.0	1202.8	1376.4
2	1,164.8	1,142.4	840.0	1086.4	1243.2
3	1,289.6	1,264.8	930.0	1202.8	1376.4
4	1,248.0	1,224.0	900.0	1164.0	1332.0
5	1,289.6	1,860.0	806.0	1202.8	1376.4
6	2,124.0	1,800.0	780.0	1176.0	1260.0
7	2,194.8	1,860.0	806.0	1215.2	1302.0
8	2,194.8	1,860.0	806.0	1215.2	1302.0
9	2,124.0	1,860.0	806.0	1176.0	1260.0
10	1,289.6	1,264.8	930.0	1202.8	1376.4
11	1,248.0	1,224.0	900.0	1164.0	1332.0
12	1,289.6	1,264.8	930.0	1202.8	1376.4

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-23: PG&E All-Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	R CZ 13 (kWh)	S CZ 11, 12 (kWh)	T CZ 1-3, 5 (kWh)	X CZ 4 (kWh)	Y CZ 16 (kWh)
1	3,310.8	2,938.8	1,599.6	1810.4	2976.0
2	2,990.4	2,654.4	1,444.8	1635.2	2688.0
3	3,310.8	2,938.8	1,599.6	1810.4	2976.0
4	3,204.0	2,844.0	1,548.0	1752.0	2880.0
5	2,467.6	2,207.2	880.4	1810.4	2976.0
6	2,388.0	2,136.0	852.0	1020.0	1440.0
7	2,467.6	2,207.2	880.4	1054.0	1488.0
8	2,467.6	2,207.2	880.4	1054.0	1488.0
9	2,388.0	2,136.0	852.0	1020.0	1440.0
10	3,310.8	2,938.8	1,599.6	1810.4	2976.0
11	3,204.0	2,844.0	1,548.0	1752.0	2880.0
12	3,310.8	2,938.8	1,599.6	1810.4	2976.0

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-24: SCE Basic Electric (Tier 2) Baseline Allowance

Month	CZ 5 (kWh)	CZ 6 (kWh)	CZ 8 (kWh)	CZ 9 (kWh)	CZ 10 (kWh)	CZ 13 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)	CZ 16 (kWh)
1	570.4	341.0	319.3	372.0	375.1	378.2	368.9	300.7	384.4
2	552.0	308.0	288.4	336.0	338.8	341.6	333.2	271.6	347.2
3	570.4	341.0	319.3	372.0	375.1	378.2	368.9	300.7	384.4
4	552.0	330.0	309.0	360.0	363.0	366.0	357.0	291.0	372.0
5	570.4	341.0	319.3	372.0	375.1	378.2	368.9	300.7	384.4
6	510.0	342.0	378.0	507.0	579.0	666.0	576.0	1350.0	441.0
7	527.0	353.4	390.6	523.9	598.3	688.2	595.2	1395.0	455.7
8	527.0	353.4	390.6	523.9	598.3	688.2	595.2	1395.0	455.7
9	510.0	342.0	378.0	507.0	579.0	666.0	576.0	1350.0	441.0
10	570.4	341.0	319.3	372.0	375.1	378.2	368.9	300.7	384.4
11	552.0	330.0	309.0	360.0	363.0	366.0	357.0	291.0	372.0
12	570.4	341.0	319.3	372.0	375.1	378.2	368.9	300.7	384.4

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-25: SCE All-Electric (Tier 2) Baseline Allowance

Month	CZ 5 (kWh)	CZ 6 (kWh)	CZ 8 (kWh)	CZ 9 (kWh)	CZ 10 (kWh)	CZ 13 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)	CZ 16 (kWh)
1	837.0	390.6	381.3	430.9	508.4	713.0	654.1	539.4	719.2
2	756.0	352.8	344.4	389.2	459.2	644.0	590.8	487.2	649.6
3	837.0	390.6	381.3	430.9	508.4	713.0	654.1	539.4	719.2
4	810.0	378.0	369.0	417.0	492.0	690.0	633.0	522.0	696.0
5	837.0	390.6	381.3	430.9	508.4	713.0	654.1	539.4	719.2
6	504.0	261.0	294.0	375.0	477.0	726.0	555.0	720.0	405.0
7	520.8	269.7	303.8	387.5	492.9	750.2	573.5	744.0	418.5
8	520.8	269.7	303.8	387.5	492.9	750.2	573.5	744.0	418.5
9	504.0	261.0	294.0	375.0	477.0	726.0	555.0	720.0	405.0
10	837.0	390.6	381.3	430.9	508.4	713.0	654.1	539.4	719.2
11	810.0	378.0	369.0	417.0	492.0	690.0	633.0	522.0	696.0
12	837.0	390.6	381.3	430.9	508.4	713.0	654.1	539.4	719.2

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-26: SCE Basic Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	CZ 5 (kWh)	CZ 6 (kWh)	CZ 8 (kWh)	CZ 9 (kWh)	CZ 10 (kWh)	CZ 13 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)	CZ 16 (kWh)
1	2281.6	1364.0	1,277.2	1,488.0	1,500.4	1,512.8	1475.6	1202.8	1537.6
2	2208.0	1232.0	1,153.6	1,344.0	1,355.2	1,366.4	1332.8	1086.4	1388.8
3	2281.6	1364.0	1,277.2	1,488.0	1,500.4	1,512.8	1475.6	1202.8	1537.6
4	2208.0	1320.0	1,236.0	1,440.0	1,452.0	1,464.0	1428.0	1164.0	1488.0
5	2281.6	1364.0	1,277.2	1,488.0	1,500.4	1,512.8	1475.6	1202.8	1537.6
6	2040.0	1368.0	1,512.0	2,028.0	2,316.0	2,664.0	2304.0	5400.0	1764.0
7	2108.0	1413.6	1,562.4	2,095.6	2,393.2	2,752.8	2380.8	5580.0	1822.8
8	2108.0	1413.6	1,562.4	2,095.6	2,393.2	2,752.8	2380.8	5580.0	1822.8
9	2040.0	1368.0	1,512.0	2,028.0	2,316.0	2,664.0	2304.0	5400.0	1764.0
10	2281.6	1364.0	1,277.2	1,488.0	1,500.4	1,512.8	1475.6	1202.8	1537.6
11	2208.0	1320.0	1,236.0	1,440.0	1,452.0	1,464.0	1428.0	1164.0	1488.0
12	2281.6	1364.0	1,277.2	1,488.0	1,500.4	1,512.8	1475.6	1202.8	1537.6

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-27: SCE All-Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	CZ 5 (kWh)	CZ 6 (kWh)	CZ 8 (kWh)	CZ 9 (kWh)	CZ 10 (kWh)	CZ 13 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)	CZ 16 (kWh)
1	3348.0	1562.4	1,525.2	1,723.6	2,033.6	2,852.0	2616.4	2157.6	2876.8
2	3024.0	1411.2	1,377.6	1,556.8	1,836.8	2,576.0	2363.2	1948.8	2598.4
3	3348.0	1562.4	1,525.2	1,723.6	2,033.6	2,852.0	2616.4	2157.6	2876.8
4	3240.0	1512.0	1,476.0	1,668.0	1,968.0	2,760.0	2532.0	2088.0	2784.0
5	3348.0	1562.4	1,525.2	1,723.6	2,033.6	2,852.0	2616.4	2157.6	2876.8
6	2016.0	1044.0	1,176.0	1,500.0	1,908.0	2,904.0	2220.0	2880.0	1620.0
7	2083.2	1078.8	1,215.2	1,550.0	1,971.6	3,000.8	2294.0	2976.0	1674.0
8	2083.2	1078.8	1,215.2	1,550.0	1,971.6	3,000.8	2294.0	2976.0	1674.0
9	2016.0	1044.0	1,176.0	1,500.0	1,908.0	2,904.0	2220.0	2880.0	1620.0
10	3348.0	1562.4	1,525.2	1,723.6	2,033.6	2,852.0	2616.4	2157.6	2876.8
11	3240.0	1512.0	1,476.0	1,668.0	1,968.0	2,760.0	2532.0	2088.0	2784.0
12	3348.0	1562.4	1,525.2	1,723.6	2,033.6	2,852.0	2616.4	2157.6	2876.8

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-28: SDG&E Basic Electric (Tier 2) Baseline Allowance

Month	CZ 7 (kWh)	CZ 10 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)
1	370.8	386.9	519.9	439.3
2	334.9	349.4	469.6	396.8
3	370.8	386.9	519.9	439.3
4	358.8	374.4	503.1	425.1
5	370.8	386.9	519.9	439.3
6	351.0	405.6	530.4	620.1
7	362.7	419.1	548.1	640.8
8	362.7	419.1	548.1	640.8
9	351.0	405.6	530.4	620.1
10	362.7	419.1	548.1	640.8
11	358.8	374.4	503.1	425.1
12	370.8	386.9	519.9	439.3

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-29: SDG&E All-Electric (Tier 2) Baseline Allowance

Month	CZ 7 (kWh)	CZ 10 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)
1	354.6	491.7	890.6	689.1
2	320.3	444.1	804.4	622.4
3	354.6	491.7	890.6	689.1
4	343.2	475.8	861.9	666.9
5	354.6	491.7	890.6	689.1
6	234.0	339.3	592.8	663.0
7	241.8	350.6	612.6	685.1
8	241.8	350.6	612.6	685.1
9	234.0	339.3	592.8	663.0
10	241.8	350.6	612.6	685.1
11	343.2	475.8	861.9	666.9
12	354.6	491.7	890.6	689.1

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-30: SDG&E Basic Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	CZ 7 (kWh)	CZ 10 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)
1	1,140.8	1,190.4	1599.6	1351.6
2	1,030.4	1,075.2	1444.8	1220.8
3	1,140.8	1,190.4	1599.6	1351.6
4	1,104.0	1,152.0	1548.0	1308.0
5	1,140.8	1,190.4	1599.6	1351.6
6	1,080.0	1,248.0	1632.0	1908.0
7	1,116.0	1,289.6	1686.4	1971.6
8	1,116.0	1,289.6	1686.4	1971.6
9	1,080.0	1,248.0	1632.0	1908.0
10	1,140.8	1,190.4	1686.4	1971.6
11	1,104.0	1,152.0	1548.0	1308.0
12	1,140.8	1,190.4	1599.6	1351.6

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-31: SDG&E All-Electric (Tier 3, >400% of Baseline) Baseline Allowance

Month	CZ 7 (kWh)	CZ 10 (kWh)	CZ 14 (kWh)	CZ 15 (kWh)
1	1,091.2	1,512.8	2740.4	2120.4
2	985.6	1,366.4	2475.2	1915.2
3	1,091.2	1,512.8	2740.4	2120.4
4	1,056.0	1,464.0	2652.0	2052.0
5	1,091.2	1,512.8	2740.4	2120.4
6	720.0	1,044.0	1824.0	2040.0
7	744.0	1,078.8	1884.8	2108.0
8	744.0	1,078.8	1884.8	2108.0
9	720.0	1,044.0	1824.0	2040.0
10	1,091.2	1,512.8	1884.8	2108.0
11	1,056.0	1,464.0	2652.0	2052.0
12	1,091.2	1,512.8	2740.4	2120.4

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-32: LADWP Basic Electric (Tier 2) Baseline Allowance

Month	Zone 1 CZ 6, 16 (kWh)	Zone 2 CZ 8, 9 (kWh)
1	361.8	516.8
2	326.8	466.8
3	361.8	516.8
4	350.1	500.0
5	361.8	516.8
6	350.1	500.0
7	361.8	516.8
8	361.8	516.8
9	350.1	500.0
10	361.8	516.8
11	350.1	500.0
12	361.8	516.8

Source: Data published by utilities and compiled by California Energy Commission staff

Table A-33: LADWP Basic Electric (Tier 3) Baseline Allowance

Month	Zone 1 CZ 6, 16 (kWh)	Zone 2 CZ 8, 9 (kWh)
1	1085.0	1,550.0
2	980.0	1,400.0
3	1085.0	1,550.0
4	1050.0	1,500.0
5	1085.0	1,550.0
6	1050.0	1,500.0
7	1085.0	1,550.0
8	1085.0	1,550.0
9	1050.0	1,500.0
10	1085.0	1,550.0
11	1050.0	1,500.0
12	1085.0	1,550.0

Source: Data published by utilities and compiled by California Energy Commission staff

APPENDIX B:

Annual Bill Savings – Decarbonization Packages

This appendix provides modeled annual bill savings results for several existing home decarbonization retrofit packages, including single-family, multifamily, and manufactured home prototypes in all the vintage categories and utility rates included in this analysis.

Building segments are defined as follows:

- Single-family building is a residential building with two or less dwelling units, including townhouses.
- Multifamily building is a residential building with three or more dwelling units, excluding townhouses.
- Manufactured home is a home completely constructed in a factory and delivered to the site.

Table B-1 shows modeled annual bill savings by home type, including all vintage categories included in this analysis. The results in Table B-1 represent the retrofits that include at least an HPWH or an HP HVAC. This table shows there is not much variation in modeled bill savings by building type for single family and manufactured home prototypes. The multifamily prototype shows lower bill increases compared to the single family and manufactured home prototypes.

Table B-1: Annual Bill Savings Range by Home Type

Home Type	Minimum Bill Savings	Maximum Bill Savings
Single Family (1,250 sqft)	-69.74%	46.37%
Single Family (1,750 sqft)	-68.98%	46.79%
Single Family (2,250 sqft)	-68.00%	47.21%
Low Rise Multifamily (6,960 sqft)	-3.00%	35.10%
Midrise Multifamily (95,028 sqft)	-12.88%	33.47%
Single Wide Manufactured Home (910 sqft)	-64.29%	43.67%
Double Wide Manufactured Home (1,512 sqft)	-64.69%	49.16%

Source: California Energy Commission staff

Table B-2 shows modeled annual bill savings by vintage category. The results represent the retrofits that include at least an HPWH or an HP HVAC. Since they are different, the vintage categories for single-family and multifamily prototypes are shown separately from the vintage categories for manufactured home prototypes. This table shows there is not significant variation in modeled bill savings by vintage category.

Table B-2: Annual Bill Savings Range by Home Vintage Category

Home Vintage	Minimum Bill Savings	Maximum Bill Savings
Single Family (Pre-1975)	-69.74%	47.21%
Single Family (1975-1983)	-65.99%	45.04%
Single Family (1984-2005)	-65.52%	44.39%
Multifamily (Pre-1975)	-12.88%	35.01%
Multifamily (1975-1983)	-10.36%	35.09%
Multifamily (1984-2005)	-10.14%	35.10%
Manufactured Home (Pre-1976)	-64.29%	43.67%
Manufactured Home (1976-1994)	-57.33%	49.16%
Manufactured Home (Post-1994)	-52.24%	42.75%

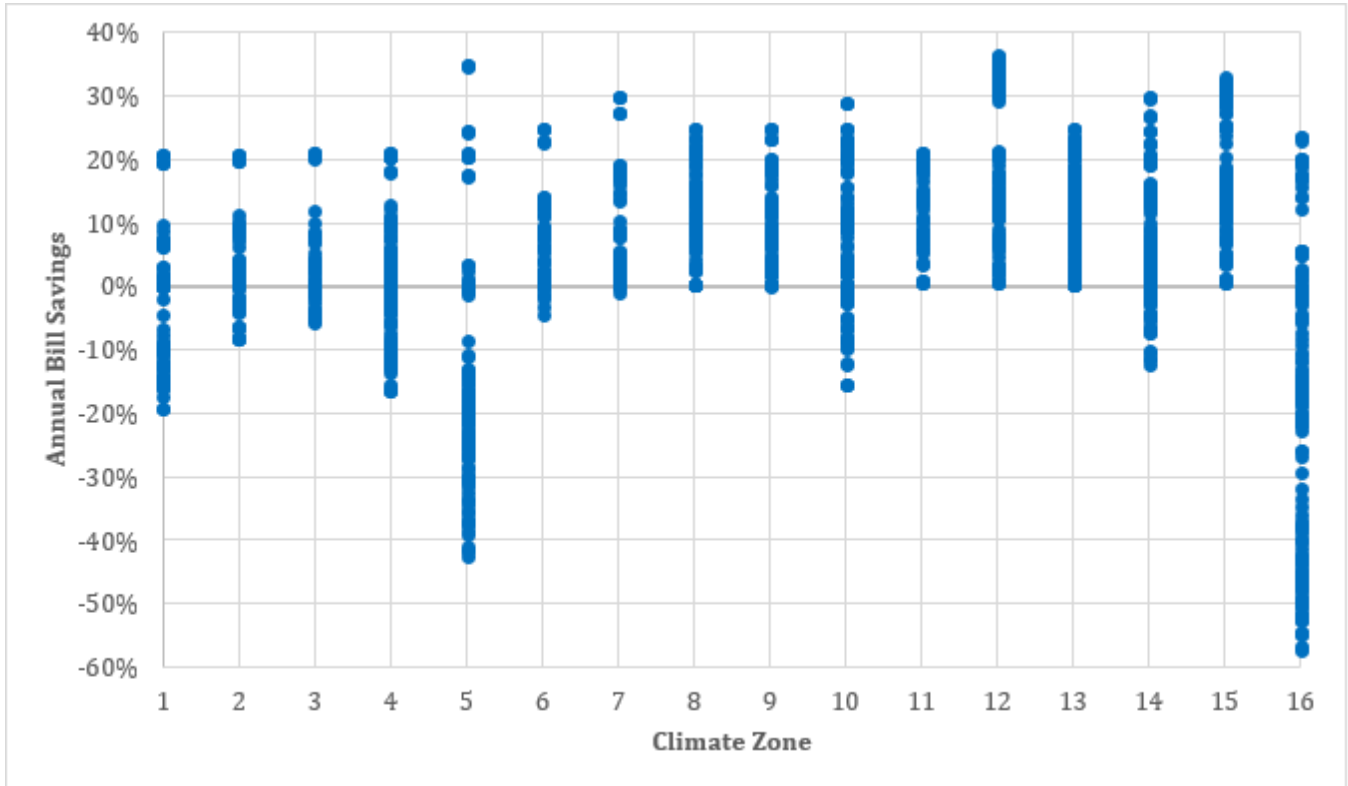
Source: California Energy Commission staff

Figures B-1 to B-10 show the modeled annual bill savings by climate zone for a number of decarbonization retrofit packages. Details of the measures included in the modeled retrofit are listed before each figure. The decarbonization retrofit packages in this appendix are:

- Heat pump package (Figure B-1)
- High-efficiency heat pump package (Figure B-2)
- HP HVAC envelope package (Figure B-3)
- High-efficiency HP HVAC envelope package (Figure B-4)
- HP HVAC envelope plus solar film package (Figure B-5)
- High-efficiency HP HVAC envelope plus solar film package (Figure B-6)
- All-electric package (Figure B-7)
- High-efficiency all-electric package (Figure B-8)
- Full retrofit package (Figure B-9)
- High-efficiency full retrofit package (Figure B-10)

Figure B-1 shows modeled annual bill savings by climate zone for heat pump package retrofits. The heat pump package includes an HPWH and HP HVAC plus duct sealing for single-family and manufactured home prototypes. For multifamily prototypes, duct sealing is not included as ducts are modeled in conditioned space. In Climate Zones 7–9, 11–13, and 15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 2, 3, 6, 10, and 14, more than half of the data points are above zero percent. In Climate Zones, 1, 4, 5, and 16, more than half of the data points are below zero percent.

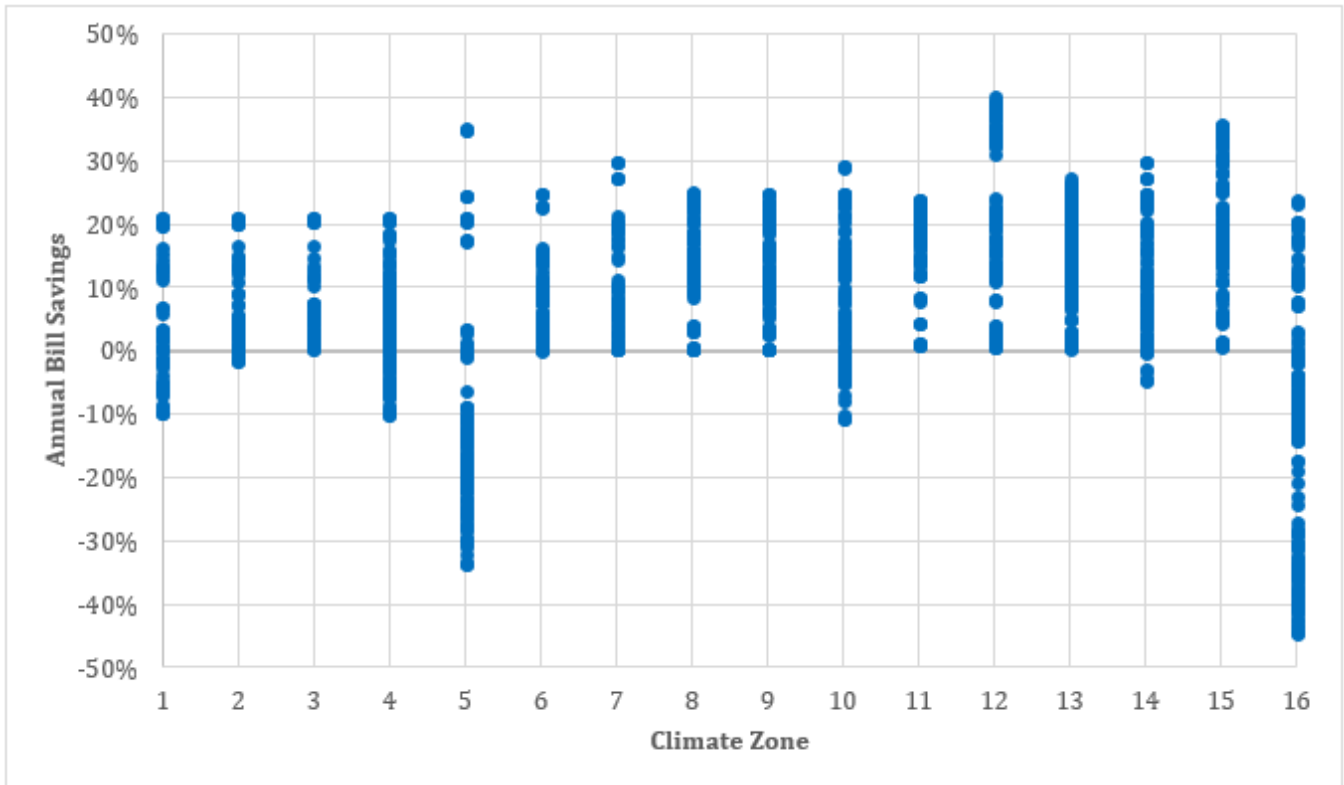
Figure B-1: Annual Bill Savings of Heat Pump Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-2 shows modeled annual bill savings by climate zone for high-efficiency heat pump package retrofits. The high-efficiency heat pump package includes an HPWH and a high-efficiency HP HVAC plus duct sealing for single-family and manufactured home prototypes. For multifamily prototypes, duct sealing is not included as ducts are modeled in conditioned space. In Climate Zones 2, 3, 6–9, and 11–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 1, 4, and 10, most of the data points are above zero percent. In Climate Zones 5 and 16, more than half of the data points are below zero percent.

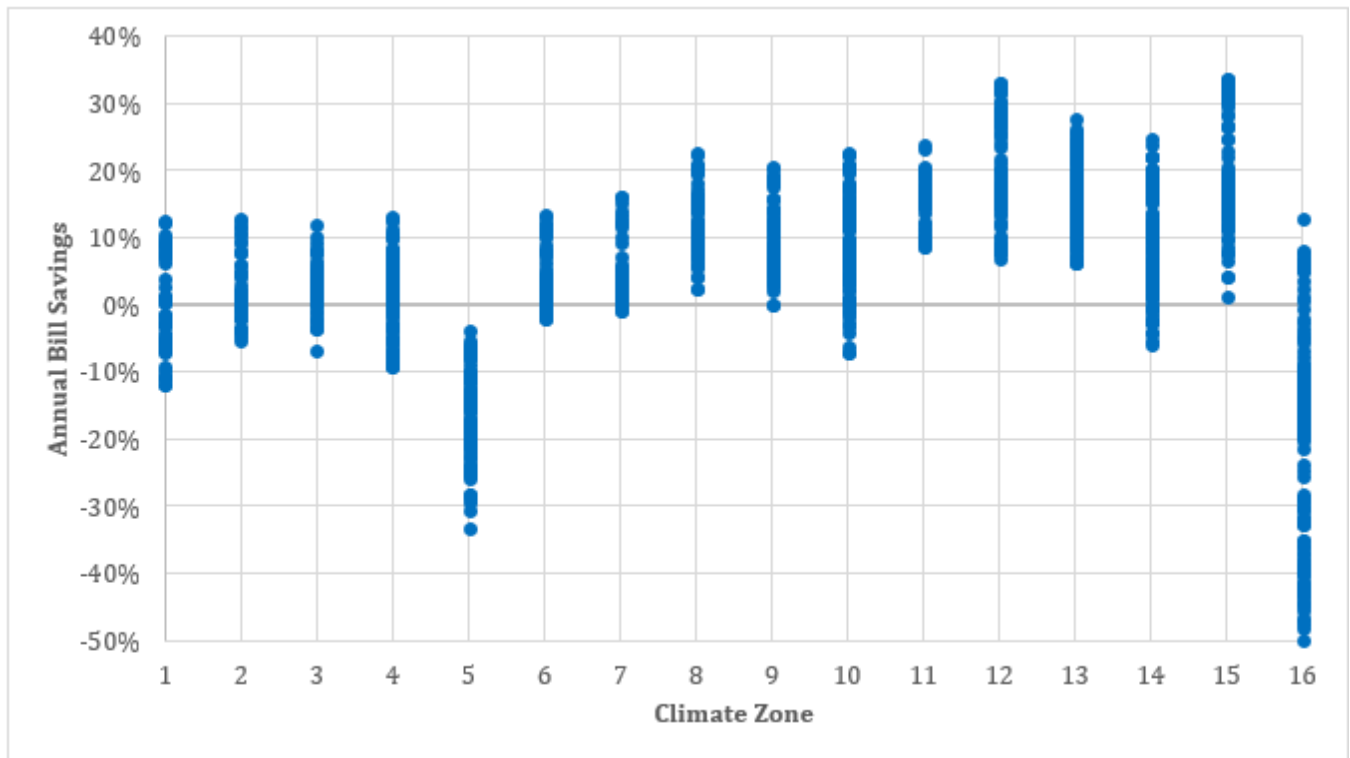
Figure B-2: Annual Bill Savings of High-Efficiency Heat Pump Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-3 shows modeled annual bill savings by climate zone for HP HVAC envelope package retrofits. The heat pump HVAC (HP HVAC) package for the single-family prototypes includes an HP HVAC, duct sealing, attic insulation, and air sealing. For manufactured home prototypes, this package includes an HP HVAC, duct sealing, floor insulation, air sealing, and attic insulation for the double-wide manufactured home prototypes. Multifamily retrofit prototypes do not have duct sealing or improved attic insulation, so multifamily prototypes are not included in the HP HVAC envelope package. In Climate Zones 11–13 and 15, all the data points are above zero percent, representing bill savings. In Climate Zones 1–4, 6–10, and 14, at least half of the data points are above zero percent. In Climate Zones, 5 and 16, most of the data points are below zero percent.

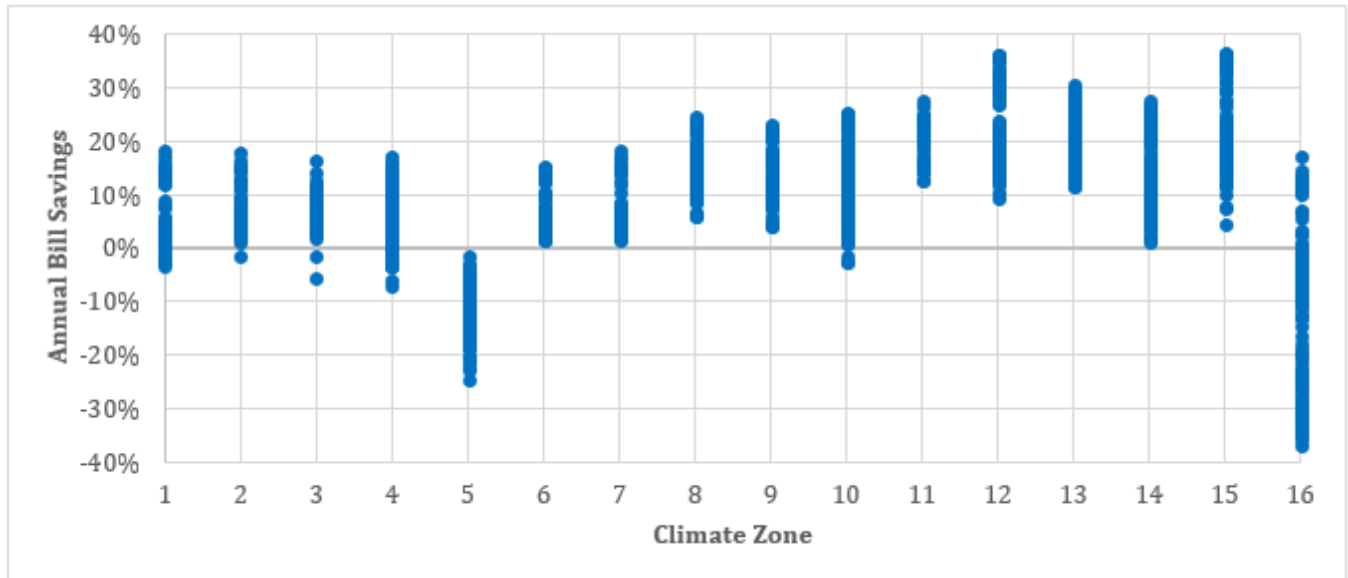
Figure B-3: Annual Bill Savings of HP HVAC Envelope Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-4 shows modeled annual bill savings by climate zone for high-efficiency HP HVAC envelope package retrofits. The high-efficiency HP HVAC package for the single-family prototypes includes a higher-efficiency HP HVAC, duct sealing, attic insulation, and air sealing. For manufactured home prototypes, this package includes a higher-efficiency HP HVAC, duct sealing, floor insulation, air sealing, and attic insulation for the double-wide manufactured home prototypes. Multifamily retrofit prototypes do not have duct sealing or improved attic insulation, so multifamily prototypes are not included in the high-efficiency HP HVAC envelope package. In Climate Zones 6-9 and 11-15, all the data points are above zero percent, representing bill savings. In Climate Zones 1-4 and 10, most of the data points are above zero percent. In Climate Zones, 5 and 16, most of the data points are below zero percent.

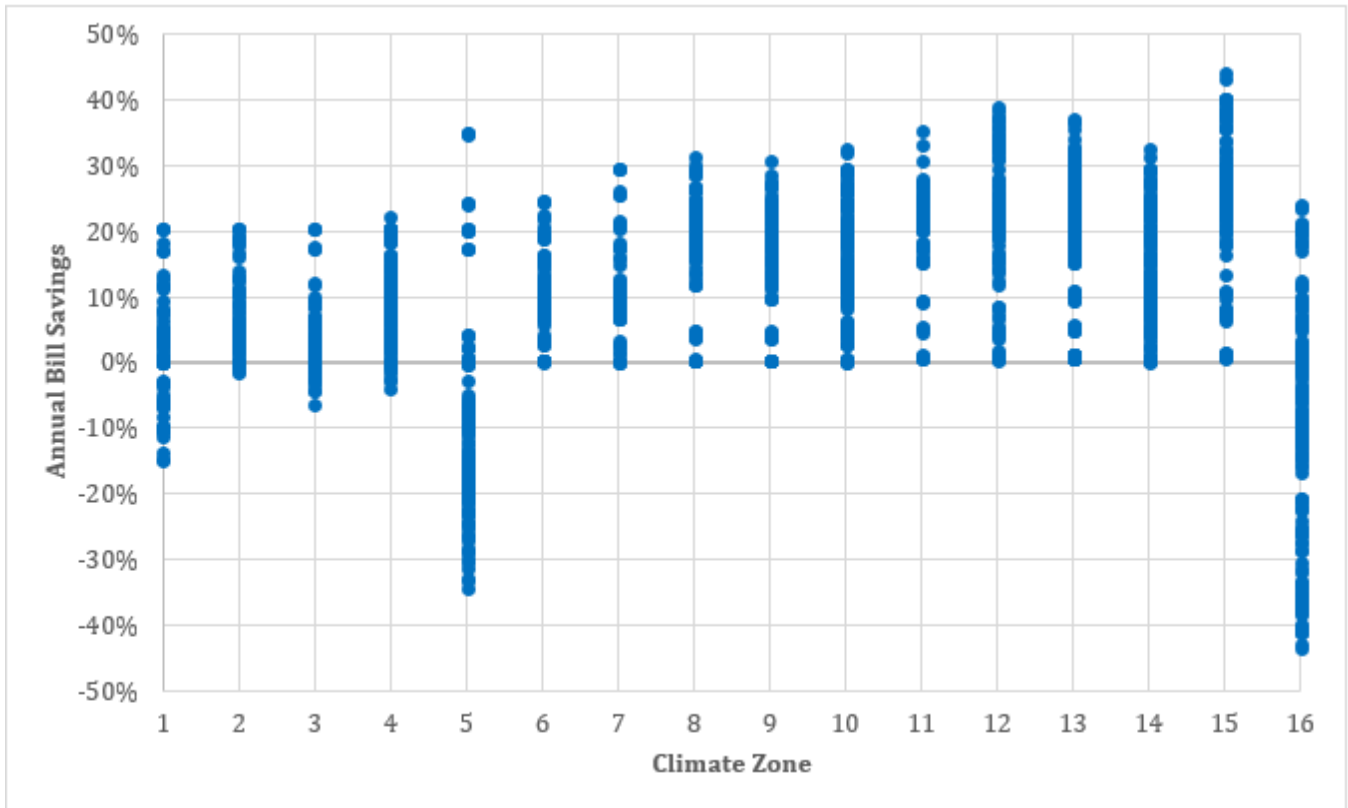
Figure B-4: Annual Bill Savings of High-Efficiency HP HVAC Envelope Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-5 shows modeled annual bill savings by climate zone for HP HVAC envelope plus solar window film package. The HP HVAC envelope plus solar film package for the single-family prototypes includes an HP HVAC, duct sealing, attic insulation, air sealing, and solar window films. For multifamily prototypes, this package includes an HP HVAC, air sealing, and solar window films. Duct sealing is not modeled in multifamily prototypes, as ducts are in conditioned space. Attic insulation retrofit is not modeled in multifamily prototypes, as the roof is flat with no attic space. For manufactured home prototypes, this package includes an HP HVAC, duct sealing, floor insulation, air sealing, and solar window films. The double-wide manufactured home prototype also includes attic insulation. In Climate Zones 6–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 1–4 most of the data points are above zero percent. In Climate Zones 5 and 16, most of the data points are below zero percent.

Figure B-5: Annual Bill Savings of HP HVAC Envelope Plus Solar Window Film Package Retrofits by Climate Zone

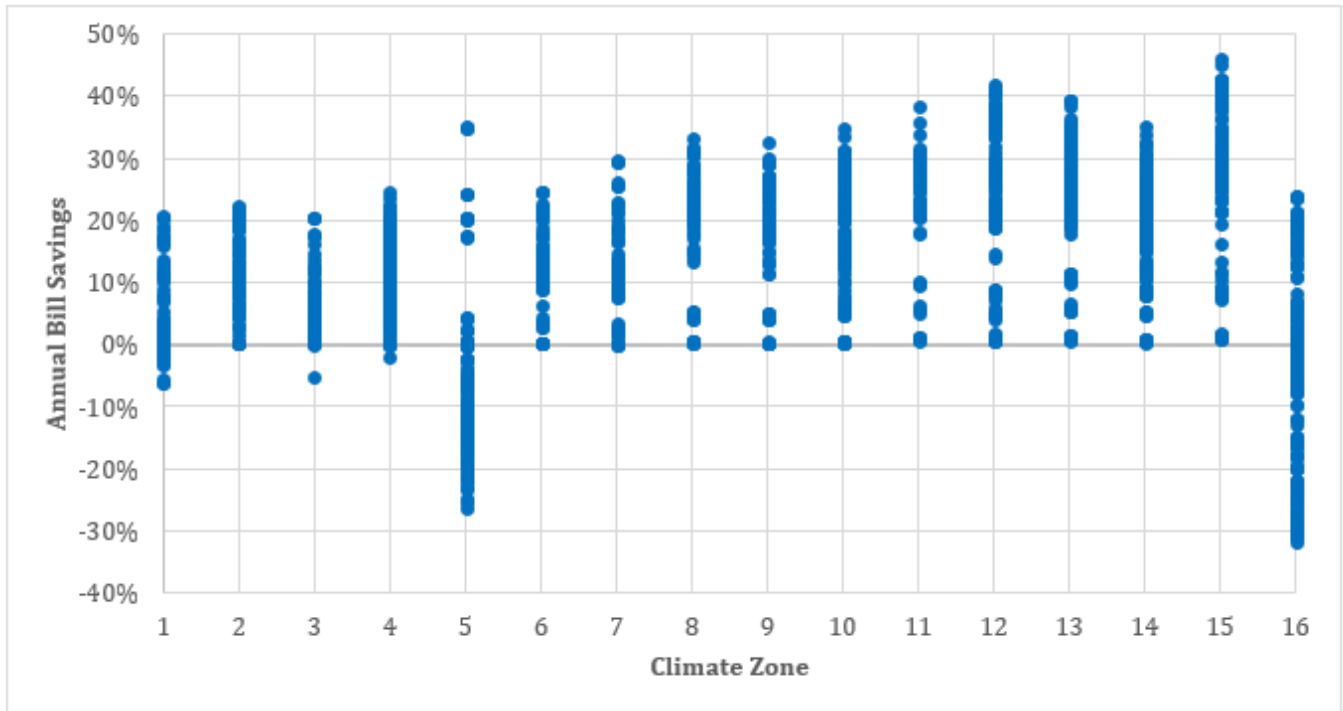


Source: California Energy Commission staff

In Climate Zones 6–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 1–4 most of the data points are above zero percent. In Climate Zones 5 and 16, most of the data points are below zero percent.

Figure B-6 shows modeled annual bill savings by climate zone for the high-efficiency HP HVAC envelope plus solar window film package. The high-efficiency HP HVAC envelope plus solar film package for the single-family prototypes includes a high-efficiency HP HVAC, duct sealing, attic insulation, air sealing, and solar window films. For multifamily prototypes, this package includes a high-efficiency HP HVAC, air sealing, and solar window films. Duct sealing is not modeled in multifamily prototypes, as ducts are in conditioned space. Attic insulation retrofit is not modeled in multifamily prototypes, as the roof is flat with no attic space. For manufactured home prototypes, this package includes a high-efficiency HP HVAC, duct sealing, floor insulation, air sealing, and solar window films. The double-wide manufactured home prototype also includes attic insulation. In Climate Zones 6-15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 1-4 most of the data points are above zero percent. In Climate Zones, 5 and 16, most of the data points are below zero percent.

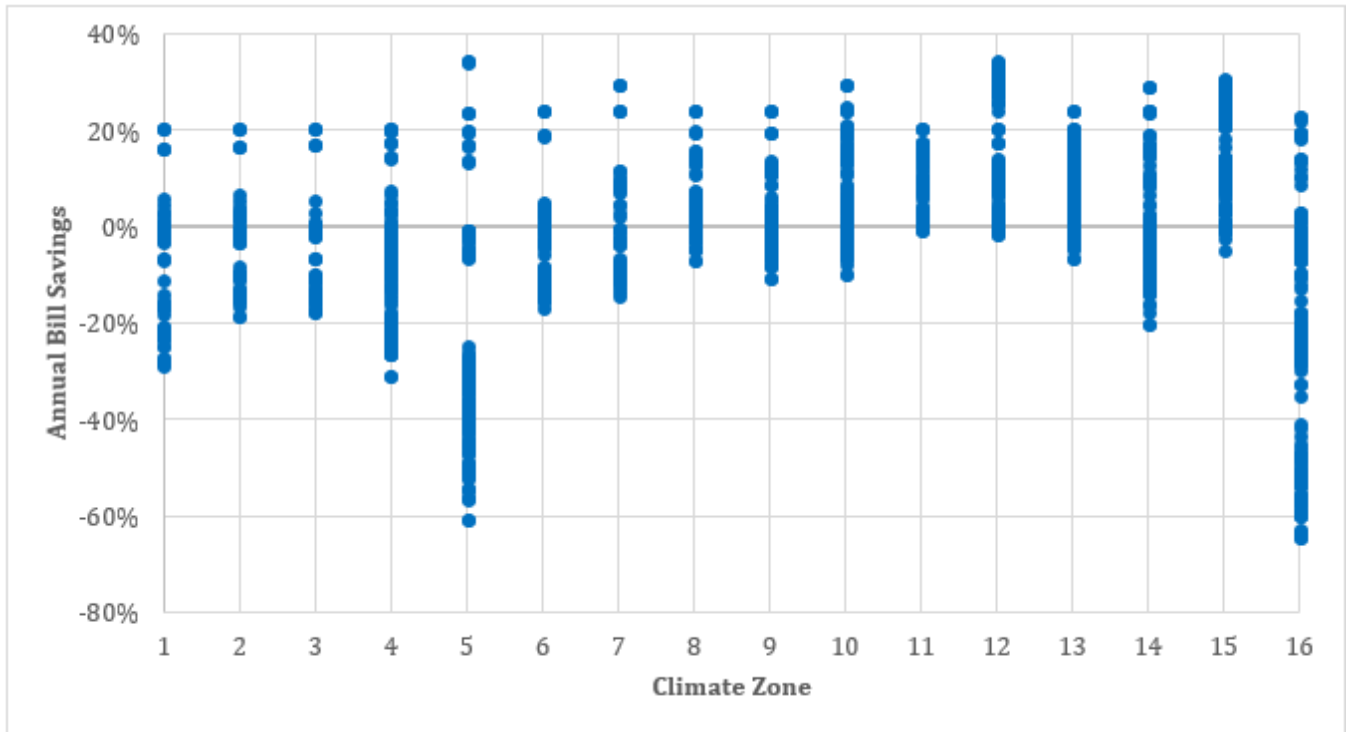
Figure B-6: Annual Bill Savings of High-Efficiency HP HVAC Envelope Plus Solar Window Film Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-7 shows modeled annual bill savings by climate zone for all-electric package retrofits. The all-electric package for all prototypes, except for multifamily prototypes, includes an HPWH, HP HVAC, duct sealing, electric cooktop, and electric clothes dryer. This package for the multifamily prototypes includes all the same measures, except duct sealing as ducts are modeled in conditioned space. In Climate Zones 11, 12, and 15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 8–10 and 13 and 14, most of the data points are above zero percent. In Climate Zones 1–7 and 16, most of the data points are below zero percent.

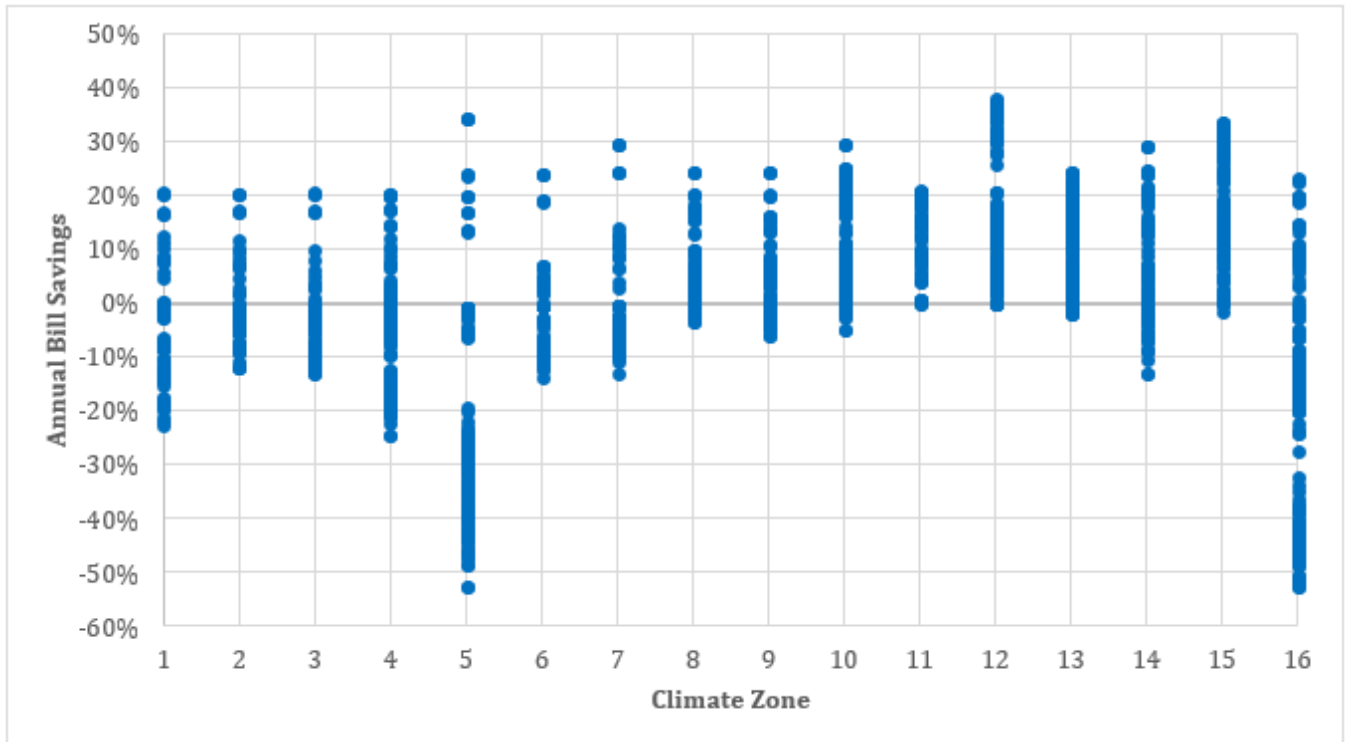
Figure B-7: Annual Bill Savings of All-Electric Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-8 shows modeled annual bill savings by climate zone for high-efficiency, all-electric package retrofits. The high-efficiency, all-electric package includes an HPWH, higher-efficiency HP HVAC, duct sealing, electric cooktop, and electric clothes dryer. The multifamily prototypes do not include duct sealing. In Climate Zones 11–13 and 15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 7–10 and 14, most of the data points are above zero percent. In Climate Zones 1–6 and 16, most of the data points are below zero percent.

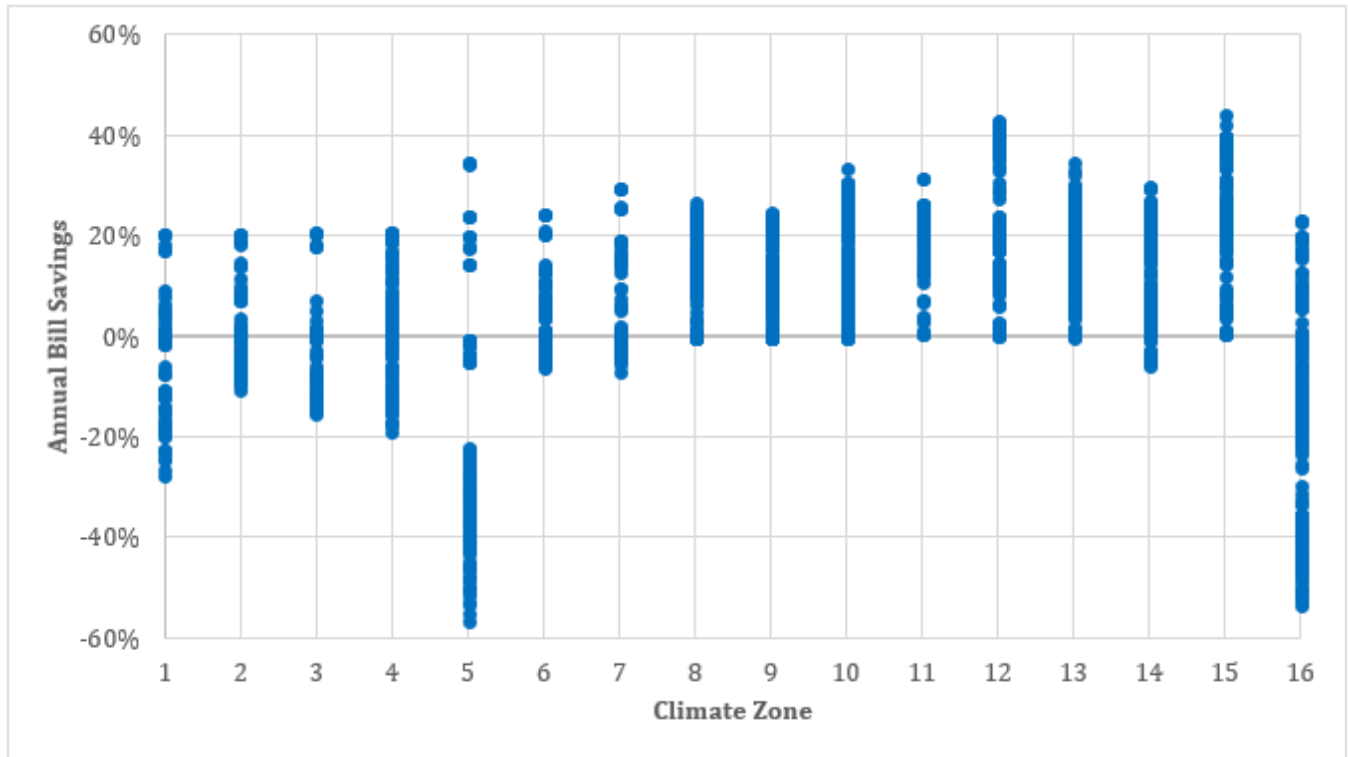
Figure B-8: Annual Bill Savings of High-Efficiency All-Electric Package Retrofits by Climate Zone



Source: California Energy Commission staff

Figure B-9 shows modeled annual bill savings by climate zone for full package retrofits. The full retrofit package for the single-family prototypes includes an HPWH, HP HVAC, duct sealing, attic insulation, air sealing, electric cooktop, and electric clothes dryer. For multifamily prototypes, this package includes HPWH, HP HVAC, air sealing, electric cooktop, and electric clothes dryer. Duct sealing is not included in multifamily prototypes as the ducts are modeled in conditioned space. For manufactured home prototypes, this package includes an HPWH, HP HVAC, duct sealing, floor insulation, air sealing, electric cooktop, electric clothes dryer, and attic insulation for the double-wide manufactured home prototypes. In Climate Zones 8–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 2, 4, 6, and 7, most of the data points are above zero percent. In Climate Zones 1, 3, 5, and 16, most of the data points are below zero percent.

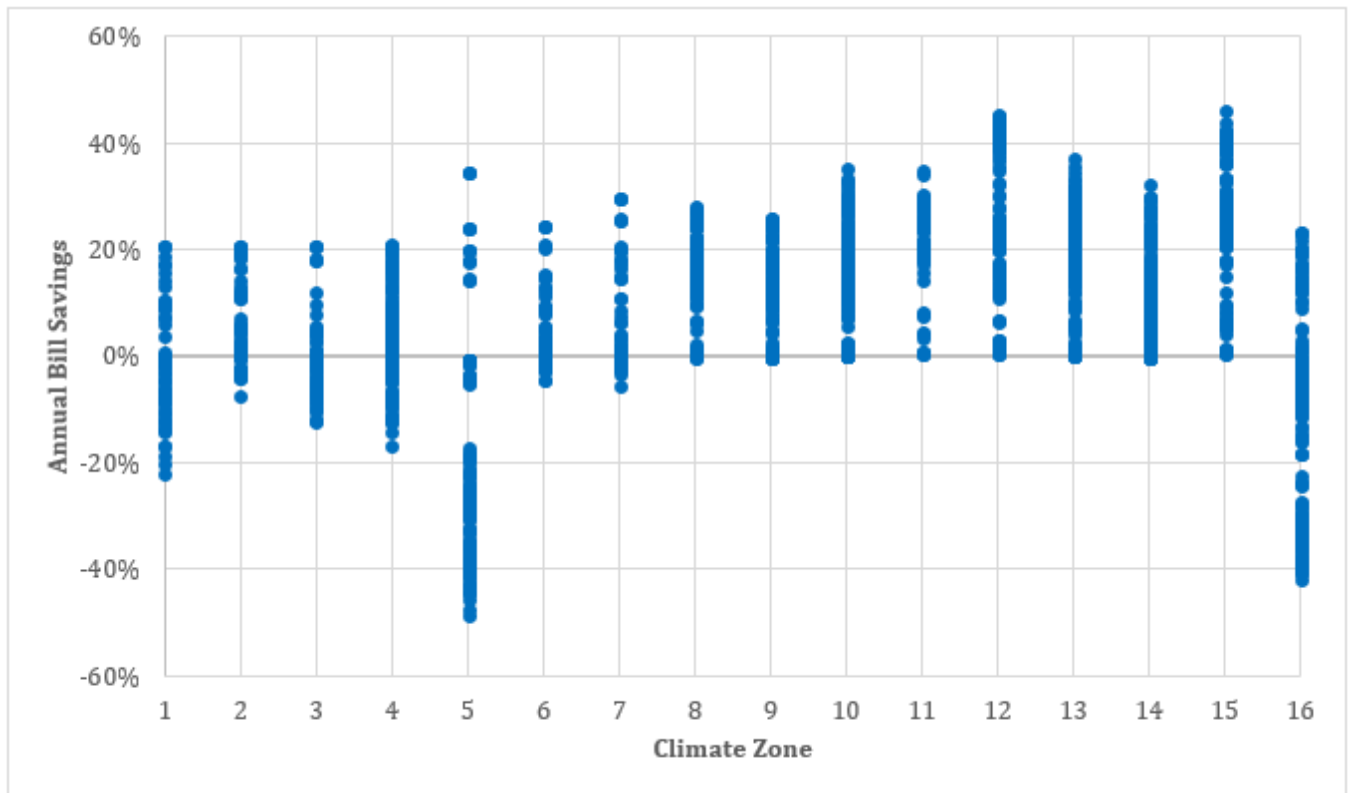
Figure B-9: Annual Bill Savings of Full Retrofit Package by Climate Zone



Source: California Energy Commission staff

Figure B-10 shows modeled annual bill savings by climate zone for high-efficiency, full package retrofits. The high-efficiency, full retrofit package for single-family prototypes includes an HPWH, higher-efficiency HP HVAC, duct sealing, attic insulation, air sealing, electric cooktop, and electric clothes dryer. For multifamily prototypes, this package includes an HPWH, higher-efficiency HP HVAC, air sealing, electric cooktop, and electric clothes dryer. For manufactured home prototypes, this package includes an HPWH, higher-efficiency HP HVAC, duct sealing, floor insulation, air sealing, electric cooktop, electric clothes dryer, and attic insulation for the double-wide manufactured home prototypes. In Climate Zones 6–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 2–4, most of the data points are above zero percent. In Climate Zones 1, 5, and 16, most of the data points are below zero percent.

Figure B-10: Annual Bill Savings of High-Efficiency Full Retrofit Package by Climate Zone



Source: California Energy Commission staff

In Climate Zones 6–15, nearly all the data points are above zero percent, representing bill savings. In Climate Zones 2–4, most of the data points are above zero percent. In Climate Zones 1, 5, and 16, most of the data points are below zero percent.

Figure B-11 shows modeled annual bill savings by climate zone for HP HVAC with incremental savings from efficiency measures. The bars show a starting point when retrofitting to an HP HVAC plus duct sealing. The stacked bars are then incremental savings provided by high-efficiency HP HVAC, air sealing, and attic insulation. These results represent the single-family home prototypes. This figure shows modeled starting points with savings found in Climate Zones 6–15 when retrofitting to an HP HVAC plus duct sealing, whereas all other climate zones showed bill increases. Climate Zones 1–4 were able to achieve bill savings after modeling a high-efficiency HP HVAC. However, Climate Zones 5 and 16 were not able to achieve overall annual bill savings despite modeling all three incremental savings.

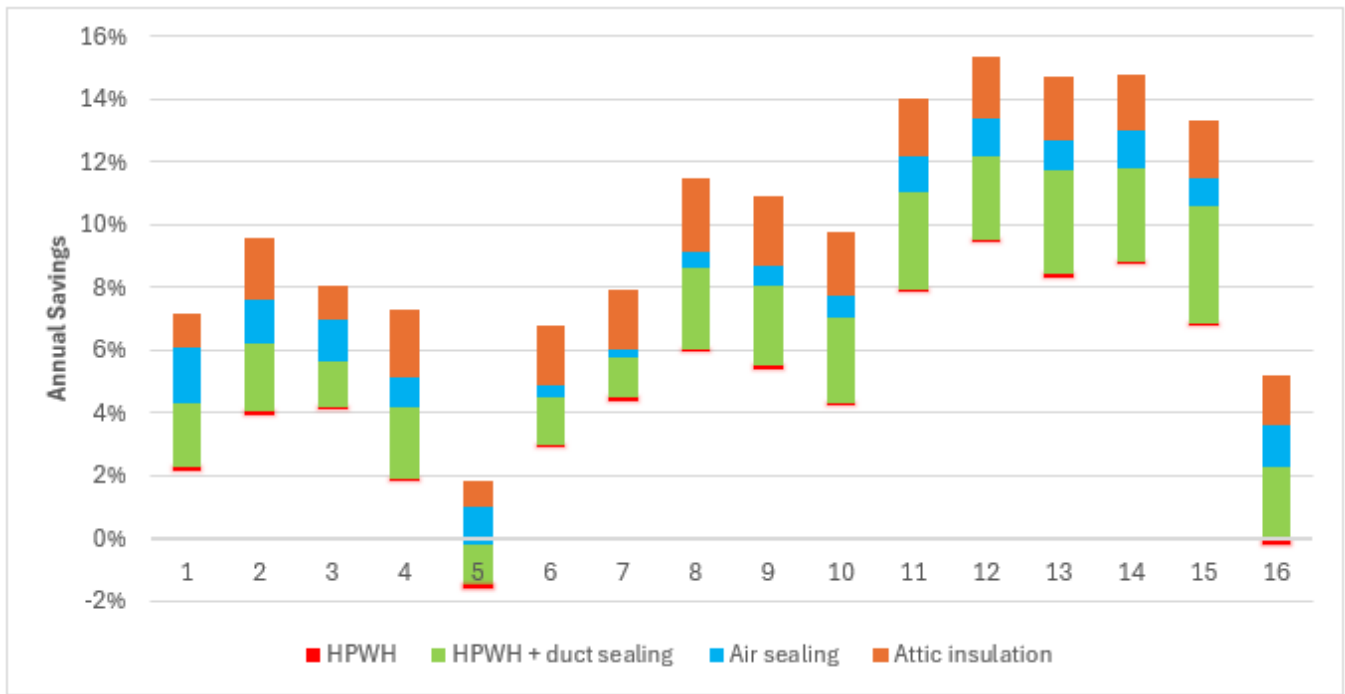
Figure B-11: Annual Bill Savings for HP HVAC With Incremental Measures by Climate Zone



Source: California Energy Commission staff

Figure B-12 shows modeled annual bill savings by climate zone for HPWH with incremental savings from efficiency measures. The bars show a starting point when retrofitting to an HPWH. The stacked bars are then incremental savings provided by duct sealing, air sealing, and attic insulation. These results represent the single-family home prototypes. This figure shows modeled starting points with savings found in all climate zones when retrofitting to an HPWH, except for Climate Zones 5 and 16. Climate Zones 5 and 16 were able to achieve bill savings after including incremental efficiency measures.

Figure B-12: Annual Bill Savings for HPWH With Incremental Measures by Climate Zone



Source: California Energy Commission staff

Table B-4 summarizes the bill savings results for single family, multifamily, and manufactured home prototypes by retrofit package and climate zone. The retrofit package descriptions are listed above in Appendix B. Table B-3 is a key of the summary result symbols.

Table B-3: Retrofit Package Summary Results Key

Symbol	Description
✓	The green check symbolizes that all prototypes result in positive bill savings.
~	The blue tilde symbolizes that, on average, results are positive bill savings.
✗	The orange x-mark symbolizes that, on average, results are negative bill savings.

Source: California Energy Commission staff

Table B-4 summarizes the data shown in Figures B-1 to B-10. As shown by the red x-marks, heat pump retrofit packages in Climate Zone 5 result in bill increases. As shown by the green and yellow check marks, there are mostly positive bill savings for all heat pump retrofit packages in high cooling load and low heating load climates, Climate Zones 8 and 9 in Southern California, Climate Zones 11-13 in the Central Valley, and Climate Zone 15 in the desert. Generally, the high-efficiency heat pump packages result in higher bill savings than their standard efficiency heat pump package counterparts.

Table B-4: Residential Building Retrofit Package Bill Savings Summary

Retrofit Package	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Heat pumps	✗	~	~	✗	✗	~	~	✓	✓	~	✓	✓	✓	~	✓	✗
High-efficiency heat pumps	~	~	~	~	✗	~	✓	✓	✓	~	✓	✓	✓	~	✓	✗
HP HVAC envelope	✗	~	~	~	✗	~	~	✓	✓	~	✓	✓	✓	~	✓	✗
High-efficiency HP HVAC envelope	~	~	~	~	✗	✓	~	✓	✓	~	✓	✓	✓	✓	✓	✗
HP HVAC envelope plus solar film	✗	~	~	~	✗	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✗
High-efficiency HP HVAC envelope plus solar film	~	✓	~	~	✗	✓	~	✓	✓	✓	✓	✓	✓	✓	✓	✗
All-electric	✗	✗	✗	✗	✗	✗	✗	~	✗	~	~	~	~	✗	~	✗
High-efficiency all-electric	✗	✗	✗	✗	✗	✗	✗	~	~	~	✓	~	~	~	~	✗
Full retrofit	✗	✗	✗	✗	✗	~	~	~	~	~	✓	✓	~	~	✓	✗
High-efficiency full retrofit	✗	~	✗	✗	✗	~	~	~	~	~	✓	✓	~	~	✓	✗

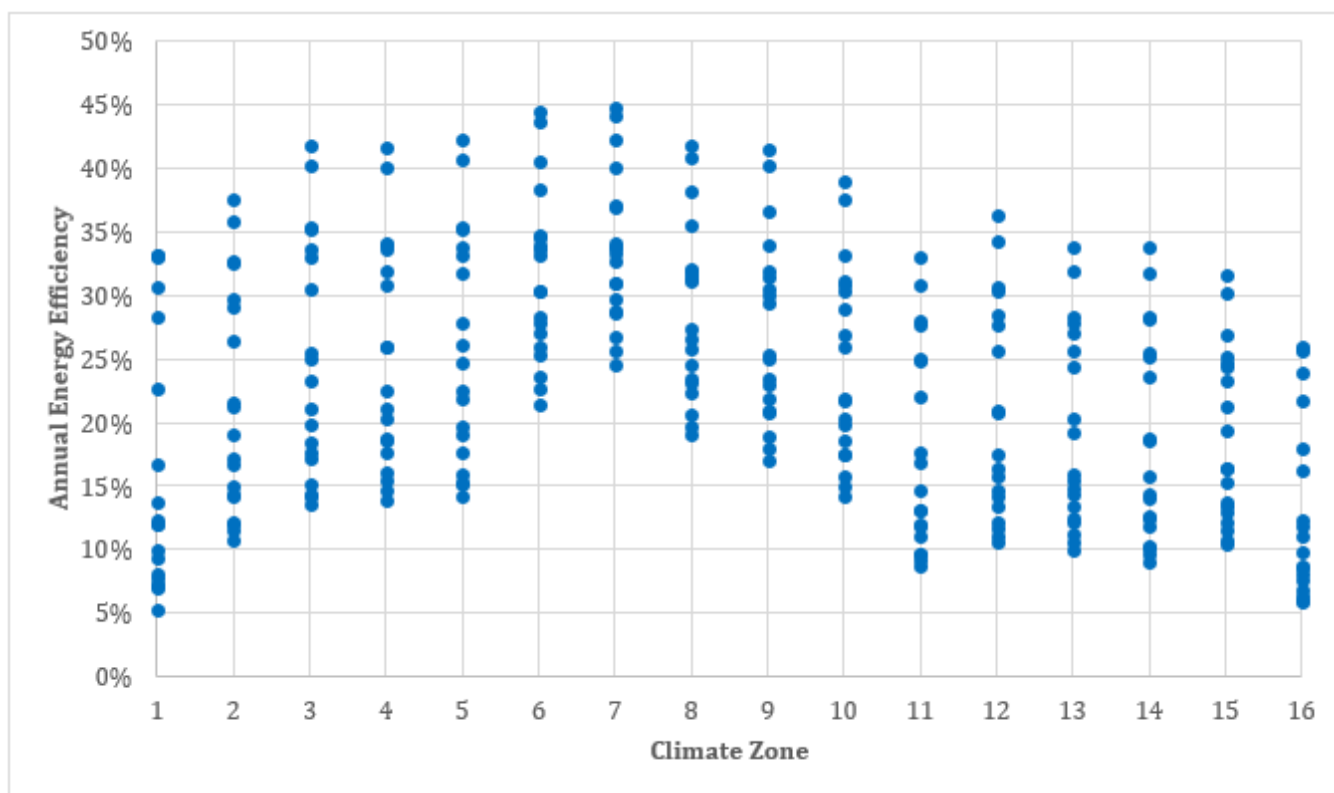
Source: California Energy Commission staff

APPENDIX C: Energy Efficiency — Modeled Results

This appendix includes annual energy efficiency results for the HPWH and HP HVAC retrofits in the single-family, multifamily, and manufactured home prototypes in all the vintage categories included in this analysis.

Results in Figures C-1 and C-2 show total energy efficiency, so it includes gas and electricity both converted to BTU. The energy savings from avoidance of burning gas through decarbonization measures outweigh any additional use of electricity.

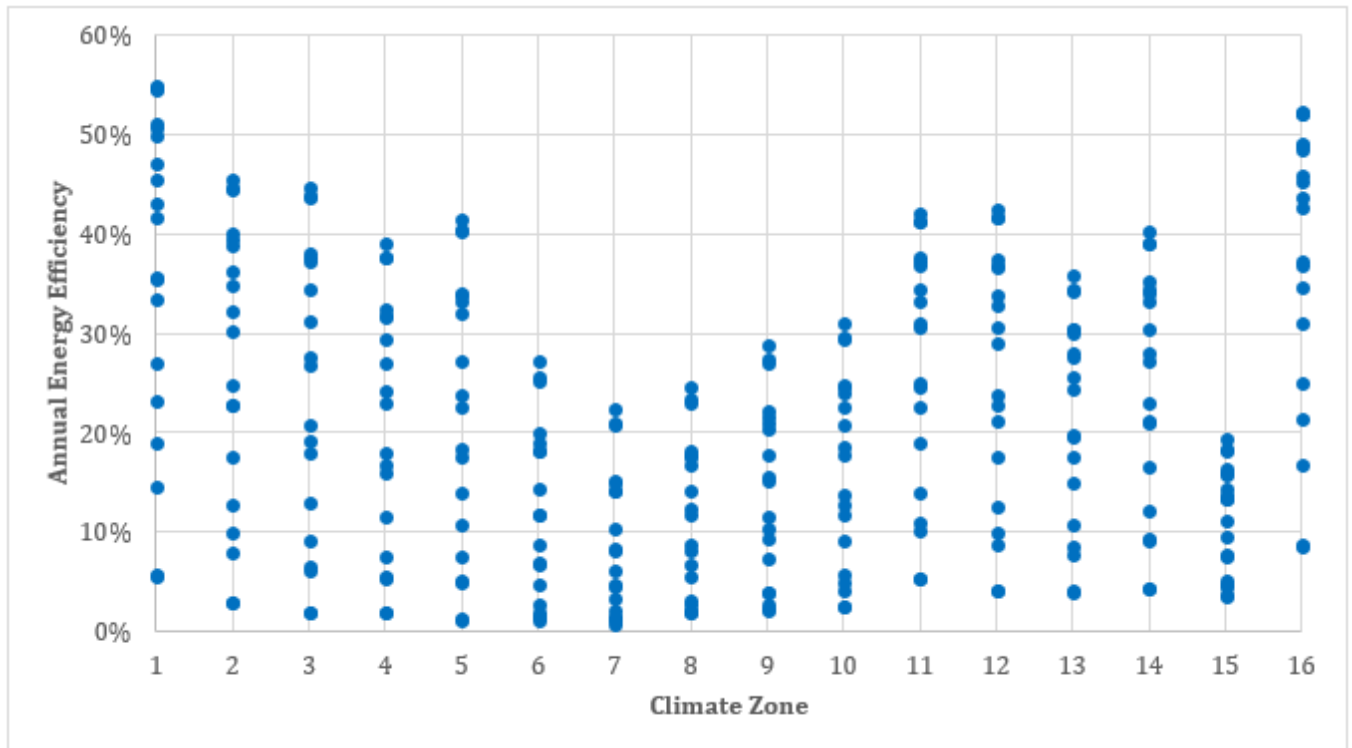
Figure C-1: Energy Efficiency of Heat Pump Water Heater Retrofit by Climate Zone



Source: California Energy Commission staff

Figure C-1 shows the modeled energy efficiency of HPWH retrofits by climate zone. There is positive energy efficiency in all climate zones. In Climate Zones 6–9, the modeled energy efficiency range is above 15 percent.

Figure C-2: Energy Efficiency of HP HVAC Retrofit by Climate Zone



Source: California Energy Commission staff

Figure C-2 shows the modeled energy efficiency of HP HVAC retrofits by climate zone. There is positive energy efficiency in all climate zones. There is higher potential for energy efficiency in climate zones that have a higher heating load, mainly Climate Zones 1 and 16, which are the North Coast and Sierra Nevada mountain region, respectively. Although there are savings in Climate Zone 15, there is not as much energy savings potential compared to other climates due to having the lowest heating load.

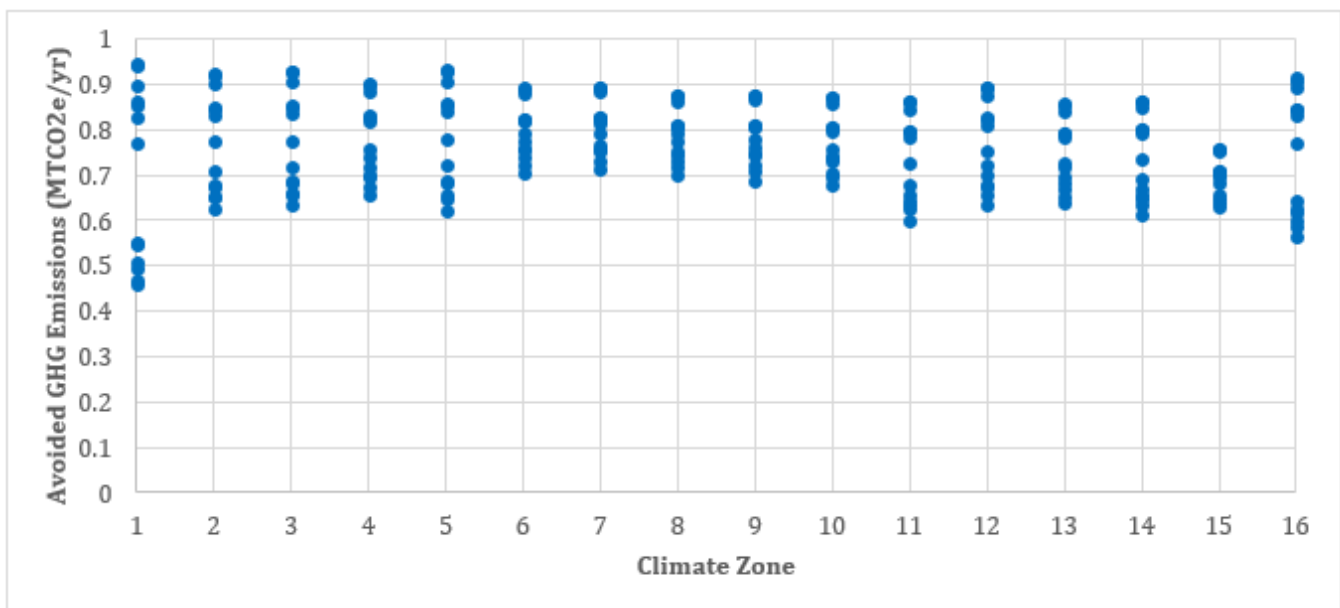
The modeled energy efficiency of other retrofit combinations would increase from the results shown in Figures C-1 and C-2. With the addition of decarbonization and envelope measures, modeled energy efficiency results increase.

APPENDIX D: GHG Emissions — Modeled Results

This appendix shows modeled avoided annual GHG emissions results for the HPWH and HP HVAC retrofits in the single-family and manufactured home prototypes for all the vintage categories included in this analysis.

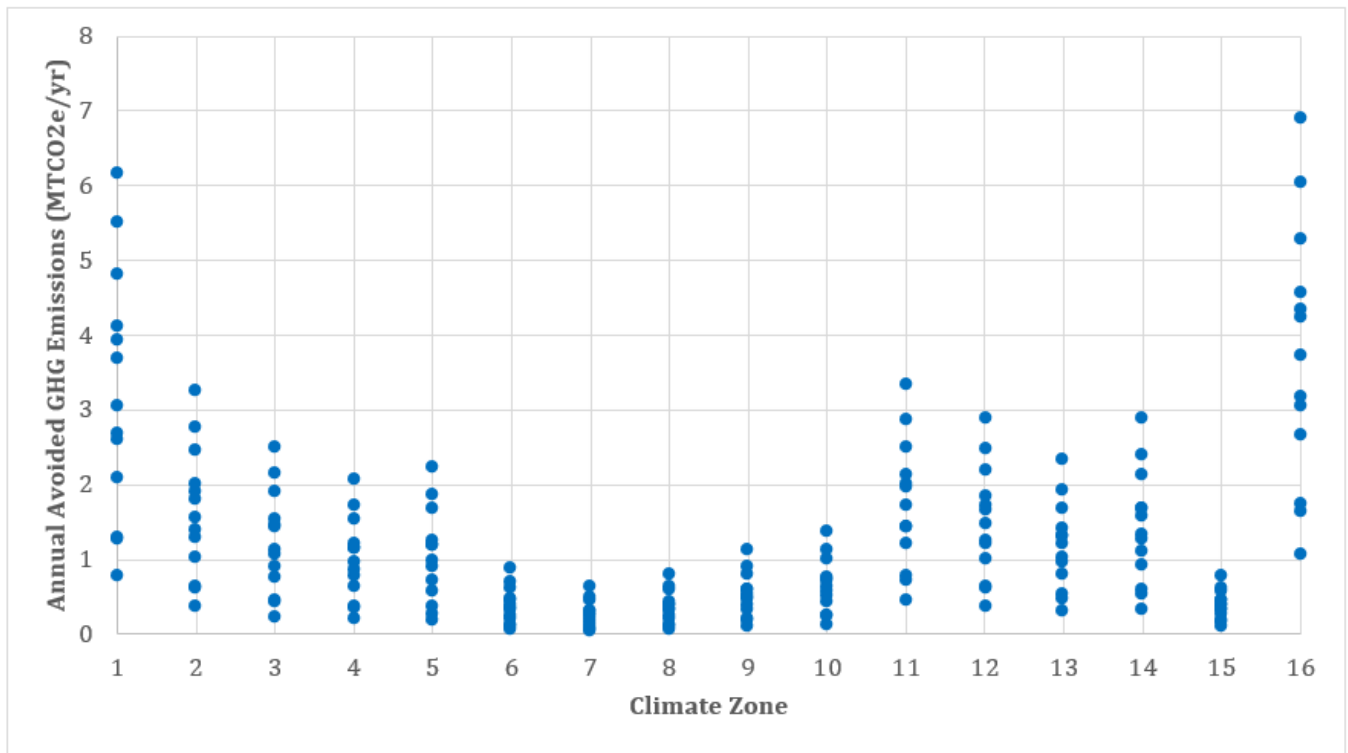
There are positive avoided GHG emissions for all retrofits modeled in this analysis. Figures D-1 and D-2 show there is more potential for avoided GHG emissions with an HP HVAC compared to HPWH. There is also higher potential for avoided GHG emissions in climate zones that have a higher heating load, mainly Climate Zones 1 and 16, as seen in Figure D-2. This higher potential is due to eliminating the combustion of gas for space heating.

Figure D-1: Avoided GHG Emissions of Heat Pump Water Heater Retrofit by Climate Zone



Source: California Energy Commission staff

Figure D-2: Avoided GHG Emissions of HP HVAC Retrofit by Climate Zone



Source: California Energy Commission staff

The modeled avoided GHG emissions of other retrofit combinations would increase from the results shown in Figures D-1 and D-2. With the addition of decarbonization and envelope measures, modeled avoided GHG emission results increase due to the reduced use of energy. Incrementally avoided GHG emissions can be achieved with the addition of envelope measures or with a higher-efficiency HP HVAC. Electrifying cooking and clothes drying would further increase the avoided GHG emissions.